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Abstracts

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Plenary talks

1 Oral contributions

Into the cold - extragalactic astronomy with ALMA

Aalto, Susanne (-)

ALMA - the Atacama Large Millimeter/submillimeter Array is getting ready for its third call for proposals -and there is now a flood of scientific images and results from the Early Science period. ALMA is targeting the cold Universe - from stars and planet formation in our own Galaxy to the structure and physics of the distant, young Universe. In this presentation I will focus on ALMA studies of external galaxies - near and far - including results on complex gas motions and structures around active galactic nuclei (AGN), dynamics of spiral arms and bars, star formation, and a peek behind the veil of dust-obscured Compton thick galaxy nuclei. Finally, I will discuss molecular outflows in AGN and starburst galaxies. These dense winds are extremely important vehicles of evolution and I will explain why the science of cold extragalactic winds will transform with ALMA.

The origin of the primordial perturbation

Enqvist, Kari (University of Helsinki)

I discuss the origin of the primordial perturbation in inflationary universe. I compare the predictions of slow-roll inflaton models for the spectral features and statistics of the CMB temperature fluctutions with the Planck results. I also discuss curvaton models, where the primordial perturbation is generated after inflation ends.

Gamma-Ray Bursts as probes of galaxy evolution

Fynbo, Johan (-)

Gamma-Ray Bursts (GRBs) are extremely energetic cosmic explosions that can be detected throughout the Universe even back to the epoch of the very first galaxy formation. The study of GRB physics is very exiting on its own, but in addition to this GRBs constitute a fantastic probe of galaxy evolution. Specifically, GRBs open two interesting routes to study galaxy evolution. First, with spectroscopy of the afterglows of GRBs we can determine essential properties of the interstellar-medium of galaxies such as abundances, molecular content and kinematics of the absorbing gas. Second, using the positions of GRBs we consequently have the positions of their host galaxies. After the afterglows have faded away these positions can then be studied to great depth whereby we can build a sample af galaxies selected by their on-going star-formation. In the talk I will try to highly some of our most important results following both of these two routes.

Herschel Space Observatory - Highlights of star formation studies

Juvela, Mika (University of Helsinki)

The *Herschel Space Observatory* is a cornerstone mission in the European Space Agency (ESA) science programme. The satellite was launched in 2009 together with *Planck*. *Herschel* has carried out photometric and spectrometric observations at far-infrared and sub-millimetre wavelengths, combining a sensitivity and a spatial resolution unprecedented in this wavelength range. After very successful operations exceeding the projected lifetime of 3.5 years, *Herschel* will finally finish observations in the spring of 2013.

Star formation studies, from high-z galaxies to local Milky Way, constitute a significant part of the scientific legacy of Herschel. With data available in Herschel Science Archive, these studies will continue for many years to come. I will present some highlights of the already published results, concentrating on studies of star formation within our own Galaxy. In this context, I also will discuss the project *Galactic Cold Cores* that is comparing the conditions for star-formation in different Galactic environments.

Luminous flares from tidally disrupted stars, and the search for supermassive black holes in quiescent galaxies

Komossa, Stefanie (MPIfR Bonn)

The close link between the host galaxies, and the supermassive black holes (SMBHs) at their centers, is key to understanding the formation and evolution of galaxies across cosmic times. Two main, complementary, methods have been used to search for SMBHs at the cores of non-active galaxies: one method is based on the motions of gas and stars within the SMBH's sphere of influence. The other method makes use of the extreme tidal forces of SMBHs on single stars in their immediate vicinity. Stars closely approaching a SMBH will be torn apart by tidal forces, followed by a luminous flare of radiation when the stellar debris is accreted. These outbursts are unique signposts of SMBHs, out to high redshifts. Tidal disruption events (TDEs) represent a new probe of strong gravity, and have opened up a new window of studying accretion physics and jet formation when a new accretion disk forms rapidly. Initially discovered in X-rays during the ROSAT all-sky survey, and more recently also in the UV, optical, radio and gamma-ray regime, upcoming transient surveys will detect TDEs in the thousands. This talk provides an overview of the observations and astrophysical implications, and an outlook into future applications, including the use of TDEs as signposts for supermassive binary black holes and recoiling black holes.

Symposium S1

Solar activity and its manifestations in the heliosphere

1 Oral contributions

Proton stochastic re-acceleration in the downstream region of a coronal shock

Afanasiev, Alexander (University of Helsinki), Rami Vainio

It has been recently suggested (e.g. Kocharov et al. ApJ, 2011, 735, 4) that, in addition to diffusive acceleration of particles at a shock, their stochastic re-acceleration by the shock-amplified turbulence downstream from the shock can play an important role at early phases of large SEP events. A developed test-particle model of the particle re-acceleration process demonstrated that the re-acceleration effect can account for the observed hard spectral features at deca-MeV energies, which are difficult to explain based on a model of diffusive shock acceleration alone. However, in this case it is not enough to have just a test-particle model since such a model treats the turbulence as an infinite source of energy to be transferred to the particles. We will present results of our self-consistent simulations of the re-acceleration of protons in the downstream region of a coronal shock, which take the energy exchange between particles and waves into account. This approach allows us to model the simultaneous evolution of the wave frequency and proton energy spectra with time and to study how the parameters of the resultant proton energy spectrum developed due to the re-acceleration are related to the initial parameters of turbulence and particles (e.g., to the ratio between the initial wave and proton energy densities).

Solar Energetic Electron Sources as Inferred from a Comparison of In-situ and Electromagnetic Observations

Agueda, Neus (University of Barcelona), N. Agueda, K.-L. Klein, R. Vainio, B. Sanahuja, O.E. Malandraki, A. Papaioannou, N. Vilmer, R. Rodríguez-Gasén, R. Miteva, E. Valtonen, H. Aurass, S. Braune, B. Heber, W. Dröge, Y. Kartavykh, A. Nindos for the SEPServer Consortium

Detailed measurements of solar energetic particles (SEPs) in the heliosphere provide constrains to unravel their complete source and interplanetary propagation history. We present a set of eleven carefully-selected near-relativistic (NR) electron events observed by the ACE spacecraft during quiet interplanetary medium periods.

Inversion methods developed within the FP7 SEPServer project are used to extract, from directional intensities observed near 1 AU, the electron injection histories and the values of the electron radial mean free path that are most consistent with the observations. We compare the injection histories with associated solar electromagnetic emissions due to energetic particles, especially radio waves and hard X-rays, in order to infer the most probable acceleration site(s) and/or mechanism(s) for each of these events.

Global hybrid modelling of solar energetic particles in the plasma environments of Mars and Venus

Alho, Markku (Finnish Meteorological Institute), Esa Kallio, Riku Järvinen

Mars and Venus have no intrinsic magnetic field, thus exposing the planets' atmospheres to the solar wind. The resulting interactions create small, induced magnetospheres with comparably low magnetic field magnitudes compared to that on and around Earth. Consequently, ion gyroradii quickly reach length scales comparable to that of the planet with increasing inertia - one must thus consider the effect of ion kinetics in these environments, necessitating the use of a hybrid model.

Solar energetic particles, in particular, are quite free to impinge on the planets and their small m'spheres. Phobos-2 was the first satellite to look into the suprathermal particle kinetics of the Martian plasma environment with the SLED instruments, operating in the energy range of 30keV up to several MeV for protons. During a long, pronounced gradual SEP event in March 1989, the instrument detected significant flux modulation by the planet and its plasma environment on its (comparably high) orbit of 2,8 Mars radii, namely flux enhancements on lowest energy channels and shadowing effects on all channels. The HYB model, with SEPs included in the simulation was used to reproduce the observations, giving a global view on the energetic particle environment around Mars. The model has also been used to model Mars and Venus Express observations on more contemporary SEP events.

Influence of Beam Particles' Pitch-Angle Distribution on Wave Generation in Solar Type II Radio Burts

Ganse, Urs (University of Helsinki), Rami Vainio

Particle-in-Cell simulations of wave interaction processes leading to Type II radio burst emission have shown to be a successful and versatile tools to obtain insight into microphysical processes at the bursts' emission site.

Due to PiC codes' limitation of simulating the plasma microphysics, analytic assumptions have to be used to model unresolved large-scale structures involved, such as the shock's geometry and acceleration processes. Additionally, due to the limited number of particles in a numerical simulation, care must be taken to properly represent the electron phase space in the regions most important for wave excitation.

We have implemented different numerical models of electron beam pitch angle distribution as caused by shock drift acceleration, and quantitatively compared the wave excitation strength that resulted.

Solar MHD discontinuities as one of the features of the solar activity

Grib, Sergey (Central (Pulkovo) astronomical observatory of Russian academy of sciences)

There are many real sources for the generation of solar strong MHD discontinuities. Some of them are fast shock waves and tangential discontinuities observed often in difference to slow shock waves. It seems that the latest type of waves is damping due to the decay of Landau inside the coronal plasma heating the corona of the Sun. Forward and reverse slow shock waves may appear near the magnetic clouds in the result of splitting of the arbitrary discontinuity.The collision of rotational discontinuities with the stationary contact discontinuities in some specific cases gives also slow MHD shock waves. The comparison of the results obtained due to the classical investigation with the Helios 1, SOHO and CLUSTER data shows a good confirmation. The work was done in the frame of the program of the Presidium of RAN P-22 and with the partial support by the RFFI grant 11-01-00235a.

The First Ground Level Event of Solar Cycle 24 and its longitudinal distribution in the inner heliosphere

Heber, Bernd (Christian-Albrechts-Universität zu Kiel), Nina Dresing [1], Wolfgang Dröge[2], Raúl Gómez-Herrero[3], Konstantin Herbst[1], Yulia Kartvykh[2], Andreas Klassen[1], Patrick Kühl[1], Johannes Labrenz[1], Olga Malandraki[4], Christoph Terasa[1], and Eino Valtonen[6]
[1] Christian-Albrechts-Universität zu Kiel, Germany, [2] Julius-Maximilians Universität Würzburg, Germany), [3] Universidad de Alcalá, Spain, [4] Institute of Astronomy and Astrophysics, National Observatory of Athens,

Ground level events (GLEs) are the most energetic solar particle events (SEPs) that are detected not only by space born instrumentation but also by ground-based instruments like e.g. neutron monitors. On May 17 2012 at 01:25 UT a M5.1 X-ray flare from the active region 1476 (N07, W88) was detected. The event was

accompanied by a type III radio burst starting at 1.30 UT and a coronal mass ejection heading towards Stereo A. The corresponding shock wave passed STEREO A on May 18 at 12:43 UT but missed the Earth. The event onsets of near relativistic electrons have been detected at at 06:05 UT, 03:38 UT, and 01:51 UT aboard STEREO A and B (125-335 keV) and at SOHO (250 -700 keV), respectively. In contrast to observations close to the Earth no strong anisotropies have been observed at both STEREO A and B. The neutron monitor network recorded the first GLE for solar cycle 24. The Electron Proton Helium INstrument on board SOHO measured protons with energies of more than 600 MeV (rigidities of more than 1.2 GV). The interplanetary field direction was such that neutron monitor stations with asymptotic direction in the 1 to 2 GV range over Australia were connected best and recorded the biggest increase of 17% (Apatity and Oulu) with an onset time of 1:52 UT. Data observed close to and at Earth will be presented and the longitudinal structure of the event in the inner heliosphere will be discussed.

Particle acceleration in shock-shock interaction

Hietala, Heli (Imperial College, London, UK), Neus Agueda, Arto Sandroos, Rami Vainio, Katerina Andreeova, Stuart Nylund, Emilia K. J. Kilpua, and Hannu E. J. Koskinen

Shock-shock interaction is a a fundamental acceleration mechanism in astrophysical and space plasmas, but difficult study with direct observations. We have performed a detailed analysis of a shock-shock interaction event with the best spacecraft coverage reported so far: the interplanetary shock collision with the bow shock of the Earth on 1998 August 10. We can distinguish the seed population and its reacceleration at the bow shock, as well as the Fermi acceleration of particles trapped between the shocks. Apart from ion acceleration to MeV-range energies, the interaction accelerated electrons to relativistic energies. The novel result is the first in situ observations of the particle release at shock collision, further verified with a simulation study. We also study the radio emissions related to the interaction, providing a connection to remote observations of more distant plasma environments.

Three-dimensional evolution of ejected flux ropes from the Sun to 1 AU

Isavnin, Alexey (University of Helsinki), Angelos Vourlidas, Emilia K.J. Kilpua

Studying the evolution of magnetic clouds entrained in coronal mass ejections using in-situ data is a difficult task since only a limited number of observational points is available at large heliocentric distances. Remote sensing observations can, however, provide important information for events close to the Sun. In this work we estimate the flux rope orientation first by studying the associated prominences and/or post-eruptive arcades using STEREO/EUVI and SOHO/EIT observations, then in the close vicinity of the Sun using forward modeling of STEREO/SECCHI and SOHO/LASCO coronagraph images of coronal mass ejections and, finally, in-situ using Grad-Shafranov reconstruction of the magnetic cloud at 1 AU. We show that it is possible to reconstruct the three-dimensional orientation and geometry of the flux rope in each of these three stages of its evolution. Thus, we are able to measure changes in the orientation of the erupted flux ropes as they propagate from the Sun to 1 AU. In contrast to past studies, our method allows one to deduce the evolution of the three-dimensional orientation of individual flux ropes rather than on a statistical basis.We study 15 magnetic clouds observed during the minimum following Solar Cycle 23 and the rise of Solar Cycle 24. The results of our analysis confirm earlier studies showing that the flux ropes tend to deflect towards the solar equatorial plane. We also find evidence of rotation on their travel from the Sun to 1 AU. We further compare the orientations of the studied flux ropes with the local orientation of the heliospheric current sheet using global MHD simulations of the solar corona.

Hybrid modelling studies of planetary-solar wind interactions

Jarvinen, Riku (Finnish Meteorological Institute), Esa Kallio

We present hybrid modelling of solar wind interactions of unmagnetized Solar System bodies and, especially, we discuss the physics of solar wind induced ion escape and the structure of induced magnetospheres at Venus and at Mars. The modelling work is based on the HYB hybrid simulation model family, which has been developed and used to study plasma environments of unmagnetized and weakly magnetized celestial objects at the Finnish Meteorological Institute (FMI) for over a decade. In the hybrid approach the ions are treated as particles moving under the Lorentz force and self-consistently coupled to the electric and magnetic field via Maxwell's equations and electrons form a massless, charge-neutralizing fluid. Especially,

the global HYB hybrid simulations have been used to interpret in situ observations made by the ASPERA plasma instruments on the European Mars Express and Venus Express missions. The FMI has participated in designing and building instruments on several spacecraft missions including these currently operational ASPERA instruments. Further, we present results from recent hybrid modelling studies of the solar wind interaction with magnetic anomalies or mini-magnetospheres on the lunar surface. Near future prospects of the HYB modelling work include the upcoming European Rosetta mission to the comet Churyumov–Gerasimenko and the American MAVEN (Mars Atmosphere and Volatile EvolutioN) Mars mission, which both carry in situ plasma instrumentation.

Relationship between magnetic cloud field polarity and geoeffectiveness

Kilpua, Emilia (University of Helsinki), J.G. Luhmann, L.K. Jian, C.T. Russell, and Y Li

Magnetic clouds (MC) cause a significant fraction of large magnetospheric disturbances. MCs are formed of large-scale solar magnetic flux ropes and it is well established that the flux rope structure changes systematically with the 22-year solar magnetic cycle. An important question for space weather is whether geoeffectivity of MCs varies depending on whether the fields in MCs rotates south-to-north (SN) or north-to-south (NS). We investigate geoeffectivity of the near-Earth MCs during two periods concentrated around the last two solar minima. We estimated the level of magnetospheric activity using Burton's Dst prediction formula with the measured Z-component of the interplanetary magnetic field (B_Z) and by reversing the sign of B_Z. We found that in general SN- and NS-type MCs were equally geoeffective, but their geoeffectiveness was clearly modified by the ambient solar wind structure. Geoeffectivity of NS-polarity clouds was enhanced when they were followed by a higher-speed solar wind, while the majority of geoeffective SN-polarity clouds lacked the trailing faster wind. A leading shock increased the geoeffectiveness of both NS- and SN-polarity clouds, in particular, in the case of an intense storm. We found that in 1995–1998, SN-polarity clouds were more geoeffective, while in 2006–2011 NS-polarity clouds produced more storms. We will also show that during two last solar minima and the rising activity phases there was a clear asymmetry in the sign of B_Z and we estimate the effect of this asymmetry for geomagnetic activity.

Three-Dimensional View of Major Solar Energetic Particle Events

Kocharov, Leon (University of Oulu)

Production of solar energetic particles (SEPs) in major (gradual) SEP events typically starts in the solar corona and continues in the solar wind. The event's first, coronal phase is associated with liftoff of a coronal mass ejection (CME) and its near-Sun expansion in both radial and tangential dimensions. It can be studied with STEREO and SOHO particle and EUV detection and radio spectrograms from both ground-based and spaceborne instruments. A major SEP event being observed near the eruption's center starts with deka-MeV/n helium- and relativistic electron- rich production from coronal sources identified with the electromagnetic diagnostics. Observations of the initial phase of "well-connected" major SEP events support the idea that the SEP acceleration may start in the helium-rich plasma of the eruption's core well behind the CME leading edge, in association with coronal shocks and/or magnetic reconnection caused by the CME liftoff; and those "coronal" components dominate during the first hour of the event, not yet being hidden by the CME-bow shock in solar wind. In an alternative case of large angular separation between the eruption center and the particle detector onboard a spacecraft, the SEP event begins with a hard-spectrum particle production that is poor in helium, and onset of such coronal phase is delayed by an extra half hour, compared to a "well-connected" event. At the magnetic connection to the eruption's periphery, onset of SEP emission is delayed for a time of a lateral expansion that is visualized by global coronal (EIT) waves. In any case, the initial, coronal phase of major SEP events is followed by the second-phase SEP production associated with the CME-driven shock waves in solar wind.

Coronal flare sources in SDO/AIA observations

Kolomanski, Sylwester (Astronomical Institute of the University of Wroclaw, Poland), Mrozek, Tomasz

RHESSI is a powerful tool to analyse solar flares. Now this tool can be combined with razor sharp sight of SDO/AIA instrument. This combination gives us high quality data in the broad pivotal range from UV throughout EUV and X-rays to gamma radiation. With this data we can study flares in more detail than ever

before.

Among many unresolved mysteries of solar flares is a nature of loop-top sources (LTSs). This type of a coronal source is a common X-ray feature of solar flares. LTSs a are known since the mid 70s but their are not fully understood yet.

Our presentation will show analysis of coronal sources observed in long-duration flares. In the analysis data from RHESSI and AIA were used. This combination of data allowed us to answer the questions about formation and structure of LTSs.

Energetic particle cross-field propagation early in a solar event

Laitinen, Timo (University of Central Lancashire, UK), Silvia Dalla Michael Marsh

Solar energetic particles (SEPs) have been observed to have access to a wide range of heliographic longitudes, suggesting strong SEP propagation across the mean Parker spiral field. We use full-orbit simulations of a 10 MeV proton beam in a turbulent magnetic field, superposed on a constant background field, to study to what extent the spread across the mean field is due to particles following the meandering field lines rather than to diffusion in the turbulent fields. We compare the full-orbit code results to solutions of a Fokker-Planck equation including spatial and pitch angle diffusion, and of one including also propagation of the particles along random-walking magnetic field lines. The diffusion parameters for the latter models are consistent with the full-orbit simulations, with a parallel scattering mean free path 0.3 AU. We find that the cross-field spread of the particles at 1 AU is consistent with deterministic propagation of particles along meandering field lines in the beginning of the simulated event. The mean square width of these particles an hour after the injection of the beam is an order of magnitude larger than that given by the diffusion model, indicating that the diffusion description is invalid for the early phase of particle propagation in SEP events. We conclude that modelling SEP events must take into account the spreading of particle propagation along meandering field lines for the first 20 hours of the event.

Solar Energetic Particles, Coronal Mass Ejections and Space Weather effects

MALANDRAKI, OLGA (National Observatory of Athens)

Beyond the protective shield of the Earth's magnetosphere and atmosphere, we are exposed to sources of radiation that pose a serious hazard to both humans and machinery/infrastructure. High-energy particles in space include the sudden intense bursts of the Solar Energetic Particles (SEPs) that can last several days. The physical processes that accelerate SEPs to high energy remain controversial. They are considered to be accelerated either at the reconnection processes inside solar flares or by coronal shocks around coronal mass ejections (CMEs), the former being referred to as 'impulsive' and the latter as 'gradual' events. Space Weather effects of SEPs and CMEs involve among others reductions in satellite operations, upsets in electronic circuits on spacecraft, solar cell degradation, possible disruption in polar aircraft flights, radio communication problems from perturbations in Earth's ionosphere, and impacts on electrical power grids. Large 'gradual' SEP events occur at a rate of 10-20 per year, but the ones most threatening to human life occur less than once a decade. This makes them especially difficult to study or to predict. In this work, a review of the recent developments on the acceleration source and transport of SEPs as well as on the advances of SEP modeling and forecasting capabilities will be presented, emphasizing multi-point observations from an armada of spacecraft from several vantage points within the heliosphere.

Application of method for recent analysis of ground level enhancements using neutron monitor data

Mishev, Alexander (SGO (Oulu unit) University of Oulu), Ilya Usoskin

Reconstruction of energy spectra of solar energetic particles is important to study particle acceleration process in the solar corona and heliosphere as well as their heliospheric transport. Here we present a method for analysis of ground level enhancements using neutron monitor (NM) data and a newly computed NM yield function. The method consists of the definition of asymptotic viewing cones of the analyzed NM stations, calculation of the NM responses: initial guess of the inverse problem; optimization – an inverse method for determination of primary solar proton parameters, namely energy spectrum, anisotropy axis direction, pitch-angle distribution. The assymptotic viewing cones are computed using the Planetocosmics code and realistic

magnetospheric models, namely IGRF as the internal model and Tsyganenko 89 with the corresponding Kp index as the external one. The inverse problem solution is performed on the basis of non-linear least squares method, namely Levenberg-Marqurdt using MINPACK solver. The method is applied for analyses of several major GLE of the solar cycle 23 as well as the first GLE event of the solar cycle 24, namely GLE 71 of May 17, 2012. The time evolution of SEP spectra and pitch angle distribution are obtained since the event's onset. The obtained characteristics are compared with previously reported results. The obtained results are briefly discussed.

Interplanetary scintillations analysis retrieved from Venus Express observations

Molera Calvés, Guifré (Joint Institute for VLBI in Europe), Pogrebenko, S., Cimo, G., Duev, D., Bocanegra, T., Gurvits, L.

I will present a new study of the interplanetary scintillations using the Doppler frequency and residual phase data retrieved from the signal transmitted by planetary spacecraft. The observations tracked the Venus Express spacecraft radio communications link at X-band for more than three years (2009-2013) using several radio telescopes from the European VLBI Network (EVN). The analysis of fluctuations on the phase allowed us to characterise the propagation of the radio waves within the interplanetary plasma. The amount of fluctuations, in which the spacecraft signal is effected, can be estimated depending on its location and solar elongation. The results provided a model of phase scintillation index and the total electron content for the full orbit of Venus around the Sun.

Fermi Large Area Telescope observations of high-energy gamma-ray emission from solar flares

Pesce-Rollins, Melissa (INFN-Pisa), Nicola Omodei, Vahe' Petrosian, on behalf of Fermi LAT collobaration

With the current solar cycle reaching its maximum, the Fermi observatory has proven to play an active role in the study of solar flares. The Large Area Telescope (LAT) on-board Fermi has detected >30 MeV gamma-ray emission associated with GOES M-class and X-class X-ray flares accompanied by coronal mass ejections and solar energetic particle events. These detections include both the impulsive and the long duration phases including the ∼20 hours of extended emission from the 2012 March 7 X-class flares. Accurate localization with the Fermi LAT of the gamma-ray production site coincide with the solar active region from which X-ray emissions associated with the 2012 March 7 X-class flares originated. In this talk I present an overview of the Fermi solar flare detections over the past five years of operation.

The evolution of CME-initiated disturbances in the low corona: preliminary results from a data-driven modeling approach

Pomoell, Jens (KU Leuven), Stefaan Poedts

A variety of transient phenomena in the solar corona such as global EUV waves, type II radio bursts, coronal dimmings as well as coronal loop oscillations have the potential of being important diagnostic tools for space weather prediction purposes due to their intimate connection to coronal mass ejections (CMEs) and flares, and thereby, to the genesis of energetic particle populations in the heliosphere. However, the nature and interconnection of these phenomena remain veiled in spite of tremendous advancements in the observational capabilities during the past decades. In part, this stems from the inherent difficulty of interpreting the coronal remote observations as well as the complexity of the solar coronal dynamics.

A viable path for gaining insight into the physics of the eruption-associated phenomena is to construct numerical models capable of simulating the coronal dynamics with such a degree of realism that direct comparisons to observations can be made. In this talk, we propose a data-driven modeling approach, and present preliminary results discussing in particular the evolution of a CME-driven shock in the low corona and its relation to other observed transient phenomena.

In situ observations of magnetic reconnection and associated particle energization in turbulent plasmas

Retinò, Alessandro (LPP-CNRS, Palaiseau, France), A. Chasapis (1), F. Sahraoui (1), A. Vaivads (2), D. Sundkvist (3), A. Greco (4), P. Canu (1)
(1) LPP - CNRS, Palaiseau, France; (2) Swedish Institute of Space Physics, Uppsala, Sweden; (3) Space Sciences Laboratory, University of California, Berkeley, USA; (4) Dipartimento di Fisica, Univerità della Calabria, Cosenza, Italy

Magnetic reconnection occurs in turbulent plasmas within a large number of volume-filling thin current sheets. Such reconnection can efficiently dissipate magnetic energy of turbulent plasma, resulting in substantial electron and ion heating. Turbulent reconnection is also considered to play an important role for the acceleration of supra-thermal particles. Yet the detailed mechanisms of energy dissipation and particle energization during turbulent reconnection, as well as their dependence on turbulence properties, are not completely understood from an experimental point of view due to the scarcity of in situ observations. Here we present recent spacecraft observations of reconnection in different near-Earth turbulent regions (solar wind, magnetosheath, magnetotail) and we discuss the properties of energy dissipation and particle energization therein.

Space weather services at the Royal Observatory of Belgium

Rodriguez, Luciano (Royal Observatory of Belgium)

The Royal Observatory of Belgium (ROB) is a Regional Warning Centre (RWC) of the International Space Environment Service (ISES) network. ROB manages an expanding framework of space weather services, including the use of data from its own instruments (satellite and ground-based), the development of software tools to automatically detect and classify solar phenomena, and a highly trained forecaster which acts seven days per week in order to provide daily bulletins, alerts and related space weather information. ROB is a research institute, all the services provided are based upon and supported by its own research. In this talk, I will describe how this operational space weather forecasting centre works.

High energy observations of solar flares associated with SEP events

Rodríguez-Gasén, Rosa (LESIA/Observatoire de Paris-Meudon and CSNSM/IN2P3, CNRS, France), Nicole Vilmer, Jürgen Kiener, Vincent Tatischeff, Karl-Ludwig Klein, Clarisse Hamadache, and the SEPServer Consortium

Solar energetic particle (SEP) events are a major hazard in the space environment, and the analysis of their observations needs a comprehensive set of electromagnetic (EM) data to support a successful interpretation. Among the EM observations directly linked to these accelerated particles we shall focus in this work on high energetic photons, such as hard X-rays (HXR) and gamma-rays. Under the framework of the SEPServer project*) we are recollecting high energy data recorded by the INTEGRAL and RHESSI spacecraft, related to several solar flares and SEP events that occurred during the last solar cycle. On one hand, to make INTEGRAL data accessible for solar studies, we have undertaken a major effort to specify the observing conditions making use of Monte-Carlo simulations of the response of the AntiCoincidence Shield BGO detectors of the Spectrometer for several selected flares. On the other hand, we have investigated the spatial and temporal evolution of HXR emission produced during/by a solar flare, searching for evidences of long duration coronal signatures of SEPs production and their potential link with coronal mass ejections.

*) SEPServer project is funded by the 7th Framework Programme (FP7-SPACE) of the European Union.

Variability of the interplanetary medium driven by solar activity

Rouillard, Alexis P. (Institut de Recherche en Astrophysique et Planétologie), -

The variability of the solar wind, associated with transient solar activity, can be analysed with a wide range of in-situ measurements and remote-sensing techniques. Extreme ultraviolet (EUV) or white-light imaging sensed from several vantage points can be used to infer the 3-D geometry of a variety of coronal and solar

wind features. We will show that the twin STEREO spacecraft launched in 2006 offer multi-point observations of the corotating solar wind and provide direct information on its 3-D structure and variability. All these observations provide an uninterrupted coverage of plasma streaming radially outward from the Sun to 1AU and beyond, thereby allowing remote-sensing observations to be combined with in-situ measurements. They show that the spinning Sun ejects continually small- and large-scale transients that, for a fixed source region, can be distributed along a spiral rooted in that source region. These transients often have twisted magnetic fields that can extend over a wide range of scales and that may transport a significant amount of total magnetic flux. The launch of the Solar Dynamics Observatory (SDO) during the recent high solar-activity period has provided a third eye with unprecedented high-cadence and high-resolution observations. These latter observations combined with STEREO imaging permit very detailed analyses of the eruption of Coronal Mass Ejections (CMEs) and the 3-D extent of CME-driven pressure waves. Remote sensing of pressure waves launched in the near-CME environment can be compared with in-situ measurements of the onset, abundance ratios and flux of energetic particles providing critical information on the 3-D extent of the acceleration and transport of energetic particles near the Sun and in the inner heliosphere. Finally, we will present tools developed at IRAP, Toulouse to help scientist compare remote-sensing and in-situ measurements.

Solar storms and energetic particles - Shaking the Earth's atmosphere

Seppälä, Annika (Finnish Meteorological Institute)

This presentation will give an overview of the effects that energetic particle precipitation triggered by solar storms has on the atmosphere. A large solar disturbance such as a flare or a CME results in emission of high-energy protons and other ions from the Sun. If these particles reach the Earth they set off an event known as a Solar Proton Event. In addition to these impulsive events the Earth continuously undergoes precipitation of energetic charged particles originating from the solar wind and the magnetosphere. In the atmosphere the precipitating particles cause ionisation in the middle atmosphere (20-100 km). This effect is confined to polar regions, where particles are guided by the Earth's magnetic field. In the atmosphere enhanced ionisation leads to increased production of NO_x and HO_x through ion chemistry. NO_x and HO_x are gases, which participate in catalytic ozone destruction and thus important for chemical and thermal balance of the atmosphere. HO_x has a short-lived effect on the atmosphere; NO_x on the other hand is mainly destroyed by photodissociation. Hence during polar winter, when little sunlight is present, NO_x impact on the atmosphere can be long lasting (months to years). For example, after a series of major solar storms following the maximum of solar cycle 23, a 60 % ozone depletion in the Arctic upper stratosphere was observed in 2003, persisting for a month after the storms. Following from the initial chemical effect on the atmosphere, dynamical coupling between the different atmospheric layers can further provide a link between space weather and lower atmosphere, and thus have indirect implications to polar climate. However, the characteristics of the particle precipitation, particularly the energy spectrum and precipitating fluxes of electrons, crucial in determining the initial impact on atmosphere, are not well known.

THE LOW-FREQUENCY BOUNDARY OF SUN-GENERATED MAGNETOHYDRODYNAMIC TURBULENCE IN THE SLOW SOLAR WIND

Shergelashvili, Bidzina (Institut für Theoretische Physik IV, Weltraum- und Astrophysik, Ruhr-Universität Bochum, 44780 Bochum, Germany), Horst Fichtner

New aspects of the slow solar wind turbulent heating and acceleration are investigated. A physical meaning of the lower boundary of the Alfvén wave turbulent spectra in the solar atmosphere and the solar wind is studied and the significance of this natural parameter is demonstrated. Via an analytical and quantitative treatment of the problem we show that a truncation of the wave spectra from the lower frequency side, which is a consequence of the solar magnetic field structure and its cyclic changes, results in a significant reduction of the heat production and acceleration rates. An appropriate analysis is presented regarding the link of the considered problem with existing observational data and slow solar wind initiation scenarios.

On the origin of QPOs in sub-THz emission from solar flares

Stepanov, Alexander (Pulkovo Observatory), V.Zaitsev, P.Kaufmann

Mechanism of sub-second quasi-periodical pulsations (QPOs) at 200 and 400 GHz from solar flares based on the flare loop model as an equivalent electric circuit is proposed. The mechanism explains oscillation period, high Q-factor $Q > 10^3$, and observed dependence of the repetition rate vs emission flux. The solution of nonlinear equation for the electric current oscillations is obtained by Van der Pol method and a steady-state current value $I \leq 8 \times 10^{11}$ A is found. It is shown that our QPOs model favours to the plasma radiation mechanism of sub-THz emission proposed recently by Zaitsev et al (Astron. Lett. 2013).

Interaction of magnetic clouds with the Earth's magnetosphere

Turc, Lucile (LPP-CNRS-Ecole Polytechnique), Dominique Fontaine, Emilia K.J. Kilpua, Philippe Savoini

Magnetic clouds (MC) are well-defined solar wind structures, known to trigger intense geomagnetic storms. However, before encountering the magnetosphere, MCs cross the terrestrial bow shock which alters their structure. Therefore their expected geoeffectivity may be modified by the shock. In this study, we focus on the magnetic structure of MCs. A simple analytical MHD model is used to describe the interaction of a MC with the bow shock and its propagation in the magnetosheath. Several cases are presented, corresponding to different orientations of the MC axis and different impact parameters. The results show that the shock obliquity plays a major role in determining the variation of the magnetic field direction. Asymmetries can be observed inside the magnetosheath. Moreover, the magnetic field north-south component can even reverse in some parts of the magnetosheath. The outputs of the model are compared to spacecraft observations, and the implications on a MC's geoeffectivity are discussed.

A Simulated Solar Energetic Particle Event at Solar Probe Plus

Vainio, Rami (Department of Physics, University of Helsinki), Markus Battarbee, Timo Laitinen, Arttu Pönni

We consider particle acceleration in a coronal shock wave using a Monte Carlo simulation code Coronal Shock Acceleration (CSA). The model accounts for the quasi-linear interaction of energetic ions and Alfvén waves upstream of a shock. The shock itself is prescribed as a compression of plasma and tangential magnetic field, propagating through a coronal flux tube and accelerating the ambient ion populations through the diffusive shock acceleration mechanism. The model includes a self-consistent description of the injection of ions into the acceleration process. We apply the simulation model to study solar energetic particle events that would be detected by NASA's Solar Probe Plus (SPP), which will have a perihelion distance of about 8.5 solar radii. The paper will analyse the fluxes and fluences of energetic particle events as well as the intensities of Alfvén waves in the foreshock region in the outer corona at the location of SPP on its orbit at distances from 0.04 AU (8.6 solar radii) up to 0.16 AU from the Sun. We will consider times from the arrival of the shock on the magnetic field line connected to SPP until the shock passes SPP. Fluxes at larger distances for the same particle event will also be studied and compared to observations made by spacecraft missions so far flown in the inner heliosphere.

Reliability of velocity dispersion analysis in associating solar proton acceleration phase with radio emissions

Valtonen, Eino (Department of Physics and Astronomy, University of Turku), R. Laitinen, K. Huttunen-Heikinmaa, A. Kouloumvakos, A. Nindos, and the SEPServer Consortium

Type III radio emissions from the Sun are signatures of electron acceleration to tens of keV. Simultaneously, acceleration of protons and heavier ions can take place. Type II radio bursts are evidences of shock propagation from low corona to interplanetary space with fast shocks known to be efficient proton accelerators. In order to investigate the acceleration phase of protons, it is necessary to temporally associate proton release times with radio emissions. Velocity dispersion analysis (VDA) of protons observed near the Earth is one method to derive their release times. The characteristics of the time-intensity profiles of the particles caused by propagation effects in the disturbed interplanetary space and by background from previous solar particle events can often cause considerable uncertainties in the obtained results. We have carried out a statistical study of proton release times based on VDA as part of the SEPServer project*). The time period of the investigation covers the solar cycle 23 and the beginning of cycle 24. Identification of solar energetic particle events is based on the

high-energy proton observations of SOHO/ERNE. We have investigated the reliability of the VDA method in determining proton release times during different background conditions and for various source locations and compared the release times with radio observations in representative example cases. *) SEPServer project is funded by the seventh framework programme (FP7-SPACE) of the European Union.

The Solar Eruptive Event: A Synthesis of CMEs, Flares, and Energetic Particle Production

Vourlidas, Angelos (Naval Research Laboratory)

Solar eruptive activity suffers froma split personality. It has long been studied through flares as explosive release of radiation and Coronal mass ejections (CMEs) as explosive release of mass. Both phenomena have important consequences for the heliosphere and the terrestrial space environment. Both of them are associated with Solar Energetic Particles (SEPs), as well. Both of them have large, dedicated research communities with dedicated instrumentation, analysis techniques, and nomenclature. But are these two phenomena really that different? Over the last few years, observations from new solar missions (STEREO, SDO, Hinode) are challenging the dualist paradigm of solar eruptive activity. In this talk, I will attempt to provide a unifying description of eruptive activity that brings flares, CMEs, and SEPs into a coherent (and simpler) picture and discuss the outlook and challenges for future research and missions.

Dynamo driven coronal ejections

Warnecke, Joern (Nordita), Petri Kapyla, Maarit Mantere Axel Brandenburg

Observations show that the Sun sheds mass through twisted magnetic flux configurations, like Coronal Mass Ejections (CMEs). Conventionally, CMEs are modeled by adopting a given distribution of magnetic flux at the solar surface and letting it evolve by shearing and twisting the magnetic field at its footpoints at the surface. Of course, ultimately such velocity and magnetic field patterns must come from a realistic simulation of the Sun's convection zone, where the field is generated by dynamo action. Therefore a unified treatment of convection zone and CMEs is needed. We combine a convectively driven dynamo with a polytropic layer that extends to 1.6 solar radii. The temperature increases in this region to ≈ 8 times the value at the surface, corresponding to ≈ 1.2 times the value at the bottom of the spherical shell. We associate this region with the solar corona. Magnetic fields are found to emerge at the surface and are ejected to the coronal part of the domain. These ejections occur in irregular intervals and are weaker than in earlier work. We tentatively associate these events with coronal mass ejections on the Sun. We find a solar-like differential rotation with radial contours of constant rotation rate, together with a solar-like meridional circulation and a near-surface shear layer. This spoke-like rotation profile is caused by a non-zero latitudinal entropy gradient which violates the Taylor-Proudman balance via the baroclinic term. The lower density stratification compared with the Sun leads to an equatorward return flow above the surface. The mean magnetic field is in most of the cases oscillatory with equatorward migration in one case. In other cases the equatorward migration is overlaid by stationary or even poleward migrating mean fields.

2 Posters

Variations of EUV Emission of the Solar Corona in the Range of 26 – 34 nm (1996 – 2012)

Dorotovic, Ivan (Slovak Central Observatory, Komarnanska 134, SK-94701 Hurbanovo, Slovak Republic), Lorenc M., Pinter T., and Rybansky M.

The contribution deals with variations and comparing time series of the spectral intensity of radiation of the solar corona in the range from 26 to 34 nm from the satellites SOHO (since 1996), TIMED (since 2002), and SORCE (since 2003). Daily average values of measurements of the CELIAS/SEM spectrometer onboard SOHO were used (Lukac and Rybansky, 2008) to replace the coronal index of solar activity (CI), derived from ground-based measurements of the coronal spectral line of FeXIV (530.3 nm, Rybansky, 1975, Rybansky et al. 2005). We compared them with measurements from SOHO in order to use analogous data from the satellites TIMED and SORCE. It has been shown that the measurements differ significantly in absolute values (for example, values from the SOHO are two times greater than from the SORCE), although their relative temporal evolution is almost identical. Furthermore, the value of SOHO are systematically decreasing with time as the gradual reduction in the sensitivity of the instrument. We compensated deviations using correlation of CI and radio frequency radiation at 2800 MHz. The result is a homogenized time series of measurements, which

was used to extend the range of CI up to 2012. It is published at the website www.suh.sk. The contribution includes also a list of CMEs crossing the instrument CELIAS/SEM onboard SOHO and distorting the described measurements.

Rybanský, M.: 1975, Bull. Astron. Inst. Czechoslov., 28, 367. Rybanský, M., Rušin, V., Minarovjech, M., Klocok, L., Cliver, E.W.: 2005, J. Geophys. Res., 110, A08106. Lukáč B. and Rybanský M.: 2010, Solar Phys., 263, 43 – 29.

Coronal Emission Line of FeXV (28,4 nm) during a Solar Activity Cycle (1996 – 2012)

Dorotovic, Ivan (Slovak Central Observatory, Komarnanska 134, SK-94701 Hurbanovo, Slovak Republic), Minarovjech M., Lorenc M., Pinter T., and Rybansky M.

Measurements of the intensity of the green coronal line 530.3 nm (FeXIV) converted to a uniform intensity scale, which were published by the Astronomical Institute of SAS till 2008 as a homogeneous data series (HDS) in the WDC-A were the basis of many works in the field of solar physics and geophysics. We were able to develop a methodology to extend compilation of the HDS. We used observations of the EIT instrument onboard SOHO for this purpose. The EIT instrument records also almost daily coronal images in the emission line at 28.4 nm (FeXV). We compared data from common ground-based and space-borne observations (630 days) for the period 1996 - 2003, and this comparison showed correlation with a coefficient of correlation of 0.88. From the correlation study described in the contribution it follows also the methodology used in the continuation of the HDS calculation. The resulting data are used to study a cycle of solar activity in the corona and are available at www.suh.sk.

Coronal bright points tracking using a hybrid S-PSO algorithm

Dorotovic, Ivan (UNINOVA, Campus da FCT/UNL, 2829-516 Caparica, PORTUGAL), Shahamatnia E., Ribeiro R. A., Fonseca J. M.

The exact specification of the nature of the differential rotation of both the solar surface and solar interior still belongs to the most serious open issues of solar physics. In this contribution we present use a hybrid algorithm by combining PSO (Particle Swarm Optimization) and Snake models algorithms (denoted further as S-PSO algorithm) for detecting, tracking and determining the rotation of solar coronal bright points (CBPs). Full-disc solar images obtained with the Atmospheric Imaging Assembly (AIA) instrument onboard the Solar Dynamics Observatory (SDO) were used for our analysis. The S-PSO software tool has been already tested on full-disc sunspot images (Shahamatnia et al., 2012). Preliminary simulations show good conformity in the results obtained by tracking CBPs manually and with S-PSO algorithm.

EPServer solar energetic particle event catalogue in and out of the ecliptic; a Ulysses COSPIN/KET, COSPIN/LET and HISCALE particle data driven study

Heber, Bernd (Christian-Albrechts-Universität zu Kiel), Neus Agueda (Departament d'Astronomia i Meteorologia, Institut de Ciències del Cosmos, Universitat de Barcelona, Barcelona, Spain) Daniel Heynderickx (DH Consultancy BVBA, Leuven, Belgium) Karl-Ludwig Klein (LESIA-Observatoire de Paris, CNRS, UPMC Univ Paris) Olga Malandraki (Institute of Astronomy and Astrophysics, National Observatory of Athens, Greece) Athanasios Papaioannou (Institute of Astronomy and Astrophysics, National Observatory of Athens, Greece) Blai Sanahuja (Departament d'Ast

SEPServer is a three-year collaborative project funded by the seventh framework programme (FP7- SPACE) of the European Union. The objective of the project is to provide, among other things, access to state-of-the-art observations and analysis tools for the scientific community on solar energetic particle (SEP) events. The study of SEPs at different latitudes and under different conditions provides useful information about energetic particle propagation and acceleration, and is one of the focus areas of the project. The Ulysses mission, launched in 1990, explored the three dimensional heliosphere during different solar activity conditions until the spacecraft was finally switched off on June 30, 2009. The mission has been the only one that

allowed us to study the characteristics of SEPs at low and high latitudes. In this work, the Cosmic Ray and Solar Particle Investigation (COSPIN) Kiel Electron Telescope (KET) data of 38 to 125 MeV has been used to identify a number of 40 events SEPs observed in and out of the ecliptic plane over solar cycle 23. Using electron observations from the Heliosphere Instrument for Spectra, Composition and Anisotropy at Low Energies (HISCALE) and proton intensities from the COSPIN Low-Energy Telescope (LET), different characteristics of these events have been determined and compared with simulation based analysis and remote sensing data from radio and optical observation. The event catalogue presented in this paper will be available to the community for further analysis through http://server.sepserver.eu.

Asymmetric Perpendicular Transport of Solar Energetic Particles

Marsh, Michael (University of Central Lancashire, UK), Silvia Dalla James Kelly Timo Laitinen

Modelling of Solar Energetic Particle (SEP) events is crucial to the interpretation of in-situ observations. Gaining an understanding of the dynamics of SEPs between their origin and onset at 1 A.U. is critical in assessing potential space weather impact. In recent years, especially thanks to STEREO observations, it has been recognised that perpendicular transport is likely to play an important role. While several recent studies have included a scalar perpendicular diffusion coefficient into descriptions based on the focussed transport equation, the majority of SEP models assume propagation only along the field. Here we present full-orbit test particle simulations of SEP propagation within the interplanetary magnetic field which demonstrate that significant transport across the field takes place. We show that the perpendicular displacement from the initial magnetic field line is asymmetric, so that it cannot be described by a transport model with a scalar perpendicular diffusion coefficient. The traditional assumption of direct propagation of SEPs along the field may not be valid. This has important consequences for the dynamics of Sun-Earth connectivity and the assessment of space weather risk. This work has received funding from the European Commission FP7 Project COMESEP (263252).

New computation of the neutron monitor yield function – towards GLE analysis

Mishev, Alexander (SGO (Oulu unit) University of Oulu), Ilya Usoskin Genady Kovaltsov

The ground based NM64 neutron monitor (NM) is a standard tool to measure cosmic ray (CR) variations in the vicinity of Earth and to register ground level enhancements (GLE)s, which are transient increases in the cosmic ray intensity as a result of solar eruptive processes accelerating protons to high energies. It is very important to have precise information for the NM's yield function for primary cosmic rays, which is the key issue for GLE analysis. Here we present a newly computed yield function of the standard sea-level 6NM64 neutron monitor for primary proton and alpha CR nuclei. The computations have been carried out using Planetocosmics and CORSIKA codes as standardized Monte-Carlo tools for the atmospheric cascade simulation. The flux of secondary particles, namely neutrons and protons, has been obtained with Planetocosmics code using the standard electromagnetic model and QGSP_BIC_HP hadron interaction model. A curved atmospheric model is applied. An updated information concerning the NM registration efficiency for secondary neutrons and protons has been used. The NM yield function is obtained by convolution of the secondary particle flux with the NM registration efficiency. We introduce an effect of the geometrical correction of the NM effective area, which have been previously neglected. This correction enhances the relative impact of higher-energy cosmic rays, namely with energy above 5-10 GeV/nucleon in the neutron monitor count rate. In such a way the new computation resolves the long-standing problem of disagreement between the theoretically calculated spatial variability of cosmic rays over the globe and experimental latitude surveys. The newly calculated yield function, corrected for this geometrical factor is fully consistent with the experimental latitude surveys of neutron monitors performed during three consecutive solar minima in 1976-77, 1986-87 and 1996-97. The application of newly computed NM yield function for GLE analysis is discussed.

The effects of CME manifestations in the ionosphere

Sheiner, Olga (Radiophysical Research Institute), Fridman Vladimir, Rakhlin Aleksandr

Recent years much attention is paid to the study of coronal mass ejections and their manifestations in the near-

Earth space Obviously, the nature of the disturbances coming from the CME will be very effective appeared in the parameters of the ionosphere, it is possible to identify this comparing the temporal characteristics of the ionosphere and data on CME' registration on coronagraph. Manifestations of geoeffective coronal mass ejections in the ionosphere were studied using statistical data of vertical sounding of the ionosphere, obtained during regular observations carried out at the radioastrophysical observatory "Zimenki" (NIRFI, Nizhny Novgorod). The generally accepted parameter f0F2, critical frequencies of ionospheric F2 layer, was used for periods of high and low solar activity. We set a new differential parameter, deviation of f0F2, the most precisely reflecting CME' impact. The obtained data were compared with information about the CME' parameters in the Catalog of observations on SMM, at appropriate intervals. In 40-50 minutes after CME' registration on coronagraph one can see changes in the frequency deviation, which, in our opinion, are determined by a direct effect on the ionospheric plasma of ionizing radiation emerging during the CME' formation and onset. Characteristic time interval of general phenomenon of CME' impact on the ionosphere ranged from 4 to 6 days. This time is determined by existence of the perturbation generated by ICMEs in the near-Earth space.

Symposium S2

The physics of accretion on compact objects

1 Oral contributions

Session 2

On the X-ray variability and inner disk structure of dwarf novae

Balman, Solen (Middle East Technical University), Mikhail Revnivtsev (IKI)

We study structure of the inner parts of the accretion flow in dwarf novae systems basing on information on their aperiodic variability in X-ray, UV and optical bands. We present the analysis of several systems like SS Cyg, SU UMa, WZ Sge, RU Peg, VW Hyi, WW Cet, and T Leo using the RXTE, XMM-Newton, Chandra data and data from optical telescopes. We show that all analyzed systems demonstrate a band limited aperiodic noise, which can be described in the framework of the model of propagating fluctuations. We argue that observed breaks in power density spectra of flux variability of dwarf novae indicates truncation of optically thick disk and formation of hot coronal flows with a range of radii (10-3)e+9 cm. Our detailed analysis of the X-ray and optical data of SS Cyg in quiescence and outburst show that during the outburst the inner disk radius moves towards the white dwarf and recedes as the outburst declines to the quiescence. Cross-correlations between the simultaneous UV and X-ray light curves of DN above using the XMM-Newton data in quiescence show time lags in the X-rays of 90-180 sec consistent with travel time of matter from a truncated optically thick inner disk to the white dwarf surface.

session 4

Astronomical tests of General Relativity with X-ray and NIR spectroscopy in Galactic Binaries, the GC and in bright AGN

Boller, Thomas (MPE Garching), A. Müller, W. Greiner, P. Hess

Gravitation is very well described by Einstein's General Relativity. However, several theoretical predictions like the existence of curvature singularities and event horizons are under debate. This motivated to modify the standard theory of gravity. Here, we contrast predictions made by General Relativity with the pseudo–complex field theory (pc-GR) proposed recently. Among them we study the gravitational redshift effect, perihelion shift, orbital motion, timing measurements and spectral lines. We show that the orbital frequency of test particles at a given radius in pc-GR is in general lower compared to standard GR. Also the effect of frame dragging is modified (weakened) in pc-GR. Concerning the gravitational redshift of a radiation emitting object we find that it is also lower in pc-GR than in standard GR. We show for the first time that applying pc-GR to the objects, GRO J1655-40, XTE J1550-564,GX 339-4, and XTE J1752-223, the radius of the Fe K emission and the QPO emission are consistent, removing the discrepancy still present when applying standard GR. Tests of GR for the infall of G2 into the GC and for bright AGN will also be presented.

session 6

High-energy emission of Cygnus X-1: the magnetic field in the X-ray corona

Del Santo, Melania (INAF/IAPS), J. Malzac, R. Belmont, L. Bouchet, G. De Cesare

We will present six years of INTEGRAL observations of the BH binary Cygnus X-1. We have studied the

evolution of the physical parameters of the accretion flow across spectral transitions. In particular, we have used for the first time on Cyg X-1 data, the new model BELM which gives constraints on the magnetic field in the X-ray corona. We find that in the softer states, the magnetic field is at most of the order of 1E+06 G. In the harder states, if the non-thermal excess observed above a few hundred keV is produced in the same region as the bulk of the thermal Comptonization, the upper limit on the magnetic field is about 1E+05 G. On the other hand, as suggested by the recent polarization measurements, this high-energy excess may be produced in the jet: in this case the constraints on the magnetic field in the hard states are somewhat relaxed and the upper limit rises to 1E+07 G.

session 3

Probing angular momentum loss in black hole X-ray binaries: the cases of XTE J1118+480 and A0620-00

González Hernández, Jonay I. (Instituto de Astrofísica de Canarias), R. Rebolo, J. Casares

The orbital motion of secondary stars of X-ray binary systems are believed to vary with time due to different phenomena which depends essentially on the mass ratio of the binary components and duration of the period itself. Black hole binary X-ray (BHXB) systems with large mass-ratios and short periods of several hours are expected to change their orbital period due to magnetic breaking, mass loss, gravitational radiation or even more sophisticated theories which use alternative descriptions of gravity, like the Braneworld gravity. The BHXBs XTE J1118+480 and A0620-00 offer a unique opportunity to test the angular momentum loss (AML) models. These BHXBs are composed by a subsolar-mass late type secondary star orbiting a 6-8 solar-mass black hole in very short orbital periods (4-8hr). We have obtained spectroscopic observations in three nights in 2011 and one additional night in January 2012 at the 10.4m GTC telescope installed at the Observatorio del Roque de los Muchachos in La Palma (Spain) with the OSIRIS medium-resolution spectrograph. The BHXB A0620-00 has also been observed with OSIRIS/10.4m-GTC in December 2012 and January 2013. Using these data we determine the time at the inferior conjunction of the secondary star in each night which in combination with previous determinations has allowed us to derive the orbital period first derivative. Here we present the detection of a negative period derivative in the black hole X-ray binary XTE J1118+480 (see Gonzalez Hernandez et al. 2012, ApJ, 744, L25), which have been confirmed using the other observing night with OSIRIS/10.4m-GTC that has been already executed on January 2012. The secondary star in A06020-00 is also approaching the black hole but a lower rate which may be expected due to the longer orbital period of this system. We will discuss possible implications of these results for magnetic braking, mass loss and black hole mass evaporation.

session 2

Power Colours: Comparing Power Spectra without fitting

Heil, Lucy (Anton Pannekoek Institute, University of Amsterdam), Phil Uttley, Marc Klein-Wolt

The energy spectral and timing properties across different states of Black Hole X-ray binaries are remarkably similar from source to source, despite differences in mass, inclination angle and binary separation. By comparing ratios of temporal power over different frequency ranges, we can use these similarities to test for the presence of QPO-like features in observations of Cygnus X-1 in a model-independent manner. Using this method the features will appear as additional power observed over that of the broad-band noise. If this additional power can be observed in the power spectra of Cygnus X-1 it is likely to be spread over a wide frequency range as no sharp features are clearly visible. We investigate whether any broadened features are present, and postulate as to how differences in the accretion flow and system parameters, such as the presence of a strong wind from the companion star, might spread the power from the strong QPOs observed in low mass X-ray binary lightcurves over a wider range of frequencies.

session 5

The disc inner radius in the low/hard state of black hole binaries

Kolehmainen, Mari (University of Southampton), Chris Done (Durham), Maria Diaz Trigo (ESO)

The inner radius of the accretion disc around a black hole in the low/hard state can be measured in one of two ways. Firstly, via the extent of broadening of the iron emission line, and secondly, from the luminosity and temperature of the weak soft component seen in this state, assuming it is the disc. We use both of these

methods on all the low/hard state spectra taken in timing mode of XMM-Newton's EPIC-pn. We find that the two methods are not consistent with each other, and the difference is not always in a single direction. The two methods are neither model independent, nor are they independent of current calibration issues. We find that the remaining small residuals in the EPIC-pn timing mode response at the $< 3\%$ level can have a dramatic effect on the fit parameters for the reflected spectrum. There is also a mismatch in cross-calibration with RXTE, which makes it difficult to use simultaneous data to extend the bandpass of the spectral fits. Nonetheless, it is clear from the data that the iron line is noticeably broader and stronger at higher L/LEdd, which is consistent with the truncated disc models. It is also clear that the soft component changes character, from a stable component consistent with a truncated disc at high L/LEdd, to a variable one with much smaller radius at low L/LEdd. This adds to growing evidence for a complex soft component in the low/hard state, possibly with clumps torn from the edge of the truncated disc giving an additional variable, higher temperature, small area emission.

symposium 2

X-ray diagnostics of chemical composition of the accretion disk and donor star in ultra-compact X-ray binaries

Koliopanos, Filippos (Max Planck Institute for Astrophysics), Marat Gilfanov, Lars Bildsten

Non-solar composition of the donor star in ultra-compact X-ray binaries may have a pronounced effect on the fluorescent lines appearing in their spectra due to reprocessing of primary radiation by the accretion disk and the white dwarf surface. We show that the most dramatic and easily observable consequence of the anomalous C/O abundance, is the significant, by more than an order of magnitude, attenuation of the Ka line of iron. It is caused by screening of the presence of iron by oxygen - in the C/O dominated material the main interaction process for a $E \sim 7$keV photon is absorption by oxygen rather than by iron, contrary to the solar composition case. Ionization of oxygen at high mass accretion rates adds a luminosity dependence to this behavior - the iron line is significantly suppressed only at low luminosity, log(LX) less than 37-37.5, and should recover its nominal strength at higher luminosity. The increase of the EW of the Ka lines of carbon and oxygen, on the other hand, saturates at rather moderate values. Screening by He is less important, due to its low ionization threshold and because in the accretion disk it is mostly ionized. Consequently, in the case of the He-rich donor, the iron line strength remains close to its nominal value, determined by the iron abundance in the accretion disk. This opens the possibility of constraining the nature of donor stars in UCXBs by means of X-ray spectroscopy with moderate energy resolution.

session 1

Interpreting the spectral evolution of GX 339-4 through the hardness-intensity diagram

Koljonen, Karri (Aalto University Metsähovi Radio Observatory)

We have studied the classical 2002-2003 outburst of the X-ray binary GX 339-4 showing well-sampled observations across the hardness-intensity diagram (HID). Through the HID the source exhibits two distinct spectral states that correspond to the same source luminosity, an effect known as hysteresis. It is still unclear as to what mechanism drives it.

Through principal component analysis of RXTE data we found that two varying spectral components are sufficient to explain the spectral variability across the HID. Both components show the hysteresis effect. By fitting the individual pointings and relating their model parameters to the principal component evolution we look for a model which explains the source behavior in the spectral and spectrotiming domains. Based on these results we then discuss possible mechanisms that drive the spectral evolution of GX 339-4 across the HID.

session 1

Luminosity-hardness correlation in accreting neutron stars

Linares, Manuel (IAC), M. van der Klis

Spectral and timing properties of neutron star low-mass X-ray binaries (NS-LMXBs) are tightly correlated, as revealed by X-ray observations during the last decades. Together, these spectral/variability properties define a number of accretion states. Luminosity, on the other hand, has been shown to be decoupled: the same accretion states are observed at X-ray luminosities that differ by more than one order of magnitude. We will present results of a systematic study of a large RXTE dataset linking these three properties in the so-called atoll sources (NS-LMXBs accreting below 50% of the Eddington limit). For a given variability frequency

("timing state"), luminosity and spectral hardness are positively correlated. This previously unrecognized correlation provides a link between the X-ray luminosity, spectrum and rapid variability of atoll sources. We will discuss physical interpretations of this luminosity-hardness correlation and compare our results to other accreting objects.

session 4

High Mass X-ray Binaries in the Milky Way

Lutovinov, Alexander (Space Research Institute (IKI)), Revnivtsev M., Tsygankov S., Krivonos R.

We present results of the study of persistent high mass X-ray binaries (HMXBs) in the Milky Way, obtained with the help of 10 years of observations of the INTEGRAL observatory. The deep exposure spent by INTEGRAL in the Galactic plane allowed us to construct a flux limited sample of HMXBs in the Galaxy and to obtain a luminosity function of these sources in a uniquely wide luminosity interval. General properties of the population of HMXBs are explained in the framework of the population synthesis approach. In particular, it is demonstrated for the first time that the majority of persistent HMXBs have supergiant companions and their luminosity function steepens somewhere around $\sim 2 \times 10^{36}$ erg/s. We are able also to determine the most accurate up to date spatial density distribution of HMXBs in the Galaxy and connect it to the star formation rate distribution. The measured vertical distribution of HMXBs has a scale-height $h \simeq 85$ pc, that is somewhat lower than formerly recognized but still larger than the distribution of young stars in the Galaxy. Based on the elaborated model for the wind-fed NS-HMXBs population we argue that a flaring activity of so-called supergiant fast X-ray transients (SFXTs), the recently recognized sub-sample of HMXBs, is likely related with the magnetic arrest of their accretion. The resulted global characteristics of the HMXB population can be used for predictions of sources number counts in sky surveys of future X-ray missions.

session 1

Broad-band spectroscopy: from radio to gamma-rays

Malzac, Julien (IRAP)

I will discuss some recent progress and issues regarding the multi-wavelength emission of accreting compact objects

session 1

Far-Ultraviolet and Optical Spectroscopy of the black hole candidate SWIFT J1753.5-0127

Neustroev, Vitaly (University of Oulu)

The black hole candidate SWIFT J1753.5-0127 is an atypical X-ray transient system which has been of great interest after its outburst episode in 2005. Unfortunately, understanding of this object suffers from the lack of knowledge of system parameters. Neither component masses nor the orbital period are known for SWIFT J1753.5-0127. Here we present preliminary results of UV and Optical spectroscopy for this object.

session 2

Constraining the mass and moment of inertia of neutron stars fromquasi-periodic oscillations in X-ray binaries.

Petri, Jerome (Observatoire Astronomique)

Neutron stars are the densest objects known in the Universe. Being the final product of stellar evolution, their internal composition and structure is rather poorly constrained by measurements.

It is the purpose of this paper to put some constrains on the mass and moment of inertia of neutron stars based on the interpretation of kHz quasi-periodic oscillations observed in low mass X-ray binaries.

We use observations of high-frequency quasi-periodic observations (HF-QPOs) in low mass X-ray binaries (LMXBs) to look for the average mass and moment of inertia of neutron stars. This is done by applying our parametric resonance model to discriminate between slow and fast rotators.

We fit our model to data from ten LMXBs for which HF-QPOs have been seen and the spin of the enclosed accreting neutron star is known. For a simplified analysis we assume that all neutron stars possess the same properties (same mass M_* and same moment of inertia I_*). We find an average mass $M_* \approx 2.0 - 2.2\, M_\odot$. The corresponding average moment of inertia is then $I_* \approx 1 - 3 \times 10^{38}\ \mathrm{kg\,m^2} \approx 0.5 - 1.5\,(10\ \ \mathrm{km})^2\, M_\odot$ which equals to dimensionless spin parameter $\tilde{a} \approx 0.05 - 0.15$ for slow rotators (neutron stars with a spin frequency roughly about 300 Hz) respectively $\tilde{a} \approx 0.1 - 0.3$ for fast rotators (neutron stars with the spin frequency roughly about 600 Hz).

session 5

Spectra of hot accretion discs in black hole binaries

Poutanen, Juri (University of Oulu), Alexandra Veledina, Indrek Vurm

A growing number of high time-resolution and multiwavelength observations of black hole X-ray binaries have led in recent years to a breakthrough in understanding of physical processes in the vicinity of compact objects. However, many aspects of the accretion physics is still under debate. One of the challenges is the decomposition of total spectrum into separate components (accretion disc, hot inner flow, jet). It is generally accepted that the radio emission is produced in the jet far away from the black hole, while the X-rays likely originate from the very vicinity of the compact object. However, the origin of the optical/infrared spectrum is much less certain. The flat power-law continuum frequently found at these wavelengths is inconsistent with being produced by the cool accretion disc or a companion star. In many cases it does not lie on the continuation of the radio power-law and is not consistent with the optically thin extension of the jet spectrum, thus it is not dominated by the jet. Further, a complex optical/X-ray correlation rejects the scenario of simple reprocessing. We propose that the optical/IR spectrum is dominated by the synchrotron emission of an inhomogeneous inner hot flow. I will discuss the general concepts of our model and show comparison to the observations.

session 4

New Ideas on Mechanisms of Angular Momentum Transport and Variability in Boundary Layers of Accretion Disks

Rafikov, Roman (Princeton University), Mikhail Belyaev, James Stone

Disk accretion onto a weakly magnetized central object, e.g. a white dwarf or a neutron star, is inevitably accompanied by the formation of a boundary layer near the surface, in which matter slows down from the highly supersonic orbital velocity of the disk to the rotational velocity of the star. Here I will describe a novel, robust mechanism of the angular momentum transport inside the astrophysical boundary layers. Using high resolution 2D and 3D hydrodynamical simulations in the equatorial plane of a boundary layer we generically find that the supersonic shear in the boundary layer excites non-axisymmetric quasi-stationary acoustic modes that are trapped between the surface of the star and a Lindblad resonance in the disk. These modes rotate in a prograde fashion, are stable for hundreds of orbital periods, and have a pattern speed that is less than and of order the rotational velocity at the inner edge of the disk. Dissipation of acoustic modes in weak shocks provides a universal mechanism for angular momentum and mass transport even in purely hydrodynamic (i.e. non-magnetized) boundary layers. Periodicity of these trapped modes may be relevant for explaining the variability seen in accreting compact objects.

session 2

X-ray variability of compact objects as a tool of accretion physics

Revnivtsev, Mikhail (Space Research Institute, Moscow, Russia)

Time variability of emission is a vital part of information available to us from relativistic compact objects. In particular, time variability of X-ray emission of relativistic stars was in focus of astronomers from the very beginning of specialized observations. Since then rich observational material was compiled with the help of a number of orbital observatories. In my talk I would like to briefly describe the main properies of aperiodic, quasi-periodic and periodic variability of emission of compact objects (mostly neutron stars and black holes) and our current understandings of them. I will try to show how existing models of generation of variability can be used to probe different aspects of accretion physics: size of the neutron stars; sizes of magnetospheres of magnetized objects; mass transport, evaporation of accretion disks and and many more.

session 3

XMM-Newton highlights of compact objects

Schartel, Norbert (ESA)

XMM-Newton has devoted a significant part of its observing time for the observations of compact objects: individual neutron stars and Galactic black holes as well as supermassive black holes in the centre of active and non-active galaxies. X-ray observations provide a unique opportunity to study the vicinity of compact objects, i.e. the region where the strong gravitational field acts and allow the determination of black holes spin. XMM-Newton observations constrain the understanding of the underlying accretion physics. The main focus of the talk will be the discussion of scientific highlight results based on XMM-Newton observations of compact objects.

session 6

What makes the jet production efficiency in AGN so diverse?

Sikora, Marek (Nicolaus Copernicus Astronomical Center)

Magnetic fluxes required to power jets in radio-loud quasars are significantly greater than those that can develop in standard accretion disks. The required levels of those fields are achievable only by the accumulation process, which proceeds via advection of magnetic fields by the accreting matter. Eventually, this leads to the formation of a magnetosphere around the black hole and the innermost portions of the accretion flow. Since such an advection is expected not to work efficiently in geometrically thin disks, we recently suggested (in Sikora et al. 2013, ApJ, 765, 62) that such an accumulation of magnetic flux can occur via hot, quasi-spherical accretion. Without this pre-phase, the cold accretion events would result in radio quiet (or at most, moderately radio-loud) quasars, as explored by Sikora and Begelman (2013, ApJ, 764, L24). My presentation is based on these papers.

session 5

Testing α-disk Accretion Model in the Inner-Most Parsec of AGN with Water Masers

Zaw, Ingyin (New York University Abu Dhabi), Lincoln Greenhill (Harvard Smithsonian Center for Astrophysics), Andrei Gruzinov (New York University)

Water masers, located 0.1 - 1.0 pc from the central SMBH and resolvable in position and velocity, provide a unique probe of the inner-most parsec of accretion disks. Water masers only exist in the narrow temperature range of 400 K - 1000 K, providing a direct test of the predictions for the temperature gradient from different heating mechanisms for sub-parsec accretion disks. While the temperature in an accretion disk depends on many parameters, e.g. SMBH mass and accretion rate, in a given disk, the gradient of the temperature should only depend on the radius. In particular, if viscous heating for a flat α-disk is dominant, the temperature would scale with radius as $r^{-3/4}$ (Shakura & Sunyaev 1973) and the ratio of outer radius to the inner radius of maser emission should be $\sim$3.4. A significant deviation from this value would indicate a warp, non-Keplerian rotation, and/or an alternate heating mechanism. I will present the $R_{\rm out}/R_{\rm in}$ ratios from a preliminary sample of water maser systems and discuss their consistency with the α-disk model.

session 6

Contributions from jets and accretion to emission of accreting black-hole binaries

Zdziarski, Andrzej (N. Copernicus Astr. Ctr.)

We study models of emission of jets in black-hole binaries, using constraints imposed by the flux at the turnover frequency, constraints from the observed X-rays and detections or upper limits in the range at>0.1 GeV. This allows us to estimate the magnetic field strength, the distance of the jet base from the center, and the jet power. On the other hand, accretion models also predict some gamma-ray emission from black-hole binaries, and Fermi upper limits constrain the size of the emitting plasma.

2 Posters

S2_poster

DETECTION OF A QUASI-PERIODIC OSCILLATION FROM A ULX IN NGC 4736

Akyuz, Aysun (Cukurova University), Şenay Kayacı, Hasan Avdan, Şölen Balman

We report the detection of a quasi-periodic oscillation (QPO) from the ultraluminous X-ray source (ULX) X-2 in NGC 4736 based on the *XMM-Newton* and *Chandra* archival data. Power density spectrum of ULX X-2 reveals a QPO peak at $0.53^{+0.09}_{-0.35}$ mHz with a fractional rms amplitude of $5 \pm 1\%$ and at $0.73^{+0.16}_{-0.14}$ mHz with a fractional rms amplitude of $16 \pm 3\%$ in the *XMM-Newton* and *Chandra* observations, respectively. The spectra for the two observations were fitted with two models, the power-law ($\Gamma \sim 2.5$) and the multicolor disk plus power-law (T_{in}=0.7 keV, $\Gamma \sim 1.7$) models, suggesting the source was in a spectral state analogous to the high state of Galactic black hole X-ray binaries or high/soft state. A black hole mass of $\sim (1-3) \times 10^4\ M_\odot$ is estimated based on the argument that black hole mass scale inversely proportional to the QPO frequency.

S2_poster

Simulated spectra of accretion disk winds for Athena+

Boirin, Laurence (Observatoire Astronomique de Strasbourg)

In the last decade, resonant absorption lines from highly-ionized species such as Fe XXV have been discovered in many low-mass X-ray binaries that are seen almost edge-on. They are produced in the atmosphere or wind of an accretion disk. This highly photo-ionized medium is probably present in all low-mass X-ray binaries but better observed in extremely inclined objects. In those systems showing winds, the mass outflow rate was estimated to be of the order of the accretion rate, emphasizing how important this component can be for the dynamics of the system.

Here we present Athena+ simulations of spectra from accretion disk atmospheres and winds. The very high spectral resolution and sensitivity of Athena+ will reveal currently unreachable details of the disk's ionization structure via precise phase and time-resolved spectroscopy.

S2_poster

Flow dynamics modeling during the active state of accreting compact binary stars

Boneva, Daniela (Space Research and Technology Institute, Bulgarian Academy of Sciences), Georgi Latev, Kiril Stoyanov Institute of Astronomy and National Astronomical Observatory,Bulgarian Academy of Sciences

We present our modeling on the physical processes of mechanisms that are most relative to the flare-up events in two different types of compact binaries. Some of these mechanisms could be referred to as a transport of the angular momentum in accretion discs, such as turbulent zones, vortex-like patterns motion or spiral wave structures. They also include the changes in mass transfer rate and the resulting dense zones. Hydrodynamical simulations show significant changes in the flow structure during the active state of the studied binaries. We analyze luminosity's quasi-periodic variability of binary stars systems with an accretion disc. The relationship between the disc's structural transformation and brighten up or bursts activity, which has an effect on the light curve shape's behavior is confirmed. In this survey, we apply the observational data of three compact binary stars.

S2_poster

OBSERVATIONS OF 1E 1740.7-2942: ANALYSIS OF THE SOFT EMISSION

Castro, Manuel (Instituto Nacional de Pesquisas Espaciais, São José dos Campos, Brazil), Flavio D'Amico, João Braga, Jörn Wilms, Katja Pottschmidt, Taís Maiolino

1E 1740.7-2942 is a black hole candidate (BHC) and one of the brightest X-ray sources in our Galaxy. It has been well observed over the last decade regarding both its spectral and timing behaviour. The observations have shown that the source spends most of its time in the (canonical) non-thermal state. We report here spectral analysis using data from the XMM-Newton satellite (PN, MOS1 and MOS2 cameras, 1 - 15 keV) and IBIS/INTEGRAL (20 - 200 keV) for two epochs (2003 and 2005). This makes 1E 1740.7-2942 one of the few BHCs with simultaneous spectral coverage in such a wide X-ray range. Among other possible models, a fit with a single, absorbed Comptonization model is able to adequately fit the full spectrum. This Comptonization may take place in an optically thick, very hot (kT $>$ 60 keV) corona-type emission region with low energy seed photons ($\sim$ 1 keV), in good agreement to a recently proposed scenario for the high energy emission of BHCs.

S2_poster

Aquila X-1 in Outburst

Güngör, Can (Istanbul Technical University), Ersin Göğüş, Tolga Güver, Kazım Yavuz Ekşi

We present Rossi X-Ray Timing Explorer (RXTE) observations of Aql X-1 during the 2000, 2010 and 2011-12 outbursts. We model the source spectrum with a hybrid thermal/non-thermal hot plasma emission model (Eqpair in XSPEC, Coppi 1992) together with a Gaussian component to account for the Fe Kα emission line. We constructed time histories of the source flux and physical parameters for these three outbursts. We also present a broad classification of all outbursts as seen with the All-Sky Monitor on RXTE and Monitor of All Sky X-Ray Image. We identified three types of outbursts; long-high, medium-low, short-low, based on the duration and maximum flux. We evaluate the time derivative of the flux to analyze the trends in the "phase-space" of flux-derivative versus flux which demonstrates the differences in the three identified outburst types. We discuss our results in the context of modes of interaction of the star with the disc.

S2_poster

AG Draconis - rigorous period analysis of photometric observations obtained over 120 years

Gális, Rudolf (Faculty of Science, P. J. Šafárik University in Košice), Ladislav Hric, Emil Kundra

AG Draconis is one of the best studied symbiotic systems which regularly undergoes quiescent and active stages. The latter ones consist of a series of individual outbursts probably caused by increased thermonuclear burning on the white dwarf accreting matter from the wind of the cool component. The general behaviour of the symbiotic system AG Dra was studied in the context of the long-term photometry and radial velocity analysis. The period analysis of new and historical photometric data, as well as radial velocities, confirmed the continued presence of the second period found by our previous analysis, which could be due to pulsation of the cool component of the AG Dra binary system. The discussion about a general cause of the recurrence time of the active stages is also presented.

S2_poster

X-ray and Optical Activity of Intermediate Polars

Gális, Rudolf (Faculty of Science, P. J. Šafárik University in Košice), Ladislav Hric, Emil Kundra

Intermediate polars represent a major fraction of all cataclysmic variables detected by *INTEGRAL* in hard X-ray. These object have been recently proposed to be the dominant X-ray source population detected near the Galactic centre and they also contribute significantly to the X-ray diffuse Galactic ridge emission. Nevertheless, only 25% of all known intermediate polars was detected in hard X-ray so far. This fact can be related with activity state of these close interacting binaries. Our analysis based on all available observational data from *INTEGRAL*/IBIS and *INTEGRAL*/JEM-X showed that the fluxes of some intermediate polars are long-term variable. Moreover this X-ray variability is correlated with the changes in optical spectral band. Multi-frequency (from optical to X-ray) investigation of intermediate polars is essential to understand physical mechanisms responsible for observed activity of these objects.

S2_poster

RS Oph – flickering activity and accretion disc formation

Hric, Ladislav (Astronomical Institute), Kundra Emil and Gális Rudolf

RS Oph belongs to four recurrent novae (RN) which are wide binary systems classified as symbiotic binary too. The system consists of the cool M0-M2III giant and a massive white dwarf whose mass is close to the Chandrasekhar limit and which accretes material from the giant. RS Oph is one of the best studied RN with at least 6 recorded outbursts. A long-term photometric study from the last outburst in 2006 is presented. The monitoring of the flickering activity can help to understand the behaviour of an accretion disc from the period of its destruction after the nova outburst, its appearance in August 2006 up to formation of the disc till nowadays.

S2_poster

Gamma-ray monitoring of Galactic Microquasar

Sabatini, Sabina (INAF IAPS), AGILE Team

AGILE carried out an extensive survey of the Galactic Plane since July 2007. Several micro-quasars have been monitored, showing that gamma-ray emission is in general rare or not detectable by current gamma-ray telescopes. Flaring activity in gamma-rays is also poor and not related to hard X-ray outburst in general. On the other hand we will discuss the cases of Cygnus X-3 and Cygnus X-1: the former showing a clear evidence of gamma-ray flaring emission correlated to major spectral transitions, the latter having a more puzzling behaviour. The gamma-ray activity will be put in context with multi-wavelength behaviour and interpreted in terms of spectral emission models. Fast transient activity will be discussed also in view of the next generation of gamma-ray instruments.

S2_poster

On the origin of non-thermal electrons in hot accretion flows

Stepnik, Agnieszka (University of Lodz), Andrzej Niedzwiecki, Fu-Guo Xie

We study emission from radiatively inefficient accretion flows using a fully general-relativistic model with self-consistent description of leptonic and hadronic processes. We present the radiative efficiency and the spectral energy distribution as functions of the black hole spin, electron heating and magnetic field parameters. We point out that proton-proton interactions in the innermost parts of the flows may explain the presence of non-

thermal electrons, which are often required by phenomenological radiative models of accreting black holes.

Symposium S3

Science with Planck data

1 Oral contributions

The Planck Dust Polarization Sky

Alina, Dana (IRAP/CNRS), Planck Collaboration

I will summarize the findings of the Planck polarization results, which are planned to be published by summer 2013. These include all sky polarization maps at wavelengths above 850 microns, dominated at the shortest wavelengths by polarized emission from thermal dust. These maps reveal the large-scale organization of the magnetic field as projected on the plane of the sky, which, even at the modest angular resolution of Planck (5') can be followed down into the nearby star forming molecular structures. I will discuss future prospects for studying the impact of the magnetic field in regulating star formation using this data and ground follow-up surveys. If the Planck polarization results were not be published by the time of the meeting, I would anyway review what will be possible with the Planck polarization data in this domain.

Dust emission at Planck millimetre wavelengths in the Galactic plane

Alves, Marta (Institut d'Astrophysique Spatiale), Planck Collaboration

Using Planck HFI data along with radio ancillary data we are able to study the emission properties of the dust in the millimetre wavelength range, in the Galactic plane. We analyse the region l=20-44 deg, $|b| < 4$ deg, where the free-free emission can be estimated from Radio Recombination Line data. We fit the spectra at each pixel with a modified black-body model to derive the spectral index of the dust opacity within 100 to 353 GHz, beta_mm, and compare it with that derived at higher frequencies, beta_fir. The results show that beta_mm is lower than beta_fir, with median values of 1.6 and 1.8, respectively. We also find that beta_mm is correlated with the dust opacity. We interpret this empirical correlation as an evolution of the millimetre dust opacity index with the fraction of molecular gas along the line-of-sight. This translates into beta_mm $\sim$ 1.52 for a medium which is mostly atomic and beta_mm $\sim$ 1.72 when the medium is dominated by molecular gas, respectively. The results are compared with the predictions of current dust models. We find that both the Two-Level System model and the emission by ferromagnetic particles can explain the present results if spatial variations of the component or physical processes responsible for the flattening of the dust emission are allowed.

Galactic Science with the Planck spacecraft

Davis, Richard (JBCA)

I will review the published Planck papers on Galactic science. Planck allows unbiased mapping of Galactic sub-millimetre and millimetre emission from the most diffuse regions to the densest parts of molecular clouds. The main goal of another study is to estimate the far-infrared to sub-millimetre (submm) emissivity of dust in the diffuse local interstellar medium(ISM) and in the intermediate-velocity (IVC) and high-velocity clouds (HVC) of the Galactic halo. Anomalous microwave emission (AME) has been observed by numerous experiments in the frequency range $\sim$10–60 GHz. Using Planck maps and multi-frequency ancillary data, we have constructed spectra for two known AME regions: the Perseus and ρ Ophiuchi molecular clouds.An all sky map of the apparent temperature and optical depth of thermal dust emission is constructed using the Planck-HFI (350 μm to 2 mm)and IRAS (100 μm) data. The optical depth maps are correlated with tracers of the atomic (HI) and molecular gas traced by CO. A review is made of the statistical properties of the Cold Clump Catalogue

of Planck Objects (C3PO), the first all-sky catalogue of cold objects, in terms of their spatial distribution, dust temperature, distance, mass, and morphology.

Diffuse Galactic components in the Gould Belt System

Davis, Richard (JBCA)

An analysis of the diffuse low-frequency Galactic components in the Southern part of the Gould Belt system ($130° \leq l \leq 230°$ and $-50° \leq b \leq -10°$). Strong UV flux coming from the Gould Belt super-association is responsible for bright diffuse foregrounds that we observe from our position inside the system and that can help us improve our knowledge of the Galactic emission.

The Planck Legacy Archive: current status, contents and future development

Dupac, Xavier (ESA), Planck collaboration

The Planck Legacy Archive (PLA) of ESA is the official repository for all Planck mission data, from raw material to highly-processed data. The database currently contains the nine Planck frequency maps from the nominal mission period, together with a number of other maps useful for data characterization (e.g. Survey maps, Half-Ring maps, Masks), and component maps, which include the CMB and Galactic foregrounds, CO and lensing maps among others. The PLA also contains the CMB angular power spectrum together with a large number of likelihood files, cosmological parameter databases and sky power spectra. Other science products include the Planck Catalogue of Compact Sources and the SZ catalogue. The PLA also contains a large number of mission-related time-ordered information, e.g. spacecraft attitude and orbital information, instrument data quality information, operational state history, radiation environment data, as well as software and associated documentation in a set of online wiki pages (Explanatory Supplement). Data may be browsed, searched, selected, processed and downloaded online through a Java user interface, which also provides Online technical help. A machine interface also exists and provides a simple web page to download frequently requested products without launching the main interface. Added-value items included in the PLA provide the user with the possibility of processing data online, such as map cutout and re-projection, use of the drizzling re-projection algorithm, selection of effective beam information and re-projection, inter-operability with the Aladin map visualization software and the TopCat catalogue viewer. Future items to be present in the PLA include time-ordered data from the full Planck mission together with full pointing data and some house-keeping data as well. Polarization information will be included in the next generation of maps to be delivered in the PLA in 2014.

Constraints on variation of fundamental constants

Fabre, Ophélia (Institut d'astrophysique de Paris), Planck collaboration: Silvia Galli, Alessandro Melchiorri, Eloisa Menegoni, Simon Prunet, Graca Rocha and Jean-Philippe Uzan.

A variation of the fundamental constants, and more particularly of the fine structure constant and the electron mass, is expected to affect the recombination history and imprint the cosmic microwave angular power spectrum. We investigate the constraints that the recent Planck data can set on an independent time variation of the fine structure constant or electron mass. The analysis is then extended to consider the variation of several constants. The case of the spatial variation of the fine structure constant is also considered.

Using a modified version of RECFAST, we compute CMB anisotropies and constrain the time variation. We focus on a six-dimensional parameters space for the cosmological parameters besides the parameters associated with the constant. We perform a MCMC analysis and compare the results obtained from the Planck data and WMAP7 data. The analysis of the spatial variation is performed on the Smica Planck data alone by using a quadratic statistical estimator. This estimator is calibrated on realistic realisations of CMB with a special care for the choice of the galactic mask.

The results show with a high level of confidence that there is no time variation and no spatial variation for the different fundamental constants we consider.

The signature of the Warm Hot Intergalactic Medium in WMAP and PLANCK data

Isabel, Suarez-Velasquez (Leibniz-Institute for Astrophysics Potsdam), Jan P. Mücket Fernando Atrio-Barandela Francisco Kitaura

Cosmological hydrodynamical simulations predict that a large fraction of all baryons reside within mildly non-linear structures with temperatures in the range $10^5 - 10^7$K called the Warm-Hot Intergalactic Medium (WHIM). As the gas is highly ionized, it could be detected by the temperature anisotropies generated on the Cosmic Microwave Background radiation. Using the log-normal probability density function we calculate the correlation function and the power spectrum of the temperature anisotropies generated by the WHIM filaments. We also compute the cross-correlation between the Warm-Hot Intergalactic Medium and maps of Cosmic Microwave Background temperature anisotropies searching for any WHIM contribution in the data measured by the Wilkinson Microwave Anisotropy Probe. We use a template of projected matter density reconstructed from the Two-Micron All-Sky Redshift Survey as a tracer of the electron distribution. Since the thermal Sunyaev-Zeldovich effect has a specific frequency dependence, we analyse the possibility of detecting this component with Planck data.

Cosmic Microwave Background cosmology I

Jaffe, Andrew (Imperial College London), Planck collaboration

The European Space Agency's Planck satellite, dedicated to studying the early universe and its subsequent evolution, was launched on 14 May 2009 and has been surveying the microwave and submillimetre sky continuously since August 2009. In March 2013, ESA and the Planck Collaboration publicly released the initial cosmology products based on the the first 15.5 months of Planck operations, along with a set of scientific and technical papers and a web-based explanatory supplement. We describe the main scientific results of this release. The science products include a map of the cosmic microwave background. Scientific results include robust support for the standard, six parameter CDM model of cosmology and improved measurements for the parameters that define this model, including a highly significant deviation from scale invariance of the primordial power spectrum. The Planck values for some of these parameters and others derived from them are significantly different from those previously determined. Several large scale anomalies in the CMB temperature distribution detected earlier by WMAP are confirmed with higher confidence. Planck sets new limits on the number and mass of neutrinos, and has measured gravitational lensing of CMB anisotropies at 25 sigma. Planck finds no evidence for non-Gaussian statistics of the CMB anisotropies. There is some tension between Planck and WMAP results; this is evident in the power spectrum and results for some of the cosmology parameters. In general, Planck results agree well with results from the measurements of baryon acoustic oscillations. Because the analysis of Planck polarization data is not yet as mature as the analysis of temperature data, polarization results are not released. We do, however, graphically illustrate preliminary results on E-mode polarization.This talk will give an overview of the mission and data analysis

Beam deconvolution and search of variable sources in Planck LFI maps

Keihänen, Elina (University of Helsinki), Jörg Rachen, Radboud University, Nijmegen, NetherlandsMartin Reinecke, MPA, Garching, Germany

We have developed the ArtDeco beam deconvolution code for absolute CMB measurements. The code takes as input the time-ordered data stream, along with pointing data and the harmonic beam coefficients, and produces as output the harmonic a_slm coefficients of the sky. From these one can further construct a sky map which is free from beam asymmetry effects.

We give an overview of the method and demonstrate its efficiency with simulated data sets. We then apply the code to Planck LFI data, and show beam deconvolved maps from Planck 30 GHz, 44 GHz, and 70 GHz channels.

As a further application we use the method to construct beam-free variability maps at LFI frequencies. The Planck Mission provides 8 full sky surveys at the frequencies of its LFI instrument. At each frequency, a point source is observed for a few hours up to a day per survey, which repeats every six months. The Planck time lines therefore contain valuable information on variations for any point of the sky on these time scales, which allows blind searches for transients and variable sources, both in and outside of our Galaxy.

A variability map constructed from data directly, without beam deconvolution, is contaminated by beam asymmetry effects. A given point on the sky is observed in different orientations of the beam in different surveys. This gives rise to fake variability, which complicates the detection of true variability of sources. We use the ArtDeco deconvolver to reduce this undesired effect, and show results on known variable sources.

References: E. Keihänen and M. Reinecke: ArtDeco: a beam-deconvolution code for absolute CMB measurements, A&A 20183 (2012)

Euclid: A space mission to map the dark Universe

Kitching, Tom (University College London), Euclid consortium

In this talk I will give an overview of the Euclid mission. Euclid is an ESA medium class space mission selected for launch in 2020 in the Cosmic Vision 2015-2025 programme (ESA PR selection). The Euclid mission aims at understanding why the expansion of the Universe is accelerating and what is the very nature of the source of this acceleration referred to as dark energy.

Cosmic Microwave Background cosmology II

Kurki-Suonio, Hannu (University of Helsinki), Planck collaboration

The European Space Agency's Planck satellite, dedicated to studying the early universe and its subsequent evolution, was launched on 14 May 2009 and has been surveying the microwave and submillimetre sky continuously since August 2009. In March 2013, ESA and the Planck Collaboration publicly released the initial cosmology products based on the the first 15.5 months of Planck operations, along with a set of scientific and technical papers and a web-based explanatory supplement. We describe the main scientific results of this release. The science products include a map of the cosmic microwave background. Scientific results include robust support for the standard, six parameter CDM model of cosmology and improved measurements for the parameters that define this model, including a highly significant deviation from scale invariance of the primordial power spectrum. The Planck values for some of these parameters and others derived from them are significantly dierent from those previously determined. Several large scale anomalies in the CMB temperature distribution detected earlier by WMAP are confirmed with higher confidence. Planck sets new limits on the number and mass of neutrinos, and has measured gravitational lensing of CMB anisotropies at 25 sigma. Planck finds no evidence for non-Gaussian statistics of the CMB anisotropies. There is some tension between Planck and WMAP results; this is evident in the power spectrum and results for some of the cosmology parameters. In general, Planck results agree well with results from the measurements of baryon acoustic oscillations. Because the analysis of Planck polarization data is not yet as mature as the analysis of temperature data, polarization results are not released. We do, however, graphically illustrate preliminary results on E-mode polarization. This talk will concentrate on the cosmological results.

Extragalactic radio source science with Planck data

Lähteenmäki, Anne (Aalto University Metsähovi Radio Observatory)

Planck satellite provides information on a frequency range that has rarely been observed in the past, especially simultaneously. These frequencies play a major role, for example, in statistical studies and in the modelling of spectral energy distributions of extragalactic foreground sources such as active galactic nuclei (AGN). Furthermore, Planck data, when the all-sky scans are studied individually, can be used for probing the variability of

AGN at several time scales from days to years.

Planck data for extragalactic foreground sources have been so far published in mainly two occasions: the Early Release Compact Source Catalog (ERCSC) in 2011 and, more recently, the Planck Catalogue of Compact Sources (PCCS). In this talk I review the data and the scientific results released in connection to them.

Peaks in the CMBR power spectrum: Physical interpretation for any cosmological scenario

López-Corredoira, Martín (Instituto de Astrofísica de Canarias), A. Gabrielli

While the CMBR power spectrum shows repeated information in the form of multiple peaks and oscillations, its angular correlation function offers a more compact presentation that condenses all the information of the multiple peaks into a localized real space feature. Oscillations in the power spectrum arise when there is a discontinuity in a given derivative of the angular correlation function at a given angular distance. These kinds of discontinuities do not need to be abrupt in an infinitesimal range of angular distances but may also be smooth, and can be generated by simply distributing excesses of antenna temperature in filled disks of fixed or variable radii on the sky, provided that there is a non-null minimum radius and/or the maximum radius is constrained. It can be produced by a fluid with clouds of overdensities that emits/absorb radiation or interact gravitationally with the photons, and with a finite range of sizes and distances for those clouds. The standard cosmological interpretation of "acoustic" peaks is just a particular case; peaks in the power spectrum might be generated in scenarios within some alternative cosmological model that have nothing to do with oscillations

due to gravitational compression in a fluid.

We calculate the angular correlation function of the anisotropies from the WMAP-7yr and ACT data, in an attempt to derive the minimum number of parameters a polynomial function should have to fit it: a set of polynomial functions with a total of six free parameters, apart from the amplitude, is enough to reproduce the first two peaks. However, the standard model with six tunable free parameters also reproduces higher order peaks, giving the standard model a higher confidence. At present, while no simple function with six free parameters is found to give a fit as good as the one given by the standard cosmological model, we may consider the predictive power of the standard model beyond an instrumentalist approach (such as the Ptolemaic as

Measuring the thermal Sunyaev-Zeldovich (tSZ) with Planck

MACIAS-PEREZ, Juan Francisco (LPSC), on behalf of the Planck collaboration

The Plack satellite experiment was launched by ESA in May 2009 and recently finished its mission. Planck is particularly well suited for the study of the tSZ effect both on cluster of galaxies and in diffuse structures in the Universe. We will present in this talk a review of the most important results obtained from the Planck nominal mission data. These include the largest tSZ selected catalogue of clusters of galaxies (1227 clusters), detailed measurements of the clusters pressure profiles, detailed studies of clusters scaling relations,cosmological implications of the Planck cluster number counts, detection of diffuse hot structures in the inter-cluster medium of mergers and the first measurement of the power spectrum of the Compton parameter in more than 50% of the sky including for the first time angular scales from 10 arcmin to few degrees.

The CMB non-Gaussianity as seen by Planck

Mangilli, Anna (Institut d'Astrophysique de Paris), et al.

Studying the non-Gaussianity (NG) of the Cosmic Microwave Background (CMB) is an extremely powerful tool to investigate the properties of the very early Universe. The Planck nominal mission CMB maps yield unprecedented constraints on primordial non-Gaussianity. In particular, we found fNL_local= 2.7 +/- 5.8, which means that there is no evidence for primordial NG of local shape. This one of the most remarkable Planck's result thanks to which the standard single-field slow-roll inflation has survived its most stringent test to-date. Thanks to Planck's high sensitivity, we also got the first detection of the non-Gaussianity from the Lensing-Integrated Sachs Wolfe (ISW) cross correlation at 2.7 σ and we found that it is compatible with the LambdaCDM predictions.

Planck's Ability to Measure Unresolved Sources

Partridge, Bruce (Haverford College)

ESA's Planck satellite detects thousands of compact (unresolved) sources, both Galactic and extragalactic. In this talk, I review the properties of the Planck mission and observations as they relate to flux density measurements of compact sources. These properties include Planck's scan strategy, frequencies, beam solid angles and calibration. I also discuss steps the Planck Team has taken to ensure that catalogued flux densities are accurate. As noted in a companion poster by B. Walter, Planck's absolute calibration allows us to use Planck observations of unresolved sources to re-calibrate flux density scales of ground-based instruments such as the JVLA.

Planck constraints on primordial Isocurvature perturbations

Savelainen, Matti (University of Helsinki), Planck collaboration

We present constraints that Planck set on primordial isocurvature perturbations. The presentation is based on Planck 2013 results XXII, Constraints on inflation, section 10. Observation of isocurvature primordial perturbations is an important test on inflationary models. Adiabatic LCDM model is the base case in the Planck papers, with this study we also tests this adiabaticity assumption. We present results for three isocurvature perturbation modes: cold dark matter density (CDI), neutrino density (NDI) and neutrino velocity (NVI). We do not find evidence for any of these isocurvature perturbation modes. We only can set upper limits to them (<0.39, <0.27 , <0.14 for CDI, NDI and NVI respectively at pivot scale k= 0.050). Also Planck data does not specifically prefer axion nor curvaton models. We find that adding freedom to have mixture of adiabatic and isocurvature perturbations do not drive background parameters to new values nor is degenerated strongly to any other parameter. This robustness of using Planck data in isocuravature studies is clear improvement over

our earlier work Constraints on scalar and tensor perturbations in phenomenological and two-field inflation models: Bayesian evidences for primordial isocurvature and tensor modes done with WMAP data.

2 Posters

Dynamical dark energy with barotropic equation of state: constraints from Planck data

Sergijenko, Olga (Astronomical Observatory of Ivan Franko National University of Lviv), Bohdan Novosyadlyj

We consider the model of dynamical dark energy with barotropic equation of state and constant effective sound speed. We constrain the parameters of such dark energy jointly with other cosmological parameters using combined datasets including the CMB power spectrum from Planck, the baryon acoustic oscillations from BOSS DR9, the light curves of SN Ia from SNLS3 and Union2.1. We compare the precision of determination of dark energy parameters with the precision of determination of corresponding ones from WMAP7 and WMAP9. We discuss also the degeneracies in models with non-zero masses of active neutrinos, non-zero curvature or non-zero contribution from the tensor mode of perturbations and their effect on the precision of dark energy parameters estimation.

Using Planck to Calibrate Ground-Based Radio Telescopes

Walter, Benjamin (Haverford College), Bruce Partridge

The calibration of both WMAP and Planck is absolute, since it is fundamentally linked to the dipole moment in the CMB induced by the yearly motion of the satellites. The calibration is also precise; in the case of Planck $\leq 1\%$. Planck detects hundreds of compact, extragalactic sources. We have made nearly simultaneous observations of some of these in order to check the agreement between Planck flux density scales at cm wavelengths and those used at the VLA and other radio telescopes. We summarize these results and comment on two issues: steps we took to mitigate the effect of variability of the sources we observed, and the consequences for estimates of planetary brightness temperatures.

Symposium S4

The mystery of ellipticals

1 Oral contributions

Ongoing assembly of massive early-type galaxies in the HUDF12

Buitrago, Fernando (Royal Observatory of Edinburgh)

The discovery of massive spheroid-like galaxies with sizes 4-5 times smaller at z=2-3 than their local counterparts challenges our current ideas about how the mass assembly of these objects took place over time. We have utilized the deepest images to date, the HUDF12, to characterize this process to a depth never probed before. Thanks to the superb multiband coverage, we are able to retrieve color, metallicity and age maps sometimes up to 20-30 effective radii, i.e., ∼100 kpc at z=0.6-1.

These tools allow us characterizing diffuse stellar haloes and other features associated with the merging history of these objects. We will explain in this context the morphological transformations of massive galaxies since z∼3, from compact disk-like objects to "red & dead" large spheroids.

Observations and modelling of early-type galaxy dynamics

Cappellari, Michele (University of Oxford)

I review observations of the stellar kinematics of early-type galaxies and the dynamical models that have been used to interpret the observations. I summarize what these observations and models tell us about galaxy structure and formation.

The Javalambre-PAU Astrophysical Survey: A Low Resolution IFU of the Northern Sky

Cenarro, A. Javier (CEFCA), the J-PAS Collaboration

The Observatorio Astrofísico de Javalambre (OAJ) is a new astronomical facility at the Pico del Buitre, in Teruel, Spain, promoted by the Centro de Estudios de Física del Cosmos de Aragón (CEFCA; http://www.cefca.es) to carry out large sky surveys with dedicated telescopes of very large field of view (FoV). The OAJ key project is the Javalambre-PAU Astrophysical Survey (J-PAS; http://j-pas.org), a very wide field Cosmological Survey to be carried out with the Javalambre Survey Telescope, JST, a large-etendue telescope of 2.55 primary mirror and 3 deg FoV, using a set of 54 contiguous narrow-band and 5 broad-band filters over a 1.3 Gpix, 5 $\deg^2$ FoV panoramic camera. Starting in 2015, J-PAS will image 8500 $\deg^2$ of Northern Sky and obtain 0.003(1+z) precision photometric redshifts for about 90 million galaxies, particularly optimized for improving our current constraints on Dark Energy by measuring the radial scale of the Baryonic Acoustic Oscillations. The instrumental development of J-PAS involves a small fraction of the cost and complexity of a high multiplexing spectrograph, yet it will produce data which enable a much wider range of Astrophysical applications. In the end, the unique and most powerful characteristic of J-PAS is that it will provide a low resolution (R∼ 50) spectrum for every pixel of the sky, hence behaving effectively as a 5 $\deg^2$ IFU that will produce a 3D image of the whole covered sky area. In this talk I will describe the main technical characteristics and scientific breakthroughs of the OAJ and J-PAS, in particular focusing on how J-PAS can contribute to improve our understanding on the formation and evolution of galaxies.

Early formation of massive, compact elliptical galaxies by violent disc instability and mergers in cosmological simulations

Ceverino, Daniel (Universidad Autonoma Madrid), Avishai Dekel

We address the formation of massive and compact spheroids in the early Universe, using a large set of zoom-in, AMR simulations. The mass and size growth was mostly driven by violent disc instabilities (VDI), as well as rare major mergers. A disc/spheroid decomposition using stellar kinematics yields a constant, time independent spheroid fraction, S/T ≈ 0.7 for most of the runs, consistent with a steady-state growth of both disc and spheroidal component, driven by VDI. These VDI-driven spheroids have steep surface density profiles, consistent with a classical, de-Vaucouleurs profile at all times. We also provide analytical expressions for the mass and size growth. As the galaxies evolve in the mass-size plane, their mean surface density inside the effective radius remains approximately constant with time. On the other hand, galaxies with the same stellar mass but higher redshifts are denser and smaller, because the Universe at higher redshifts was denser and all processes of mass assembly were more dissipative, and more gas rich.

The Outer Halo of the Nearest Giant Elliptical: A VLT/VIMOS Survey of the Resolved Stellar Populations in Centaurus A to 85 kpc

Crnojevic, Denija (Institute for Astronomy, Royal Observatory Edinburgh), A.M.N. Ferguson, M.J. Irwin, E.J. Bernard, N. Arimoto, P. Jablonka, C. Kobayashi

I will present the first survey of resolved stellar populations in the remote outer halo of our nearest giant elliptical (gE), Centaurus A (D= 3.8 Mpc). Using the VIMOS/VLT optical camera, we obtained deep photometry for four fields along the major and minor axes at projected elliptical radii of $\sim 30-85$ kpc (corresponding to $\sim 5-14R_{\rm eff}$). We use resolved star counts to map the spatial and colour distribution of red giant branch (RGB) stars down to ~ 2 magnitudes below the RGB tip. We detect an extended halo out to the furthermost elliptical radius probed ($\sim$ 85 kpc or $\sim 14R_{\rm eff}$), demonstrating the vast extent of this system. We detect localised substructure in these parts, visible in both (old) RGB and (intermediate-age) luminous asymptotic giant branch stars, and there is some evidence that the outer halo becomes more elliptical and has a shallower surface brightness profile. We derive photometric metallicity distribution functions for halo RGB stars and find relatively high median metallicity values ($<$[Fe/H]$>_{med}\sim -0.9$ to -1.0 dex) that change very little with radius over the extent of our survey. Radial metallicity gradients are measured to be $\approx -0.002-0.004$ dex/kpc and the fraction of metal-poor stars (defined as [Fe/H]< -1.0) is $\approx 40-50\%$ at all radii. I will discuss these findings in the context of galaxy formation models for the buildup of gE haloes.

Do compact ellipticals at z$\sim$1-2 also have larger velocity dispersion?

di Serego Alighieri, Sperello (INAF - Osservatorio Astrofisico di Arcetri), M. Cappellari, F. La Barbera, P.J. McCarthy, M. Mignoli, P. Nair

Given virial equilibrium and well known scaling relations, compact early-type galaxies (ETG) should have larger velocity dispersion than normal ones with the same mass. We examine if this is the case using new VLT spectroscopic data on about 20 ETG with z$\sim$1-2 from the GDDS survey, which also have HST imaging data. We compare our results with others available in the literature, both at high redshift and locally, and with dynamical evolutionary models of ETG in order to derive clues on the formation and evolution of ETG.

The mysterious properties of local compact massive galaxies: not what we expected

Ferre-Mateu, Anna (IAC), Vazdekis, A., Trujillo, I., Sanchez-Blazquez, P., Ricciardelli, E., de la Rosa, R.

Over the past few years a revolution on our understanding of the formation and assembly of galaxies has occurred: massive galaxies in the Early Universe were found to be much more compact than their local counterparts. This finding has triggered a strong debate on how these objects evolved to the present day massive galaxy population and on what mechanism is causing this size growth. We have found a tiny fraction of such compact galaxies in the Local Universe, as predicted by some models, opening the possibility of exploring their formation mechanisms in great detail. I will present the intriguing properties of these galaxies,

which, unlike the expectations, show unprecedented large fractions of young stellar components. These object also present disky morphologies, strong rotation curves and high velocity dispersions and do not follow the relations of present day massive ellipticals or spirals. Nearby compact massive galaxies are almost perfect counterparts in terms of size, mass shape and age of the compact massive galaxies at z=2.

The progenitors of mergers with massive galaxies at z<1

Ferreras, Ignacio (UCL), I. Trujillo, E. Mármol-Queraltó, P. Pérez-González

One of the most important open questions in extragalactic astrophysics at present concerns the size evolution of massive galaxies over the past 8 Gyr of cosmic history, where galaxies with stellar mass above 1E11Msun undergo a change in effective radius of a factor 2-3, without any apparent change in their colours, except for passive evolution. In order to confirm or disprove viable scenarios of size evolution, it is important to understand the age distribution of the constituent stellar populations. Mergers (either as major or minor events, depending on the mass of the infalling satellite) are supposed to be an important channel to explain this mechanism. In this contribution, we present recent work on the analysis of the properties of the stellar populations of satellites around massive galaxies at moderate redshift (z<1), which are supposed to merge with them, and form the type of massive galaxies we see in the local Universe. The observations are extracted from the SHARDS dataset, comprising deep (<26.5 AB) photometry with a suite of medium band filters, effectively providing low-resolution (R∼50) spectra. These data allow us not only to achieve the desired accuracy in the redshift estimates for a proper selection of the targets, but to constrain the stellar age of the underlying populations.

How dead are dead galaxies?

Fumagalli, Mattia (Leiden Observatory), Marijn Franx (Leiden), Pieter van Dokkum (Yale), Ivo Labbe (Leiden), Shannon Patel (Leiden), Ivelina Momcheva (Yale), Hans Walter Rix (Heidelberg), Gabriel Brammer (ESO)

We investigate the star-formation rate of quiescent galaxies (QGs) at high redshift with 3D-HST and Spitzer data. Spectral energy distribution fitting (rest frame optical and near-IR) indicate generally very low SFRs for QGs, much lower than the predicted ones from mass loss, assuming that the gas expelled from evolved stars refuels star formation. It is therefore fundamental to understand if some mechanism prevents the mass loss gas from refuelling the star formation activity, or SF is hidden under high dust obscuration. We select quiescent galaxies in the 3D-HST survey with a color-color technique in the GOODS fields, where spectroscopic redshifts from the 3D-HST survey allow a precise evaluation of rest-frame colors, and deep MIPS 24um data is available. We stack the 24um thumbnails of quiescent objects in five redshift bins from z=0.5 to 2.2 and perform photometry on them. We obtain clear detections corresponding to SFR = 0.3-3 Msol / yr. Quiescent galaxies at each redshift have very low sSFR ($< 10^{-10.8}$ yr^{-1}), 20 times less than the typical star forming galaxy at the same redshift. We evaluate the contribution of cirrus dust eated by old stellar populations and circumstellar dust in TP-AGB stars to the L(IR), and show it accounts for most of L(IR) observed in QGs. We therefore establish an upper limit to the SFR of QGs, and show that they grow at most 20% of their mass from from redshift 2 to 0 via star formation, while the rest of their growth must come from mergers.

Kinematics of high redshift compact early-type galaxies: are they really denser?

Gargiulo, Adriana (INAF-Osservatorio Astronomico di Brera), Paolo Saracco, Marcella Longhetti, Ilaria Lonoce, Sonia Tamburri

We present FORS2 spectroscopy of 4 early-type galaxies (ETGs) spectroscopically identified at $1.2 < z < 1.5$ and the measure of their stellar velocity dispersions. High-resolution (FWHM $\sim$ 0.1") HST-NIC2 imaging (0.075"/pix) in the F160W-band (lambda $\sim$ 1.6 μm) shows that their effective radii are 2-3 times smaller than the mean effective radius of local ETGs with similar stellar mass. If this high compactness is effectively due to higher stellar mass density, then these galaxies must have stellar velocity dispersions larger than that of typical local ETG with comparable stellar mass. The analysis of results confirms that at z=1.4, when the universe was ∼4Gyr old, spheroids with stellar mass density spanning two order of magnitude fully coexist. Discussion of the results in the framework of the formation and accretion of the bulges is proposed.

Assembly histories and observational properties of simulated Early-Type Galaxies

Johansson, Peter (University of Helsinki), Thorsten Naab, Jeremiah P. Ostriker

We show that our simulated galaxies assemble in two phases, with the initial growth dominated by compact in situ star formation fueled by cold, low entropy gas streams, whereas the late growth is dominated by accretion of old stars formed in subunits outside the main galaxy. We find in general a positive correlation between the fraction of accreted stars and the final mass of our galaxies, with the most massive galaxies thus having the largest fraction of accreted stars. The two-phase formation mechanism naturally explains the observed downsizing, bimodality and size growth of the galaxy population. Very high resolution simulations show that gravitational feedback strongly suppresses late star formation in massive galaxies contributing to the observed galaxy color bimodality. However, additional heating sources probably in the form of AGN and SNI feedback are also required to prevent late gas inflows and associated residual star formation in the more massive galaxies. Consistent with their assembly histories we find that the dark matter fractions within the stellar half-mass radii continuously increase towards lower redshift from about $f_{DM} \sim 0.05$ at $z \sim 3$ to $f_{DM} \sim 0.1 - 0.3$ at z=0. In addition, the logarithmic slope of the total density profile is nearly isothermal at the present-day (gamma'$\sim$ 1.9-2.2) also in good agreement with recent lensing observations. Finally, we find a correlation between the photometric and kinematic properties of the galaxies and their formation history. The more massive galaxies with a larger accreted component are typically better fitted by single component Sersic functions and are more slowly rotating, whereas the lower mass galaxies with a larger in situ fraction are typically fast-rotators best fitted by a two-component (disk+bulge) light profile.

The formation of massive early-type galaxies in the protocluster at z=3.09

Kubo, Mariko (Tohoku University, Japan), Y. K. UCHIMOTO, T. YAMADA, M. KAJISAWA, T. ICHIKAWA, Y. MATSUDA, M.AKIYAMA, T. HAYASHINO, M. KONISHI, T. NISHIMURA, K. OMATA, R. SUZUKI, I. TANAKA, T.YOSHIKAWA, D. M. ALEXANDER, G.G. FAZIO, J.-S. HUANG, B.D. LEHMER

The protocluster at z=3.09 in the SSA22 field is known to be one of the most significant structures, very suitable to study formation history of massive early-type galaxies which dominate the center of local rich clusters of galaxies.
We have studied this protocluster using our own deep ($K_{AB} < 24$) and wide (112 $arcmin^2$) NIR data and also optical to MIR data. We selected the candidate protocluster members based on the photometric redshifts as $2.6 < z_{phot} < 3.6$. From their rest-frame UV to NIR colors, we found strong clustering of the massive quiescent galaxies, which have never been reported in other fields at similar redshift. ≈20% of the galaxies at $2.6 < z_{phot} < 3.6$ with the stellar mass $> 10^{11} M_{sun}$ in the SSA22 field are classified as the quiescent galaxies. In last year, we conducted NIR spectroscopic observations of the protocluster galaxies to confirm their redshifts. We successfully confirmed 20 K-band selected galaxies to be at $z_{spec} = 3.09$. They have large stellar mass, high SFR, red colors and some of them are luminous at MIR; they are the massive galaxies in formation. We also confirmed some multiple stellar components of large Lyman-alpha Blobs or Sub-mm source to be at $z_{spec} = 3.09$. They would grow up to be massive early-type galaxies through multiple merging. From these above, we conclude that we are just witnessing the formation epoch of the massive early-type galaxies in local rich clusters of galaxies.

Revealing the Stellar Population Content in the Outer Halo of Massive Galaxies

La Barbera, Francesco (INAF-OAC), I. Ferreras, R.R. de Carvalho, I.G. de la Rosa, G. Bruzual, S. Charlot, A. Pasquali, E. Merlin

Radial trends of stellar population properties in galaxies are a valuable tool to study the mechanisms of galaxy growth. Using a sample of 674 massive ($M^* > 3x10^{10} M_\odot$) early-type galaxies (ETGs) from the SDSS-based SPIDER survey, we have performed the first comprehensive analysis of optical-optical and optical-NIR colours out to the halo region (8Re) of ETGs. By comparing with a wide range of population synthesis models, we disentangle the radial trends in age and metallicity. We will present the dependence of such trends on galaxy mass and environment, in light of the processes leading from the formation of the central core to the growth of the stellar envelope of ETGs.

The Growth in Size and Mass of Cluster Galaxies since z= 2

Laporte, Chervin (Max Planck Institute for Astrophysics, Garching)

I follow the formation and evolution of Brightest Cluster Galaxies (BCGs) starting from a population of z=2 massive quiescent galaxies and following them to z=0. To this end, I use the suite of nine high-resolution dark matter-only simulations of galaxy clusters in a ΛCDM universe from the Phoenix Project. I have developed a scheme in which simulation particles are weighted to generate realistic and dynamically stable stellar density profiles at $z = 2$ (Laporte et al. 2013). Our initial conditions assign a stellar mass to every identified dark halo as expected from abundance matching and the sizes of the luminous components are set according to the observed relations for z∼2 massive quiescent galaxies. Our experiments supports the idea that Brightest Cluster Galaxies can form through dissipationless mergers of quiescent massive $z = 2$ galaxies, without substantial additional star formation, reproducing observed trends in stellar mass growth rate, size increase and evolution of surface brightness profiles. I will show how these simulations can be used to provide useful synthetic data to be compared with PNe surveys.

Tracing early-type galaxy assembly with nuclear stellar disks

Ledo, Hugo (University of Hertfordshire), Marc Sarzi

Early-type galaxies have long been regarded as uninteresting and passively evolving systems. A growing amount of evidence shows that this is not the case and that poses a problem, what have we missed? Intimately connected to many of our questions comes the fact that we cannot completely follow galaxy evolution through time. Although star formation history is fairly well known, mass assembly is not. In the particular case of early-type galaxies this mass assembly can also be linked to major morphological changes. It is therefore of paramount importance to be able to trace these events. We present, here, Nuclear Stellar Disks as a powerful tool to constrain the assembly history of early-type galaxies. During this work we have produced the first census of disks in nearby early-types and retrieved the properties of a sample of such disks. We also show that these properties can be combined with Integral Field Spectra to constrain the age of the disks and, thus, the epoch of the last "large" merger. Finally, we have studied disk fragility by means of hydrodynamical simulations to know in detail which mergers these disks trace.

The age of extremely red and massive elliptical galaxies at very high redshift

López-Corredoira, Martín (Instituto de Astrofísica de Canarias), Nieves Castro-Rodríguez

A statistical analysis of 353 extremely red objects (EROs) classified as old galaxies (OGs) at $0.8 \leq z \leq 3.8$ is carried out. Once we get M_V and (B-V) at rest for each galaxy, we calculate the average variation of this intrinsic color with redshift and derive the average age through a synthesis model.

The formation epochs of these galaxies are within a narrow range, of on average 2.0 ± 0.3 Gyr for the galaxies observed at 0.8<z<2.5, and $0.9^{+0.4}_{-0.8}$ Gyr for the galaxies at $2.5 < z < 3.8$, and it depends significantly on the observed redshift and stellar mass: the higher the stellar mass, the lower the age of the Universe at which it was formed. This result appears to conflict with Lambda-CDM models that claim that the most massive galaxies formed after lower mass.

The major merger origin of massive ETGs since z = 2

Lopez-Sanjuan, Carlos (CEFCA), O. Le Fèvre, T. Contini, L. de Ravel, B. Epinat, L. Tasca, et al.

In the past years several studies found that early-type galaxies (ETGs) are the dominant population over the most massive galaxies ($M > 10^{11}$ $M_\odot$) only since z = 1. One popular mechanism for ETGs formation is the (wet) major merging of two gas-rich galaxies, and we test this mechanism by confronting the observed number density (n_ETG) evolution of ETGs since z = 2 with the expected evolution due to merging. First, we estimate, for the first time, the wet major merger rate at $z > 1$ from spectroscopic close pairs thanks to the MASSIV ($0.9 < z < 1.8$) and VVDS-Deep (z = 2.35) surveys. We find that the merger rate is well described by a power-law function up to z = 1.5, then flattens at higher redshifts. Second, we develop a simple model to estimate the contribution of merging (both wet and dry) to the evolution of n_ETG. We find that (i) wet

major mergers explain the evolution of n_ETG at $0.8 < z < 2$, but at lower redshifts they only account for ∼50% of the evolution. And (ii) the contribution of dry mergers is negligible at $z > 1$, but at $z < 1$ they explain the remaining evolution in n_ETG. We conclude that the combined action of wet (2/3) and dry (1/3) mergers fully explains the emergence of massive ETGs in the last 10 Gyr.

The mysteriously simple stellar populations of elliptical galaxies

Maraston, Claudi (-), -

The stellar populations of elliptical galaxies have traditionally been an important probe of the formation and evolution of these mysterious galaxies. Featured by old ages and alpha-enhanced element ratios at low-z, and by a small spread in age at high-z, their overall properties depend more on their mass than on the environment they reside in. In this talk I shall report on the latest results on stellar population analysis of massive early-type galaxies, and will try to link the low and high- redshift population.

Testing the minor merger scenario: stellar population analysis of the outskirts of nearby massive galaxies

Marmol-Queralto, Esther (IfA/ROE), I. Trujillo, F. Buitrago

Accretion of minor satellites has been postulated as the most likely mechanism to explain the significant size evolution of the massive galaxies over cosmic time. Simulations of minor merging suggest that new accreted stars from satellites are mainly added to the outer parts of the central galaxies which produces an efficient grow in size compatible with the observations. If the satellites are significantly different in stellar content than their central galaxies, the imprints of these satellites might be found in the outer parts of massive galaxies in the local universe.

Here I present the analysis of the stellar populations (age and metallicity) of a sample of nearby massive galaxies using the very deep Stripe82 data, from the inner parts up to the outer envelopes of these galaxies to look for the imprints of satellites. This work is the key to probe whether massive early-type galaxies are built by the accretion of satellites along their cosmic life, and to solve the puzzle for the formation of massive galaxies.

Quiescent Disks in the Early Universe

McGrath, Elizabeth (Colby College), A. Kesseli, A. van der Wel, S. Wuyts, and the CANDELS collaboration

Recently, evidence has been mounting that the most massive end of the red sequence at z∼2 contains a significant fraction of quiescent, disk-dominated galaxies. These galaxies are quite unlike the quiescent spheroids that dominate the massive end of the red sequence today. Using the CANDELS survey, we investigate the environments of these quiescent disks and their fraction with time (compared to galaxies of the same mass) in order to constrain quenching scenarios. We propose that the quiescent disk phase may be a natural link between massive star-forming disks at even higher redshifts, and quenched spheroids in the local Universe.

Age and metallicity gradients support hierarchical formation for M87

Montes , Mireia (Instituto de Astrofisica de Canarias (IAC))

In order to probe the inside-out formation of the most massive galaxies, we have explored the radial ($0.1 \leq R \leq 8$ kpc) variation of the spectral energy distribution (SED) of M87 from UV to IR. For this purpose, we have combined high resolution data in 16 different bands. Our analysis indicate that the age of the stellar population of this galaxy remains almost unchanged with radius. However, the metallicity ([Fe/H]) profile presents three different zones: the innermost kpc shows a plateau with supersolar metallicity, followed by a decline in metallicity down to 5 kpc and another plateau afterwards. The inner plateau is in agreement with predictions for the size of the effective radii (Re) at z=2. The global [Fe/H] gradient is -0.41+-0.04, similar to those found in other nearby massive ellipticals. The observed change in the stellar population of M87 is consistent with a rapid formation of the central part of this galaxy followed by the accretion of the outer regions through the infall of more metal-poor material.

HST/WFC3 Confirmation of the Inside-out Growth of Massive Galaxies at 0 < z < 2 and Identification of Their Star-forming Progenitors at z ∼ 3

Patel, Shannon (Leiden), Pieter G. van Dokkum, Marijn Franx, Ryan F. Quadri, Adam Muzzin, Danilo Marchesini, Rik J. Williams, Bradford P. Holden, Mauro Stefanon

We study the structural evolution of massive galaxies by linking progenitors and descendants at a constant cumulative number density of $n_c \sim 10^{-4}$ Mpc^{-3} to $z \sim 3$. Our work employs HST CANDELS imaging to trace the assembly of these $M \sim 10^{11}$ Msun galaxies. At fixed n_c, these galaxies grow in stellar mass by a factor of ∼3 from $z \sim 3$ to $z \sim 0$. The evolution in the surface mass density profiles indicates that most of the mass at $r < 2$ kpc was in place by $z \sim 2$, and that most of the new mass growth occurred at larger radii. This inside-out mass growth is therefore responsible for the larger sizes and higher Sérsic indices of the descendants toward low redshift. At $z < 2$, the effective radius evolves with the stellar mass as re$\sim M^{2.0}$, consistent with scenarios that find dissipationless minor mergers to be a key driver of size evolution. The progenitors at z ∼ 3 were likely compact star-forming disks. By z ∼ 1.5, many of these star-forming disks disappeared, giving rise to compact quiescent galaxies. Toward lower redshifts, these galaxies continued to assemble mass at larger radii and became the local ellipticals that dominate the high-mass end of the mass function at the present epoch.

New/future observing facilities and surveys

Perez-Gonzalez, Pablo G. (-), -

Some of the most interesting topics which are still open about the properties of massive early-type galaxies at high redshift will be presented, jointly with the implications on our understanding of galaxy formation and evolution. We will pay special attention to the observational problems found when trying to characterize the star formation history (and the stellar properties in general) of those high-z ETGs, and discuss on the technical challenges we face to complete this task. We will review current and future observational programs which have been or are being designed to address the unresolved issues.

The formation and evolution of central cluster and group galaxies

Puchwein, Ewald (Heidelberg Institute for Theoretical Studies)

We study the formation and evolution of central cluster and group galaxies, as well as the origin of intracluster light in high-resolution cosmological hydrodynamical simulations. Our simulations account for feedback from active galactic nuclei, which is instrumental for obtaining realistic stellar masses and luminosities of central galaxies, as well as for reproducing the observed bright end of the galaxy luminosity function. Furthermore, we explore the assembly history of central galaxies and investigate how and when intracluster stars become unbound form their former host systems.

The Dark Halo – Spheroid Conspiracy and the Origin of Elliptical Galaxies

Remus, Rhea-Silvia (University Observatory Munich / MPE), Andreas Burkert, Klaus Dolag, Peter H. Johansson, Thorsten Naab, Ludwig Oser and Jens Thomas

Dynamical modeling and strong lensing data indicate that the total density profiles of early-type galaxies are close to isothermal, i.e., $\rho_{\rm tot} \propto r^{\gamma}$ with $\gamma \approx -2$. To understand the origin of this universal slope we study a set of simulated spheroids formed in isolated binary mergers as well as the formation within the cosmological framework. I will show that the total stellar plus dark matter density profiles can always be described by a power law with an index of $\gamma \approx -2.1$ with a tendency toward steeper slopes for more compact, lower-mass ellipticals, and that the amount of stars formed in situ is crucial to understand the origin and evolution of this universal slope. I will demonstrate that the variety of complex formation histories as present in cosmological simulations, including major as well as minor merger events, is essential to generate the full range of observed density slopes seen for present-day elliptical galaxies, and analyze the impact of different physics included in the simulations on the interplay between the stellar component and the dark matter.

Structure, dynamics and stellar population characterization of massive virtual galaxies at z=0

Ricciardelli, Elena (Universitat de Valencia), J. Navarro-Gonzalez, V. Quilis, A. Vazdekis

We present the results of a numerical adaptive mesh refinement hydrodynamical and N-body simulation in a LCDM cosmology. We focus on the analysis of the most massive galaxies (M $> 10^{11}$ Msun) identified at z=0. We discuss the main properties of our sample according to their morphological types, accretion histories and dynamical properties. We find that the galaxy merging history is the leading actor in shaping the massive galaxies that we see nowadays. Indeed, galaxies having experienced a turbulent life are the most massive in the sample, show the steepest metallicity gradients and are typically classified as fast rotators. Beside the importance of merging, only a small fraction of the final stellar mass has been formed ex-situ (10-50%), while the majority of the stars formed within the galaxy. These accreted stars are significantly older and less metallic than the stars formed in-situ and tend to occupy the most external regions of the galaxies.

Evolution of spheroids in Semi-Analytic Models of galaxy formation

Shankar, Francesco (GEPI-Observatoire de Paris)

One of the still mostly debated topics in Cosmology is the formation and evolution of massive, spheroidal galaxies. Hierarchical models claim that up to 50-80% of the stellar mass in bulge-dominated systems (i.e., ellipticals) was assembled at late times via a sequence of minor and major dry mergers. "Monolithic" models envisage instead that most of the mass in ellipticals was formed in a strong initial burst of star formation, and/or following a gas rich disky/clumpy phase fuelled by a cold flow. In my talk I will review the current status of semi-analytic models of galaxy formation in explaining the birth and growth of massive, bulge-dominated galaxies, emphasizing the existing predictions and tensions among the different models. I will then proceed by pointing to the some new working methodologies which may help us in further advance in our understanding of galaxy evolution. In particular, I will focus on recent results by different groups obtained via semi-empirical models based on Sub-halo Abundance Matching techniques.

By comparing with a variety of large data sets, I will show how we might be successful in breaking existing degeneracies in the models and finally constrain galaxy evolution theories. In particular, I will discuss the extremely hot topic of the size and number density evolution of early type galaxies and the role of environment versus mergers, and conclude with the correlation with central super-massive BHs.

ESO325-G004: A massive elliptical galaxy with a lightweight IMF

Smith, Russell (University of Durham), John Lucey (Durham)

Recent evidence suggests that massive ellipticals formed stars with an initial mass function (IMF) which is "heavier" than that of the Milky Way, perhaps due to an excess of low-mass stars. An IMF which varies systematically with galaxy properties would have wide-ranging implications both for star-formation physics and for interpreting extragalactic observations, so it is important to test these results carefully. I will present the results for ESO325–G004, a very massive elliptical which, at $z = 0.034$, is also the closest-known strong gravitational lens galaxy. We have recently measured the redshift of the lensed background galaxy, and hence secured the mass of the elliptical inside the Einstein radius. Because the lens is so close, the Einstein radius is small compared to the effective radius, and the lensing mass is dominated by stars. Hence lensing, with only a small correction for dark matter, provides the *stellar* mass-to-light ratio. Combined with age constraints from high-S/N spectroscopy, the lensing mass firmly excludes a "heavyweight" IMF in *this* $\sigma = 340\,\mathrm{km\,s^{-1}}$ elliptical. An IMF similar to that in the Milky Way is consistent with the observations. Is this galaxy simply an outlier among massive ellipticals in having a Milky-Way-like IMF? Or does it point to tension with the methods that prefer heavier IMFs? Upcoming VLT observations of dwarf-star-sensitive spectral features in ESO325–G004 should be able to answer this question by the time of the meeting.

The XLENS Project: Luminous & Dark Matter in massive Early-Type Galaxies

Spiniello, Chiara (Kapteyn Institute), L.V.E.Koopmans, S.C.Trager, T.Treu, M.Barnabè, O.Czoske

In this talk I present results from The X-Shooter Lens Survey (XLENS). XLENS targets a sample of massive

lens early-type galaxies (ETGs) from the SLACS Survey with velocity dispersions greater than 250 km/s using the X-Shooter spectrograph on ESO's VLT. The XLENS goal is to study the internal structures and mass profiles of massive ETGs, as well as their stellar population, to understand the interplay of stellar and dark mass in order to probe directly their formation and dynamical evolution. We combine precise strong gravitational lensing and dynamical constraints on the mass distribution (few % accuracy) with high signal-to-noise spectroscopy in the entire rest-frame visible to the NIR, and mass-to-light ratios with 10-20% absolute accuracy. With this technique we obtain accurate stellar masses and the most precise dark-matter mass fractions to date, disentangling the contributions of stellar and dark matter in the inner regions of the galaxies. Moreover, with XLENS we are also able, for the first time ever, to simultaneously constrain the low-mass end of the IMF normalization and slope directly from galaxies spectra.

The evolution and formation of star forming and quiescent galaxies to z=4 from Z-FOURGE

Straatman, Caroline (Leiden Observatory), Z-FOURGE team (PI: Dr. Ivo Labbé)

We have employed the very deep FourStar Galaxy Evolution Survey (Z- FOURGE) to study the galaxy population out to z $\sim$ 4 in three of the CANDELS fields. The strength of this survey lies in the use of unique medium-bandwidth filters (J1,J2,J3,Hs,Hl,Ks) in the near-infrared to ultradeep limits (25-26 AB mag 5 sigma). These medium-band filters allow for a precise sampling of the age-sensitive 4000Å Balmer break at z > 1.5 to obtain accurate photometric redshifts for a large sample of galaxies and determine their stellar populations.

In this talk I will discuss the evolution in number density of passive and actively star forming galaxies between z = 0.5 and z = 4.0. We find a prominent contribution from a dust-obscured star-forming population of galaxies that dominates the high-mass end at z=2-3 and which could be an important evolutionary phase in the formation of the most massive ellipticals. We also report a significant population of quiescent galaxies as early as redshift z=3.5-4.0.

Early-type galaxies in the most dense high-redshift environments: a study in the Cl J1449+0856 cluster at z=2

Strazzullo, Veronica (CEA Saclay), R. Gobat, E. Daddi

Cl J1449+0856 at z=2 is the most distant galaxy cluster for which an extended X-ray emission has been detected. A likely representative progenitor of today's typical massive clusters, it allows the study of galaxy populations in most dense environments 10 billion years ago, a crucial time bridging proto- clusters to the first established clusters, and marking the main formation epoch of massive cluster early-type galaxies. In the core of this system, a remarkably diverse galaxy population clearly shows how galaxy evolution is in a much more active phase as compared to cluster cores at z<1-1.5. Nonetheless, together with still actively forming galaxies, we identify a population of massive sources already showing quiescent stellar populations and early-type morphologies. These galaxies are mostly segregated within $\sim$200kpc from the cluster center, in the most dense region of this structure. As observed also in the field up to similar epochs, we find a strong correlation between stellar populations and galaxy structure, with most passive galaxies showing an early-type morphology (and viceversa). Although these passive cluster early-types appear smaller than similarly massive early-types in the nearby Universe, as routinely found in high-redshift studies, they seem to be generally larger than their z$\sim$2 field counterparts. These results, albeit still hampered by poor statistics, would support recent claims of an accelerated structural evolution in high-redshift dense environments.

Unravelling mysteries of galaxy size evolution with cosmology & feedback

Stringer, Martin (Observatoire de Paris), Francesco Shankar, Greg Novak

In the context of the wealth of recent work focussing on the contribution of discreet evolutionary processes to galaxy size growth, we aim to re-establish their connection to the underlying cosmic evolution; understanding how the radii of collapsed structures predicted by standard cosmology maps on to mass-size trends in the galaxy population. In particular, we demonstrate that trends in galactic radii can be seen as emerging from a stellar mass content that varies strongly as a function of host structure properties (for physical reasons which we review), but that carries a characteristic specific angular momentum which remains an imprint of its host's. This perspective is complementary to well known merger-based arguments, which it naturally incorporates as a limiting case, but takes a more holistic standpoint which incorporates the effect of cooling, feedback and

underlying cosmic evolution. To illustrate these simple physical arguments, we assess its premises against both cosmological simulations and semi-analytic models, and show in the process that the true evolution of these model populations would be incorrectly deduced if they were observed within common observational limits and progenitor-matching assumptions.

The stellar populations of elliptical galaxies

Thomas, Daniel (-), -

The stellar populations in a galaxy represent a record of the galaxy?s star formation history. The age distribution of the stars in a galaxy trace the main epochs of star formation activity, while stellar metallicities carry information about the efficiency of star formation as well as the history of gas accretion and outflows of gas and heavy elements. Finally, the element abundance ratios in stars can be used to constrain the chemical enrichment history of the galaxy, as well as the timescale over which stars were formed. I will review the state-of-the-art in our current understanding of the observed stellar population properties of elliptical galaxies and discuss implications for galaxy formation theory.

The growing history of massive galaxies

Trujillo, Ignacio (-), -

Compared to present-day objects, the structural properties of massive galaxies at z=2 were strikingly different. Understanding the size and mass evolution of these galaxies since that epoch has been the focus of a significant amount of work in the last years. During this talk, I will summarize the observational evidence favouring or disfavouring the different evolutionary mechanisms that have been proposed. I will pay particular attention to the observations that are still controversial or that do not clearly fit with the most favoured channel of evolution: the minor merging scenario.

Stellar kinematics of z∼2 galaxies and the inside-out growth of quiescent galaxies

van de Sande, Jesse (Leiden Observatory), Mariska Kriek; Marijn Franx; Pieter G. van Dokkum; Rachel Bezanson; Rychard J. Bouwens; Ryan F. Quadri; Hans-Walter Rix; Rosalind E. Skelton

The remarkable compactness of massive quiescent galaxies at z $\sim$ 2 remains a highly debated issue. Whereas the size measurements of these compact galaxies have now been confirmed using deep imaging with WFC3 on HST, the stellar masses remain highly uncertain. To measure independent dynamical masses, we obtained high signal to noise, ultra-violet to near-infrared spectra of 5 massive ($\sim$1e11 Msun) quiescent galaxies at a redshift of z = 1-2 with X-Shooter on the VLT. Using a combination of deep WFC3 imaging and velocity dispersions as measured from our spectra, we determine a dynamical mass for each galaxy in our sample. I will present the comparison between photometric and dynamically derived masses for our distant galaxy sample, and discuss whether massive quiescent galaxies indeed were denser and smaller at earlier times!

How much of the red sequence is built through gas-rich major mergers?

Wild, Vivienne (University of St Andrews), James Dunlop, Omar Almaini, Michele Cirasuolo, Victoria Bruce

Observationally quantifying the importance of gas-rich major mergers in contributing to the integrated star formation rate of the Universe and in the formation of elliptical galaxies remains a challenge. In Wild et al. 2009 (MNRAS, 395, 144) I used data from the VVDS survey to select a sample of post-starburst galaxies at z$\sim$0.7, combining with mock observations from hydrodynamic simulations to show that they could represent an important pathway from gas-roch merger induced starburst to red sequence galaxies, accounting for $\sim$40% of the mass flux onto the red sequence. However, this result was based on a very small number of galaxies, with poor morphological information. To overcome the small number statistics suffered by spectroscopic surveys and extend the results to higher redshifts, I have developed a new method to extract complete samples of post-starburst galaxies over a wide redshift range from broad band multi-wavelength photometry. I will present results from a combined multiwavelength SED, FORS/VIMOS spectra and morphological analysis of galaxies from the UDSz and CANDELS HST legacy survey, focussing on the amount of red-sequence growth accounted for by post-starburst galaxies at z<2, and the evolution in the size of post-merger/post-starburst galaxies as they age onto the red sequence.

The chemical evolution of elliptical galaxies: Insights from semi-analytic models

Yates, Rob (MPA), Bruno Henriques, Peter Thomas, Guinevere Kauffmann, Jonas Johansson, Simon White

I will present the latest results from a new implementation of chemical enrichment in the Munich semi-analytic model. Our new model includes delayed enrichment from stellar winds, SNe-II and SNe-Ia, as well as metallicity-dependent stellar yields and a reformulation of the associated supernova feedback.

Our new model is able to simultaneously reproduce the z=0 gas-phase mass-metallicity relation, the [Fe/H] and [O/Fe] distributions of Milky Way disc G dwarfs, and positive slopes in the mass-[alpha/Fe] relations of local ellipticals, without the need for a variable IMF. We find that the correlation between mass, age and alpha enhancement in elliptical galaxies is best reproduced when only a small fraction of SNe-Ia explode promptly (i.e. <50 per cent within ∼100 Myrs). Alternatively, metal-rich winds that drive light alpha elements directly out into the CGM can also produce positive slopes in the mass-[alpha/Fe] relations.

I will discuss the implications of our findings on the delay-time distribution of SNe-Ia, the production and ejection of metals from massive stars, and the canonical thinking about how ellipitcal galaxies form and evolve.

2 Posters

Bottom-heavy initial mass function in a nearby compact $L^\star$-galaxy

Läsker, Ronald (-)

We present orbit-based dynamical models and stellar population analysis of a low-redshift ($z = 0.116$) early-type galaxy (ETG) which, for its moderate luminosity ($L_i = 4.7 \times 10^{10} L_\odot \approx L^\star$), has an exceptionally high velocity dispersion ($\sigma_\star = 360 kms^{-1}$). We aim to determine the central black hole mass ($M_\bullet$), the stellar mass-to-light ratio ($\upsilon_\star \equiv M_\star/L_i$), and the slope ($\Gamma$) of the initial mass function (IMF). Combining the constraints from HST imaging and long-slit kinematic data with the those from fitting the spectrum with stellar population models of varying IMF, we show that this galaxy has an extremely high fraction of low-mass stars. The concurrent i-band $\upsilon_\star$ is $\sim 50\%$ higher even than implied by a Salpeter IMF. We also find strong indications for super-solar metallicity and α-abundance. Although these results conform to known correlations with $\upsilon_\star(\Gamma)$, our study demonstrates that a very bottom-heavy IMF can exist even in an $L^\star$ ETG. Moreover, the combination of density, morphology and kinematics of this galaxy is rare in the local universe, but typical of the compact ETGs ubiquituous at $z \sim 2$. We surmise that it is a merger-deprived survivor of said era of early rapid star formation, and that compliance with the local $\upsilon_\star(\Gamma)$-correlations (especially with $\sigma_\star$) supports the view that massive ETGs grew mainly by intermediate-to-minor and dry merging over the last ~ 10 Gyr. Improved kinematic data for this target is currently under analysis and expected to constrain $M_\bullet$ better than the current upper limit of $10^{10.5} M_\odot$.

STAR FORMATION HISTORY OF z∼1 EARLY-TYPE GALAXIES

Lonoce, Ilaria (INAF - Osservatorio Astronomico di Brera), Marcella Longhetti, Paolo Saracco, Adriana Gargiulo, Sonia Tamburri

I present a detailed spectral analysis of a sample of about 20 morphologically selected early-type galaxies in the redshift range 0.7<z<1.1, in the GOODS-SOUTH field. The selected galaxies are all the up to now available objects with spectroscopic data of sufficient high quality in the GOODS-S field with z>0.7 to allow the measurement of the main age-dependent spectro-photometric indices in the optical restframe region around 4000Å, i.e the Δ(4000) and the H+K(CaII). The measurements of both of these two indices revealed detailed information about the age of the stellar populations of galaxies, in a critical redshift range for their evolution. From the comparison of the obtained results with a wide range of synthetic stellar population models, we found that in general all the analysed galaxies are composed mainly of rather old stellar populations, with ages from 3 to 5 Gyrs, also for objects with the highest redshifts. Some of them present composite stellar populations, where the most of their stellar mass belongs to old stellar populations and the remaining small fraction belongs to many-Gyrs younger populations; in some cases the younger component presents evidences of ongoing star formation, thus indicating that these objects have possibly undergone minor merging events during their last Myrs. In conclusion, this work shows the complexity and diversification of the star formation

history of early-type galaxies and proves what a deep spectroscopic analysis can reveal.

Early-type galaxies across the UV-optical color magnitude diagram

Marino, Antonina (Dept. of Physics and Astronomy G.Galilei, University of Padova), Mazzei, P, Rampazzo, R., Bianchi, L.

We aim at studying the mechanisms driving the evolution of galaxies in nearby groups. We use SPH simulations with chemo-photometric implementation, to match Early-Type Galaxy (ETG) photometric and morphological properties, and trace back their evolution. We present the results obtained for 8 ETGs in two groups (USGC U376 and LGG 225) in the Leo II cloud. We use the UV-optical rest-frame ($NUV - r$) vs. M_r color magnitude diagram to follow the evolution of ETGs, from the blue cloud (BC) to the red sequence (RS), through the green valley (GV). ETGs brighter than M_r=-21 are old (13-14 Gyr) and spend ≈10 Gyr of their overall evolutionary time into the BC before to reach the RS. ETGs fainter than M_r=-21 are slightly younger (11-12 Gyr), and stay about 7-8 Gyrs in the BC. Both bright and faint ETGs spend about 3-4 Gyrs to cross the GV, i.e. corresponding to $z \approx 0.3 - 0.4$. The faintest ETG (UGC 6324) in the sample, still oscillates in the GV. The mechanism of the morphological and photometric transformation of ETGs is gravitational in origin (merging and/or interaction). The SPH simulations suggest that today ETGs could have independently evolved toward the RS before (and partly during) the group collapse phase.

Scaling relations of high-z Early Type galaxies: dependence on selection criteria

Tamburri, Sonia (INAF-Osservatorio Astronomico di Brera), Saracco Paolo, Longhetti Marcella, Gargiulo Adriana, Lonoce Ilaria

I will present an accurate study of the effects that different criteria used to select and to define Early-Type galaxies (ETGs) have on the mean sample properties and on the study of scaling relations. The samples of galaxies we used are selected from the GOODS-MUSIC (Santini+2009), a multicolour catalogue extracted from the southern field of the Great Observatory Origins Deep Survey (GOODS-South; Giavalisco+2004), which assure a good photometric and spectroscopic coverage over a wide range of wavelength (from U-band to 24 μm). The analysis considered different samples of ETGs according to the following selection criteria: a sample of ETGs (∼250) selected on the basis of their visual morphology (E+S0 of the Hubble sequence) and on their surface brightness profiles (Sérsic profile); a sample of ETGs selected on the basis of their star formation activity (∼300), i.e. passive galaxies with specific star formation rate SSFR=SFR/M*≤10-11 derived by Spectral Energy Distribution fitting, using synthesis population models (Bruzual & Charlot 2003) with seven different Initial Mass Function (IMF). The IMF adopted are the classical Salpeter and Chabrier IMF and other five power law IMF (Φ(m)$\propto m^{-s}$) with slope in the range 1.5-3.5. The analysis has been carried out on the main distributions (i.e. stellar mass, SFR, age, size) and scaling relations describing ETGs, in a wide redshift range from z∼0.6 to z∼2.0.

Numerical studies of the chemical enrichment in disk galaxy merger remnants

Yli-Kankahila, Heidi (University of Helsinki)

Observations have shown that disk galaxies typically exhibit negative metallicity gradients. In general, negative metallicity gradients are thought to result from the fact that the number of stars in the central regions is large compared to the outer parts, which naturally leads to stronger metal enrichment of the inner regions. Additionally, the gravitational potential well in the central regions of a galaxy is deeper, preventing the escape of heavy elements. Typically, disk galaxies also exhibit a mass-metallicity correlation with low-mass galaxies having lower metallicities. This correlation is primarily due to different star formation histories in galaxies of different masses, combined with the effects of gas inflows and outflows.

Mergers are important factors in the evolution of galaxies and thus their role needs to be taken into account when studying the chemical evolution of galaxies. Observations have shown that the centers of interacting galaxies are underabundant in metals when compared to non-interacting galaxies of similar masses. This underabundance is believed to be due to central inflows of lower metallicity gas from the outskirts of the merging galaxies.

In my Ph.D. thesis, I am studying the chemical evolution of galaxy mergers and the distribution of heavy elements in merger remnants using high-resolution SPH simulations.

Symposium S5

Local group, local cosmology

1 Oral contributions

The internal kinematics and mass content of Local Group dwarf galaxies

Battaglia, Giuseppina (INAF - Astronomical Observatory of Bologna)

In this contribution I will tour through the most recent findings on the internal kinematic properties of Local Group dwarf galaxies, in particular as determined from extensive spectroscopic surveys of their stellar component.

I will also discuss the current status on determinations of the dark matter content and distribution in these objects, with particular focus on the Milky Way dwarf spheroidals, for which the available data-sets allow the application of sophisticated mass modeling techniques.

Carbon-Enhanced Metal-Poor (CEMP) Stars: Probes of Nucleosynthesis from the First Generation of Stars in the Universe

Beers, Timothy (National Optical Astronomy Observatory, Tucson, Arizona, USA)

CEMP-no stars are a subclass of very ([Fe/H] < -2.0) and extremely ([Fe/H] < -3.0) metal-poor stars in the Milky Way (including the most iron-deficient stars known) with no strong enhancements of s-process elements (which might be attributed to mass-transfer from a binary companion). In addition to C, these stars exhibit enhancements of N, O, and other light elements such as Na, Mg, Al, and Si, a pattern that may be uniquely produced by the first generation stars in the early Universe. These stars have also been recently linked to the observed abundance pattern in a high redshift (z = 3.1), very metal-poor ([Fe/H =-2.8) damped Lyman-alpha cloud. I will discuss the discovery of CEMP-no stars, connections with their progenitors in the outer-halo component of the Galaxy, new surveys that are expanding their numbers, and planned future spectroscopic exploration of these interesting objects.

Resolved and Unresolved Stellar Populations in the nearby Universe in the E-ELT era

bono, giuseppe (University of Rome Tor Vergata)

We present a selection of stellar astrophysics science cases for the E-ELT. We will focus our attention on a few open problems concerning resolved and unresolved stellar populations in the nearby Universe. We will also outline the role that the first generation of E-ELT instruments (photometry

and spectroscopy) will have in addressing current and future challenges of local cosmology.

What Current Observations Can Teach Us About The Properties of Galaxies in the Early Universe

Bouwens, Rychard (Leiden University)

Over the large few years, astronomers have made enormous progress in our understanding and characterization of galaxies in the first two billion years of the universe thanks to the capabilities of the new WFC3/IR instru-

ment on the Hubble Space Telescope together with supporting observations with the Spitzer Space Telescope, the optical HST ACS camera, and large ground-based telescopes. Already from the existing observations, we know of 3-4 highly-quality z∼10-11 candidates and ∼400-500 galaxy candidates at z∼7-8. From these samples, we have tight constraints on the build-up of galaxies in the first 500 Myr of cosmic time, their dust properties and stellar populations, the probable contribution of these galaxies to cosmic reionization, and (with some challenges) the stellar mass in these sources. In this presentation, I provide a summary of the key advances in this field over the last few years.

The Formation History of the Ultra-Faint Dwarf Galaxies

Brown, Thomas (STScI)

We present results from an HST survey of the ultra-faint dwarf galaxies. These Milky Way satellites were recently discovered in the Sloan Digital Sky Survey, and appear to be an extension of the classical dwarf spheroidals to low luminosities, offering a new front in the efforts to understand the missing satellite problem. Because they are the least luminous, most dark matter dominated, and least chemically evolved galaxies known, the ultra-faint dwarfs are the best candidate fossils from the early universe. The primary goal of the survey is to measure the star-formation histories of these galaxies and discern any synchronization due to the reionization of the universe.

Stellar evolution models: current uncertainties and their impact on population synthesis tools

Cassisi, Santi (INAF - Astronomical Observatory of Teramo)

In this talk we review the most important uncertainties affecting the stellar evolutionary framework that is one of the crucial ingredients for population synthesis tools. We discuss the accuracy and reliability of evolutionary stellar models by showing the level of agreement between theory and some suitable observational constraints. We also discuss briefly how the recent discovery of the multiple population phenomenon in Galactic globular clusters can affect the use of these star clusters as a benchmark for population synthesis models.

Assessing the dynamics and abundances of Andromeda's dwarf spheroidal galaxies

Collins, Michelle (MPIA), S. C. Chapman, R. Ibata, R. M. Rich, N. F. Martin, H-W Rix

Over the past few years, we have been conducting a systematic survey of the dwarf spheroidal galaxies of M31 using the Keck II DEIMOS spectrograph as part of the Pan Andromeda Archaeological Survey (PAndAS) project. This has allowed our group to measure systemic velocities, central masses and average metallicities for 21 of the 28 M31 dSphs. In this talk I will present this homogeneous dataset, and highlight some of our more unusual findings. These include the curiously low mass objects, Andromeda's XIX, XXI and XXV, and the tidally disrupting Andromeda XXVII. In addition, I will discuss the results of our new pilot program to map the chemical abundances of individual stars in the Andromeda II dSph using the LBT MODS spectrograph.

A global view of the resolved stellar populations in M31 dwarf elliptical satellites

Crnojevic, Denija (Institute for Astronomy, Royal Observatory Edinburgh), A.M.N. Ferguson, M.J. Irwin

We present the first truly global view of the closest elliptical galaxies, the dwarf elliptical (dE) companions of M31. In particular, we focus on NGC147 and NGC185, which have similar luminosities and metallicity content but present otherwise stunning differences in their recent evolutionary history (e.g. NCG185 contains gas, dust and young stars as opposed to NGC147). We use wide-field optical (PAndAS) and near-IR (WFCAM) data in order to investigate the resolved stellar content and structure of these dEs. They both unexpectedly extend out to much larger galactocentric distances than previously believed (~ 20 r_{eff}), and NGC147 shows pronounced tidal tails likely due to its interaction with M31. The photometrically derived metallicity distribution functions for old red giant branch (RGB) stars reveal a radial gradient in both dEs. On the other hand, the near-IR data allow us to study intermediate-age luminous asymptotic giant branch (AGB) stars, which appear to be more centrally concentrated than RGB stars and thus hint at an additional age gradient. From the colors and luminosities of C- and O-rich AGB stars we are moreover able to constrain their metallicity and the main epoch of intermediate-age star formation in the target dEs. Our findings are discussed in a cosmological

context of galaxy evolution, and are fundamental to adequately interpret the evolution of similar objects at higher redshift.

The chemical evolution of the Galactic Bulge seen through micro-lensing events

Feltzing, Sofia (Lund Observatory), Sofia Feltzing, Thomas Bensby, Andy Gould, Jennifer Johnson, Jennifer Yee, Jorge Melendez, Martin Asplund, Sara Lucatello

We study the elemental abundances in stars and the stellar ages in the inner Galactic bulge by obtaining spectra of main-sequence and turn-off dwarf stars whilst they are being lensed by an object between the star and the Earth. The spectra have high-resolution and in many cases a high SNR enabling a detailed elemental abundances study of the stars and the determination of their ages based on the stellar parameters. To date spectra of 60 such stars have been observed and analysed. We find that overall the elemental abundances show trends very similar to those we see for the thick disk in the solar neighbourhood, i.e., enhanced in the alpha-elements below [Fe/H]=-0.5 and then declining to solar values. This solar values continue to super-solar metallicities. The ages, somewhat surprising, seem to give an indication that there may be a small portion of fairly young stars present in the Galactic bulge. These results will be discussed in the context of the overall properties of the Milky Way bulge.

Cumulative Light from the Epoch of Reionization - the Near Infrared Background and the 21cm Line

Fernandez, Elizabeth (Kapteyn Astronomical Institute), Saleem Zaroubi, Ilian T. Iliev

Observations of the Epoch of Reionization are now becoming a distinct possibility. High-redshift galaxy surveys are discovering galaxies well into the Epoch of Reionization. However, these observations present a small portion of the total picture, providing information on only the brightest objects within the survey fields. I will discuss two other observations that can reveal information on reionization history. Cumulative light from all galaxies, including those numerous galaxies below the detection limit of high redshift galaxy surveys, would be present in the Near Infrared Background. Emission from the 21cm line would originate from neutral areas in the IGM, and would be reveal information about the early stages of reionization. I will present theoretical modeling of both the 21cm line and the Near Infrared Background, and show how these two observations are correlated. This can help reveal information about the buildup of galaxies, their stellar populations, and reionization history.

Elusive, rare, hidden: first stars

Ferrara, Andrea (Scuola Normale Superiore)

In spite of several decades of intensive searches no metal-free stars have been detected in any cosmic environment. This fact is at variance with the expectations from BBN predictions. This apparent failure can be explained by several hypothesis ranging from a fast transition to a normal, enriched star formation mode to a rarity hypothesis. I will discuss the implications for both scenarios and sketch possible strategies to solve the puzzle.

The Local Group - an observational perspective

Gilmore, Gerry (Cambridge University)

I introduce the top-level challenges to our understanding of the Local group, comparing observation to expectation. I consider what we are learning about the very earliest star and structure formation, to push progress into testing the new mechanisms proposed to save the appearances, especially early dominant baryonic feedback.

Current Signatures and Search for Pop. III stars in the Local Universe

Komiya, Yutaka (National Astronomical Observatory of Japan), Takuma Suda Masayuki Y. Fujimoto

Extremely metal-poor (EMP) stars in the Local Group are the stellar relics from the early universe. Chemical signatures of Population III (Pop. III) stars are expected to be observed on their surface abundance. Beyond

that, some recent numerical studies argue that low-mass stars can be formed even at zero-metallicity. To observe these Pop. III survivors can bring further knowledge about the first stars formation. Pop. III stars and EMP stars are thought to be formed in small mini-halos with $\sim 10^6 M_{solar}$. In the concordance cosmology, galaxies are formed hierarchically. We build a new model of chemical evolution based on the hierarchical galaxy formation scenario, and searched for the chemical signatures of Pop. III stars on EMP stars. We also discuss possibility to observe Pop. III survivors and the expected observational features of them.

In our previous studies, we represented the overall formation history of EMP stars using the hierarchical chemical evolution model. Especially, we investigated the effect of the surface pollution on Pop. III survivors by the accretion of interstellar medium. We concluded that the polluted Pop. III survivors are observed as hyper metal-poor (HMP) stars with [Fe/H]~ -5 if they are in the Milky Way. Most low-mass EMP and Pop. III stars are thought to be formed as secondary companions in binary systems. They can be escaped from their host mini-halos when their primary counterparts explode as supernovae. We compute the expected nature of these stars based on the hierarchical formation process of the Milky Way and theoretical studies about the evolution of the low-mass Pop. III stars, and evaluate the detection rate of these stars by future facilities such as Hyper Suprime-Cam.

Terzan 5: the remnant of a pristine fragment of the Galactic Bulge?

Lanzoni, Barbara (Department of Physics and Astronomy, Univ. of Bologna (Italy)), Francesco Ferraro

Terzan 5 is a stellar system commonly catalogued as a globular cluster (GC), located in the inner Bulge of our Galaxy. Two distinct sub-populations have been recently discovered in this system (Ferraro et al. 2009, Nature, 462, 483). They define two well separated red clumps in the (K, J-K) color-magnitude diagram (CMD) and show very different iron content: Delta[Fe/H] $\sim$0.5 (such a large difference in iron abundance has been found only in another GC-like stellar system, omega Centauri, in the Halo of the Galaxy). Moreover, the abundance of light elements measured in both sub-populations has been found not to follow the typical anti-correlations observed in genuine GCs and the overall chemical patterns of the two populations appear strikingly similar to those of the Bulge stars (Origlia et al. 2011). These observational results demonstrate that Terzan 5 is not a genuine GC, but a stellar system that experienced complex star formation and chemical enrichment histories. The strong chemical similarity with the Bulge, together with the location in the inner region of it, suggest that Terzan 5 (at odds with omega Centauri) is not the nucleus of an accreted dwarf galaxy, but possibly the relic of one of the pristine fragments that contributed to form the Bulge itself.

Using Radial Metallicity Gradients in Dwarf Galaxies to Study Environmental Processing.

Leaman, Ryan (Instituto de Astrofisica de Canarias)

I will present recently published spectroscopic results of the radial variation in [Fe/H] for a sample of Local Group dwarf galaxies. By combining this metallicity data for dSphs, dEs, and dIrrs with detailed stellar kinematics, we demonstrate that the dwarfs show a correlation between the strength of their metallicity gradient and their angular momentum content. The higher angular momentum dwarf galaxies show flatter abundance profiles on average, and we discuss how this may provide constraints on how ram pressure and tidal stripping could operate to transform dIrrs into dSphs.

Is GBT 1355+5439 a dark galaxy?

Oosterloo, Tom (Astron), George Heald, Erwin de Blok

We present HI imaging, performed with the Westerbork Synthesis Radio Telescope, of GBT 1355+5439, a dark HI object recently discovered close to the nearby galaxy M101. We find GBT 1355+5439 to be an elliptically shaped HI cloud 5×3 arcmin in size. Both the total H i image and the kinematics show that the cloud consists of condensations that have small ($\sim$10 km s^{-1}) motions with respect to each other. The column densities of the HI are low; the observed peak value is 7.1×10^{19} cm^{-2} . The velocity field shows a small velocity gradient over the body of GBT 1355+5439, possibly due to rotation, but it may also indicate large-scale radial motions. Although our data are limited in sensitivity, at all positions the HI velocity dispersion is larger than 6 km s^{-1} and no narrow, cold, HI component is seen. Because its distance is not known, we consider various options for the nature of GBT 1355+5439. We find that both the option that it is a tidal remnant near M101 and that it is a dark dwarf companion of M101 meet difficulties. The data also do not exactly fit the properties of known CHVCs in the Galactic halo, but we cannot entirely exclude this option and deeper observations are required.

We also consider the possibility that GBT 1355+5439 is a gas-rich dark minihalo in the outer regions of the Local Group. Interestingly, it would than have similar properties as the clouds of a proposed Local Group population recently found in the ALFALFA survey. In this case, the HI mass of GBT1355+5439 would be of order a few times $10^5 M_\odot$, its size about 1kpc and the dynamical mass Mdyn $> 5 \times 10^7 M_\odot$. However, if GBT 1355+5439 is a dark Local Group object, the internal kinematics of the HI appears different from that of gas dominated, almost dark dwarfs of similar size.

The star formation history of dSphs: with and without interactions

Pascale, JABLONKA (EPFL)

I shall present the analysis of a large set of high resolution simulations of dwarf spheroidal galaxies, run with the chemo-dynamical tree-sph code, GEAR. This study uniquely uses the stellar chemical abundance ratios to constrain the physics of galaxy formation. It allows to discuss the extent to which the Local Group dwarf dSphs can be formed within a common framework, despite today apparent different age and abundance properties and examine the main driving parameters leading to formation of these small galactic systems.

How the interaction between a low mass galaxy and an Milky Way sized galaxy affects the star formation inside the dwarf galaxy is currently unknown. I shall examine whether environmental interactions between model dSph and the MW greatly alter the chemodynamical properties of the dSphs and what this may reveal about the progenitor properties of some of the classical dwarf spheroidals.

The first galaxies: assembly of disks and prospects for observation

Pawlik, Andreas (MPA Garching)

I will discuss how radiative feedback from the first stars affects the assembly of the first galaxies. First, I will present results from our published zoomed cosmological radiation-hydrodynamical simulations of dwarf galaxies at z > 10. A key outcome of these simulations is the assembly of rotationally supported galactic disks. I will address the impact of feedback from star formation on the assembly of these disks and discuss the prospects for observations of the first disk galaxies with the JWST. Second, I will present initial results from a new suite of radiation-hydrodynamical simulations of the interplay of galaxy formation and reionization on cosmological scales. The simulations are designed to address key quantities essential to all reionization models, such as the clumping factor of the intergalactic medium and the ionizing efficiencies of the first galaxies, and to make contact with the relevant observables, such as the UV galaxy luminosity function and the 21 cm signal of the neutral hydrogen.

Very Metal-Poor Damped Lyman alpha Systems: A Window on Early Nucleosynthesis

Pettini, Max (Institute of Astronomy, University of Cambridge), Ryan Cooke

It has now become recognised that damped Lyman alpha system–gas clouds of neutral hydrogen observed in the high redshift Universe–play an important role in helping us unravel the origin of chemical elements. In this talk, I will describe the main results of a recently completed survey of the most metal-poor DLAs, aimed at complementing and extending studies of the oldest stars in Local Group galaxies. The survey has clarified a number of lingering issues concerning the abundances of C, N, O in the low metallicity regime, has revealed the existence of DLA analogues to Carbon-enhanced metal-poor stars, and is providing some of the most precise measures of the primordial abundance of Deuterium. Parallels with the wealth of new data being obtained on old stellar populations in Local Group galaxies help in putting our nearest neighbours in their cosmological context.

The Living Fossils of the First Galaxies

Ricotti, Massimo (Institut d'Astrophysique de Paris), Massimo Ricotti

I will review ideas on the cosmological origin of dwarf galaxies in the Local Group emphasizing the exciting possibility that some ultra-faint dwarfs are well preserved fossils of the first population of dwarf galaxies formed before reionization.

New insights into the Sagittarius stream

Smith, Martin (Shanghai Astronomical Observatory), Ling Zhu, Jing Li

Even though the Milky Way's recent accretion history has been relatively quiescent, there is spectacular evidence for hierarchical growth in our stellar halo. The most prominent example of this is the on-going devouring of the Sagittarius dwarf galaxy. Debris from its accretion has been traced across vast swaths of sky in beautiful panoramas from surveys such as the Sloan Digital Sky Survey (SDSS). Spectroscopic data from SDSS is now allowing us to make detailed studies of the properties of the stream, tracing its chemistry and orbital history. We have taken a large sample of stellar spectra from SDSS to investigate these issues, using a variety of tracer populations. It has been shown that the stream has a faint counterpart, although the origin of this feature is still under debate. Our analysis shows that the faint counterpart has a smaller velocity dispersion and lower metallicity than the bright stream, supporting the argument that this stream formed from a different progenitor. We also find evidence for Sagittarius debris towards the Galactic anti-centre, tracing the stream in unexplored regions. Such work is crucial if we are to constrain the orbit of this system and, as a consequence, constrain the shape and profile of the dark matter distribution in the Milky Way.

How does inhomogeneous reionization impact the gas content of galaxies?

Sobacchi, Emanuele (Scuola Normale Superiore di Pisa), Andrei Mesinger

The reionization of the intergalactic medium (IGM) was likely inhomogeneous and extended. By heating the IGM and photo-evaporating gas from the outskirts of galaxies, this process can have a dramatic impact on the growth of structures and suppress the observed number of dwarf galaxies. We tackle this problem using a tiered approach: combining parameterized results from suites of single-halo collapse simulations with large-scale models of reionization. We present an expression for the halo baryon fraction which is an explicit function of: (i) halo mass; (ii) an ionizing UV background (UVB) intensity; (iii) redshift; (iv) redshift at which the halo was exposed to a UVB. The latter has been shown to significantly impact the observed abundance of local dwarf galaxies. We then fold-in our parametrized results into large-scale simulations of reionization, such that the ionizing emissivity of galaxies depends on the local values of the reionization redshift and the UVB intensity, evolving in a self-consistent manner. We present a physically-motivated analytic expression for the resulting average minimum mass of star-forming galaxies, M_{min}, which can be readily used in modeling galaxy formation, as well as interpreting observations of dwarf galaxies at all redshifts.

Chemical substructure in the Local Group

Venn, Kim (U. Victoria), Else Starkenburg, Ryan Leaman, Alan McConnachie, Mike Irwin, Matthew Shetrone, Eline Tolstoy, Vanessa Hill, Pascale Jablonka, Bertrand Lemasle

We know that there are a variety of stellar populations within the Galaxy and Local Group dwarf galaxies. Surprising abundance ratios can be found due to differences in star formation histories and efficiencies, and subsequent nucleosynthetic yields. In this talk, we ask if there is an epoch when dwarf galaxies had similar abundances to stars in the Galaxy, as predicted by CDM galaxy formation scenarios. We ask if there is evidence for First Stars in the Galaxy or in the dwarf galaxies, including the CEMP-no stars. We also notice that chemical inhomogeneity and metallicity gradients in dwarf galaxies are great opportunities for studying the small scale mixing processes in galaxy formation.

The first galaxies: primordial enrichment

Wise, John (Georgia Institute of Technology)

I review recent results from early dwarf galaxy simulations that particularly focus on the transition from metal-free Population III stars to the formation of the first galaxies before redshift 7. We have investigated the variations in galaxy properties when changing the Pop III characteristic mass, critical metallicity, UV backgrounds, metal cooling, and feedback from radiation pressure. One constant result from all the simulations is a metallicity floor between [Z/H] = -3 to -4. We show that momentum transfer from ionizing radiation plays an important role in providing turbulent support and mixing metals, preventing the overproduction of stars and metals. This results in a stellar population with a tight metallicity distribution function centered at [Z/H] = -2, agreeing with the observed luminosity-metallicity relation in dwarf galaxies.

2 Posters

Growth of dust grains in a low-metallicity gas and its effect on the cloud fragmentation

CHIAKI, Gen (University of Tokyo), Takaya Nozawa, Naoki Yoshida

In a low-metallicity gas, rapid cooling by dust thermal emission is considered to induce cloud fragmentation and play a vital role in the formation of low-mass stars ($<\sim$ 1 M_sun) in metal-poor environments. I will describe how the growth of dust grains through accretion of heavy elements in the gas phase onto grain surfaces alters the thermal evolution and fragmentation properties of a collapsing gas cloud. In the calculations, grain growth and dust emission cooling are directly treated in a self-consistent manner. As a result, MgSiO3 grains grow sufficiently and the grain growth can have important effects on cloud fragmentation. The condition for efficient dust cooling is insensitive to the initial condensation factor of pre-existing grains within the realistic range of 0.001–0.1, but sensitive to metallicity. The critical metallicity is Zcrit $\sim 10^{-5.5}$ Zsun for the initial grain radius $r_{MgSiO3,0} <\sim 0.01$ μm and Zcrit $\sim 10^{-4.5}$ Zsun for $r_{MgSiO3,0} <\sim 0.1$ μm. The formation of a recently discovered low-mass star with extremely low metallicity ($\leq 4.5\times10^{-5}$ Zsun) could have been triggered by grain growth.

Unravelling a complex system: The Fornax Dwarf Spheroidal Galaxy.

del Pino Molina, Andrés (Instituto de Astrofísica de Canarias), Hidalgo, S.L.Aparicio, A.

We present the results of an extended photometrical and spectroscopical study of the Fornax dSph galaxy. Using wide field, deep photometry ($\sim (0.86°)^2, V \sim 24$), we have studied the spatial distribution of the stellar populations in Fornax. Metallicity and line of sight velocity meassurements, allow us to carry on a chemical, dynamical and spatial analysis of Fornax. Constrains on the formation and evolution of Fornax are provided.

On the absolute age of the Galactic Bulge globular M71

Di Cecco, Alessandra (ASDC - OAR/INAF), Di Cecco, G. Bono, M. Monelli, P. Prada Moroni, F. Allard, R. Buonanno, I. Ferraro, G. Iannicola, M. Nonino

We investigated the Galactic Bulge globular cluster M71 (NGC6838) using optical ground-based images (u',g',r'i,'z') collected with the MegaCam wide field camera at Canada-Franch-Hawaii-Telescope (CFHT). The PSF photometry was performed simultaneously (ALLFRAME) over the five bands and the final catalog was calibrated on the basis of a large sample of local standard stars. We performed a robust selection of field and cluster stars using a new approach based on magnitude-color-color 3D plots. The Color-Magnitude-Diagrams (CMDs) of candidate cluster stars were compared with a new set of cluster isochrones transformed into the observational plane using Phoenix atmosphere models. Together with the classical method (main sequence turn-off) we also used the photometric properties of the r',g'-r' and r',u'-g' CMDs to constrain the absolute age using the main sequence knee. The key advantage of this approach is that it is independent of uncertainties affecting cluster distance and reddening. To further improve empirical constrains, we performed a similar analysis using space images collected with the Advanced Camera for Survey on board of the Hubble telescope. We found that the M71 age (12+/-1 Gyr) is within the literature estimates for canonical globulars. This evidence indicates that the chemical enrichment of the Galactic Bulge took place on a short time scale and supports the hypothesis that old stellar populations do not obey to an age-metallicity relation.

The contribution of AGB stars to cosmic dust production: a theoretical approach

Di Criscienzo, Marcella (INAF-Osservatorio di Capodimonte, Napoli), Dell'Agli, Flavia; Ventura, Paolo; Schneider, Raffaella; Valiante, Rosa; La Franca, Fabio; Rossi, Corinne; Gallerani, Simona; Maiolino, Roberto

In order to understand the contribution of AGB stars in early cosmic dust enrichmentwe have recently computed the dust masses released by stars with masses in the range 1 $M_\odot \leq M \leq 8$ $M_\odot$ and metallicities of Z = 0.001, (5×10^{-2} $Z_\odot$), Z = 0.008, (0.4 $Z_\odot$) and Z = 0.0003 (0.015$Z_\odot$) We find that the both the total mass of dust released and its chemical composition are a strong function of the initial stellar mass and metallicity. In this poster we summarize the results oobtained so far and the implications for cosmic dust enrichment recently published in Ventura et al. 2012a(MNRAS, 420.1442V), Ventura et al. 2012b (MNRAS, 424, 2345V) and Di

Criscienzo et al. 2013 (arXiv1304.7120D)

STREGA: STRucture and Evolution of the GAlaxy. I. Overview and First Results.

Di Criscienzo, Marcella (INAF-Osservatorio di Capodimonte, Napoli), STREGA@VST collaboration

The STRucture and Evolution of the GAlaxy (STREGA) survey plans to use VST telescope to investigate the Galactic halo formation mechanisms through the two following main approaches: i) tracing tidal tails and halos around stellar clusters and galaxies; ii) mapping extended regions of the southern portion of Fornax orbit to investigate the hypothesized Fornax Stream. In this poster I discuss the status of the survey and preliminary results.

Star forming regions in nearby galaxies: a potential application for Gaia's observations.

Drazinos, Petros (National and Kapodistrian University of Athens), E. Kontizas, M. Kontizas, A. Dapergolas, I. Bellas-Velidis,A. Karampelas, E. Livanou.

Our aim is to investigate whether Gaia can contribute to the study of star forming regions in nearby galaxies. A Friend of Friend algorithm has been applied to a number of galaxies in the Local Group to study star forming regions for the detection of young stellar structures. The detection limit of Gaia is G $<$ 20 mag that corresponds to V $\sim$ 20.1 mag (for B-V values from -0.5 to 0.25 mag) whereas the spatial resolution is comparable to HST. For a number of nearby galaxies (LMC, SMC, M31, M33, NGC 6822) the young main sequence stars within Gaia detection limit were selected from their CMD. Stellar structures were detected with sizes varying from small clusters up to stellar supercomplexes.

From star forming regions to star clusters: N-body simulations of young star clusters

Fujii, Michiko (Leiden Observatory), Simon Portegies Zwart

From observed star forming regions it is suggested that stars form in filaments of molecular gas. These structures are successfully reproduced in numerical simulations of turbulent gas. However, there is an important omission in our understanding of the evolutionary process. The discrepancy is quite noticeable in the mass of observed clusters. Embedded cluster have a mass of $10^3 M_\odot$, whereas the young massive clusters are an order of magnitude more massive. We propose that the latter type of massive clusters are formed though mergers of multiple clumps with a mass similar to those of the embedded clusters.

We performed a series of N-body simulations starting from initial conditions constructed from results of hydrodynamics simulations of turbulent molecular clouds. After the free-fall time of the cloud, we convert a part of gas particles to stellar particles with a star formation efficiency depending on the local density, and continue the N-body simulations assuming an instantaneous gas expulsion. While SPH/N-body simulations with sink particles have a higher resolution, our method is faster, and therefore it can treat larger systems e.g., with a gas mass of $\sim 10^5 M_\odot$ and a stellar mass of $\sim 10^4 M_\odot$.

We find that star forming in filamentary structures can evolve to type very distinct type of stellar systems, and in this way explain the existence of associations as well as of massive young star clusters. Our simulations satisfactorily reproduce that the mass and size distributions of young clusters, including the family of embedded clusters, galactic open clusters, and young massive clusters in the Milky Way Galaxy such as NGC3603 and R136 in the LMC.

The History of the Magellanic Clouds: A Genetic Approach

Guglielmo, Magda (SIfA (University of Sydney)), Lewis, Geraint , Bland-Hawthorn Joss

Despite new observational constraints and their proximity to us, our knowledge of the interaction history of the Magellanic Clouds is still fragmentary. Are they bound to the Milky Way? Did they come together as a pair? or did they fall as two separate galaxies? All and more questions remains unanswered due to the complexity of the parameters space.

In this talk, I will present a method for studying the orbital history of the Clouds which combines a Genetic Algorithm with a N-Body Simulations (Gadget2 code), in order to compare different orbital scenarios and

recognize those which are in good agreement with the observations.

Star-Formation in the Young Supershell GSH 305+01-24

Kaltcheva, Nadejda (University of Wisconsin Oshkosh), Valeri Golev / St Kliment Ohridski University of Sofia

Intermediate-band $uvby\beta$ photometry is utilized to identify more than 130 O and B type stars spatially related to the GSH 305+01-24 supershell seen toward Centaurus. The distance to the supershell and its physical dimensions are revised. Stellar masses and ages are calculated based on the latest evolutionary models in order to evaluate whether these stars can be the energy source for the supershell.

Formation of M31 revealed from globular clusters

Lee, Myung Gyoon (Seoull National University), Hong Soo Park, Ho Seong Hwang

M31 is an ideal archetype for massive spiral galaxies in the local universe. Interestingly M31 contains three times more globular clusters than the Milky Way Galaxy, although it is as massive as the Milky Way Galaxy. We present recent results on the kinematics, metallicity, and age of the globular systems in M31 based on the largest sample of globular clusters. Then we discuss what they imply with regard to understanding how M31 formed.

A chemical evolution of Local dwarf galaxies : LeoI

Nykytyuk, Tetyana (Main Astronomical Observatory NAS Ukraine)

Usually an open model with galactic wind is used for modeling of low-metallicity stellar population of dwarf galaxies. We suppose that it is possible to obtain the metal-poor stellar population of a dwarf galaxy in the framework of merger scenario. The term "merger scenario" means that we will consider a galactic stellar population as mixture of stars formed in different fragments before the moment of their merger. This method has been applied to the study of a chemical evolution of the Local dwarf galaxy LeoI. The set of fragments before merger and the resulting metallicity distribution function were calculated. An accretion of unenriched intergalactic gas took place during whole evolution of fragments before their merger. It is found that the observational metallicity distribution function of LeoI galaxy is reproduced quite well by merger of individual fragments; Kolmogorov-Smirnov convergence coefficient is 0.94.

Connecting dwarf galaxies and Damped Lyman Alpha systems

Skuladottir, Asa (Kapteyn), Vanessa Hill, Stefania Salvadori, Eline Tolstoy, Max Pettini

Dwarf galaxies are predicted to dominate the metal enrichment of the IGM, and therefore could be responsible for polluting gas seen in absorption line systems such as Damped Lyman Alpha (DLA) systems. We will compare abundance patterns in ancient stars in the Sculptor dwarf spheroidal galaxy to those found in DLAs observed out to $z \sim 4$. The Sculptor dwarf spheroidal galaxy is around the critical mass ($\sim 10^8$ M_{odot}) at which dwarf galaxies can form a reasonable number of stars and yet still lose most of the metals produced. This makes it an obvious target for a detailed comparison of its abundance patterns with DLAs. Sculptor's star formation history is known from detailed Colour Magnitude Diagram analysis, showing that Sculptor started to form stars at redshift $z > 6$, and stopped at $z \sim 1$. Here we will present new abundance measurements of Sulphur in a sample of ~ 80 stars in Sculptur, observed using VLT/FLAMES. Sulphur is a key diagnostic of alpha-capture elements in observation of DLA abundances, since it is not depleted onto dust.

Stellar Abundances for Galactic Archaeology Database for Stars in Dwarf Galaxies

Suda, Takuma (National Astronomical Observatory of Japan), Jun Hidaka, Miho Ishigaki, Yutaka Katsuta, Shimako Yamada, Yutaka Komiya, Masayuki Y. Fujimoto, Wako Aoki

We present a new database for observed stars in dwarf galaxies in the local group. This is an extension of the Stellar Abundances for Galactic Archaeology (SAGA) database (Suda et al. 2008, PASJ, 60, 1159) that deals

with metal-poor Galactic halo stars. The main features of the new database are the same as the database for Galactic halo stars; Users can access and select data based on various criteria, and then inspect the selected data on a diagram with user-specified axes. The database includes hundreds of stars with high-resolution spectroscopic data and more than five thousand stars with medium-resolution ones for 20 galaxies. In this paper, we discuss the characteristics of stars in dwarf galaxies using the database. In particular, we focus on the star formation history and the chemical evolution of galaxies based on comparisons of the observed element abundances with the models of stellar evolution and nucleosynthesis.

Neighbourhood cosmology with the Andromeda galaxy

Tamm , Antti (Tartu Observatory), Elmo Tempel, Peeter Tenjes, Olga Tihhonova, Taavi Tuvikene

Thanks to its proximity, size, and the wealth of observational data available, our large neighbour M31 is a tempting testbed for different methods and tools for studying stellar populations and for probing dark matter (DM) halo properties. We have interpreted the SDSS and Spitzer imaging of M31 with different stellar population models to map the stellar mass distribution in the galaxy. By combining the stellar mass distribution with the latest observational data about the motions of gas, globular clusters, and satellite galaxies in and around M31, we have constrained the DM halo parameters.

Despite the vast amount of well-calibrated high-resolution observational data, the uncertainties of the stellar mass estimates do not allow us to falsify any of the popular DM distribution models (Einasto, NFW, Moore, Burkert). The central density of the DM halo of M31 falls in the broad range of values of nearby dwarf galaxies, low-surface-brightness galaxies, and distant massive disc galaxies, suggesting that the evolution of the central properties of DM halos does not depend much on the halo mass, environment, or cosmological epoch.

Detecting filamentary pattern in the Universe

Tempel, Elmo (Tartu Observatory)

The main feature of the spatial large-scale galaxy distribution is an intricate network of galaxy filaments. We aim to detect the filamentary network in the presently largest galaxy redshift survey SDSS. We divide the detected network into single filaments and present the catalogue of filaments.

Structure of spiral arms in M31

Tenjes, Peeter (Tartu Observatory, Estonia), Taavi Tuvikene, Rain Kipper, Antti Tamm, Elmo Tempel

In addition to optical imaging, the spiral arms of the nearby Andromeda galaxy (M31) are well resolved in a broad range of emission data: Far-UV, CO, HI, Far-IR. In the present contribution, emission distribution along spiral arm cross sections in these different datasets are compared to each other, in order to detect possible shifts between the emissions distributions as predicted by the density wave theory. Ten segments were selected from the de-projected spiral arms. To reduce noise introduced by the clumpy nature of the spiral arm, emission along these segments was integrated. No systematic shifts between the Far-UV emission and CO emission across the spiral segments was detected in the observational data. Uncertainties of the derived results and possible causes of undetection of shifts are discussed.

Kinematics of Outer Halo Globular Clusters in M31

Veljanoski, Jovan (University of Edinburgh), A.M.N Ferguson; A.D. Mackey; M.J. Irwin; et al.

I will present a kinematic study of a large sample of globular clusters found in the extended halo of M31, resulting from low resolution spectroscopy. I will discuss the rotation signature exhibited by these clusters, as well as their velocity dispersion. In addition, many of these outer halo globular clusters lie along stellar streams, suggesting an accretion origin. This is backed up by compelling evidence for kinematic coherence amongst globular clusters which project on top of halo substructure, including clear signatures of infall. Finally, kinematic information contained within this cluster sample is used to estimate the dynamical mass of M31 within 200 kpc.

Abundances of heavy elements in the stellar substructures

Ženovienė, Renata (Institute of Theoretical Physics and Astronomy of Vilnius University), E. Stonkuté, G. Tautvaišiené, B. Nordström

We study the chemical composition of two kinematically identified groups of stars in the Galactic disc. Based on dynamical properties those stars were suspected to belong to disrupted satellites. Using the high resolution spectra obtained with the spectrograph FIES at the Nordic Optical Telescope, La Palma, we determine detailed elemental abundances of s- and r-process elements in those likely accreted stars. The aim is to look for possible chemical signatures that might give information about the formation history of those kinematic groups of stars. Our results reveal that abundances of chemical elements produced mainly by the r-process are overabundant in comparison with Galactic thin-disc dwarfs and models. The similar elemental abundances are observed in the Galactic thick-disc stars. The chemical composition together with the kinematic properties of stars provide additional evidence of their common origin and possible relation to an ancient merging events. The similar chemical composition of project stars and the thick-disc stars might suggest that their formation histories are linked.

Symposium S7

Stellar magnetic activity across the HR diagram

1 Oral contributions

The generation of magnetic fields in neutron stars

Bonanno, Alfio (INAF)

The origin of the magnetic field in neutron stars is still a topic of debate. In this talk the evidence for and against the possibility that the magnetic field in these objects has been generated via a dynamo action during the proto-neutron star phase, will be reviewed. In particular the MHD stability of a newborn strongly magnetized neutron star will be discussed by means of a linear analysis and non-linear 3D numerical simulations.

The solar dynamo and its spots as a shallow phenomenon

Brandenburg, Axel (NORDITA)

There is widespread uncertainty about the nature of the global solar dynamo: is it located essentially in the tachocline, in which equatorward meridional circulation transports field toward low latitudes, or is the dynamo a distributed one, as recent global simulations suggest? A proper understanding of solar activity requires a holistic approach in which the formation of active regions, sunspots, and coronal mass ejections are self-consistently included. In the tachocline scenario, the problem is avoided by postulating the existence of thin flux tubes that erupt to the surface and produce bipolar regions, but in the distributed dynamo scenario the large-scale field has a more diffuse nature and there are no extended flux ropes. Active regions would then need to be maintained by local processes.

In my talk, I will review both approaches, summarize the state of global dynamo simulations, and their coupling to the Sun's exterior through coronal mass ejections and the magnetized solar wind. Finally, I will review the current state of modeling magnetic flux concentrations as a phenomenon that is not deeply routed, as is commonly assumed.

Nonaxisymmetric large-scale dynamos in rapidly rotating spherical shell convection

Cole, Elizabeth (University of Helsinki), Petri J. Käpylä, Maarit J. Mantere, Jörn Warnecke, and Axel Brandenburg

Abstract: We report the results from turbulent convection simulations in spherical wedges, keeping the density stratification fixed and varying the rotation rate. An upper limit to the Coriolis number that resulted in solar-like differential rotation is reported, above which the simulations exhibit almost-rigid rotation profiles.

Adding a magnetic field into these rapid rotators within this interesting regime, we examine the resulting dynamo, searching for equator-ward migration and changes in the dominant dynamo mode. The wedges covering a quarter of the longitudinal extent were extended to full 2pi to search for large-scale non-axisymmetric modes. These results are put into context with observations of rapidly-rotating late-type stars.

Solar magnetic cycle

Dmitry, Sokoloff (Moscow State University)

Solar magnetic cycloe is the most well-known example of stellar magnetic activity cycles. Its evolution is recorded in instrumental data for about 400 years and in isotopic data for about 10 000 years. Comparison with much shorter and much less detailed stellar cycles data helps to illuminate various features of this spectacular and practicaly important phenomenon. Recent findings in solar cycle history will be discussed and some classical results will be reminded in order to describe what would we like to lnow about stellar cycles to get better understanding of the solar one.

Spot activity, differential rotation and dynamo waves

Hackman, Thomas (Finnish Centre for Astronomy with ESO)

The spot activity of late-type stars can be studied by applying Doppler imaging on observations of photospheric spectral lines and time series analysis on photometry. The combination of both of these tools is especially valuable for studying differential rotation and dynamo waves. Recent results show that the activity of rapidly rotating stars is more complicated than was previously acknowledged. In addition to the non-axisymmetric spot structures observed already decades ago, there are significant changes in the spot configuration happening on all timescales.

Magnetic fields in OB stars

Hubrig, Swetlana (Leibniz Intitut fuer Astrophysik Potsdam), et al.

The presence of a convective envelope is a necessary condition for significant magnetic activity. Magnetic activity is found all the way from the late A-type stars with very shallow convective envelopes down to the coolest fully convective M-type stars. On the other hand, advances in instrumentation over the past decades have led to magnetic field detections in a small but gradually growing subset of massive stars, which frequently present cyclic wind variability, Halpha

emission variations, non-thermal radio/X-ray emission and transient features in the absorption line profiles. Currently, a dozen magnetic O-type stars and

two dozens of early B-type stars (not included classical He-strong/He-weak

Bp stars) are known. Among B-type stars, different groups, such as beta Cephei stars and slowly

pulsating B stars, He-rich and He-deficient Bp stars, Be stars, BpSi stars, HgMn stars, or normal B-type stars are characterized by different magnetic field geometry and strength, from fields below the detection limit

of a few Gauss up to tens of kG. In my talk I will discuss the most recent

results from magnetic field surveys of massive stars of different classification.

SPECTRAL AND PHOTOMETRIC BEHAVIOR OF RY TAU

Ismailov, Nariman (ShAO of NAS of Azerbaijan)

The results of spectral studies of the CTTS type young star RY Tau on spectrograms of the ultraviolet range taken from IUE database and the visual range obtained at ShAO are presented. Despite a significant brightness variability in 1983-1984, the Mg II λ2800 Å emission doublet showed no synchronous variation with the UBV photometric data. A periodic variability of the intensity MgII λ2800 Å emission with a period of 23 days for the first time has been detected. The periodicity is also observed for a group of such lines as CIV λ1450 Å , He II λ1640 Å and SII λ1756 Å . Equivalent widths and shifts of the individual components of the Hα, H CaII + Hϵ, and CaII K lines also vary with of the founded period. The observed variability of the emission spectrum can be explained by the existence of the companion in the system in an orbit with a semimajor axis of about $\sim$0.16 AU. It was shown that in 1983–2004 the star's V-band brightness shows a quasi-periodical variability. The Fourier analysis detects variability period P1=377 $\pm$ 10 days with high confidence level. A statistical analysis of the star brightness distribution in the UBV bands are shows that the light variations could not be described with a normal distribution. These properties of the star can be explained with of still unformed stationary bodies existing in the circumstellar environment.

Dynamo action in the iron convection zones of OB-stars

Käpylä, Petri (University of Helsinki), Matteo Cantiello, Maarit Mantere, Axel Brandenburg

According to traditional wisdom, convection in massive OB-stars occurs only in the hydrogen-burning core.

However, recent theoretical studies have indicated that convection can be excited also in a relatively shallow layer in the outer radiative envelope of the star due to ionization of iron. Many OB-stars are also know to rotate fairly rapidly, leading to the possibility that a convection-driven dynamo is operating in the iron convection zone. This could explain the magnetic fields observed at the surfaces of some OB-stars.

We present preliminary results from self-consistent numerical simulations of magnetized convection in spherical geometry where a convectively unstable layer is sandwiched between two radiative layers representing an OB star with an iron convection zone. We find that the iron convection zone is capable of sustaining dynamically important large-scale magnetic field and differential rotation. Possible observational signatures of these features are discussed.

Polarization Survey For Bright AM CVn Systems

Katajainen, Seppo (Tuorla Observatory), Pasi Hakala, Thomas Barclay, Gavin Ramsay

It is estimated that one in four Cataclysmic variables have strong magnetic fields, but it is not known whether this extends to AM CVn type interacting binary stars. These are ultracompact binaries with orbital periods of less than 70 minutes. We have studied a sample of AM CVn systems which are bright enough to guarantee a high Signal/Noise ratio in polarimetry. We have searched for evidences of strong magnetic fields (MegaGausses) using imaging polarimetry and spectropolarimetry. A detection of any AM CVn system emitting polarized light has important consequences for binary evolution theories and allow us to place constraints on the dominant formation channel of AM CVn systems, which is a crucial ingredient in understanding CV evolution in general and even the possible evolutionary paths to SN Ia.

Magnetism and cycles in late-type stars

Korhonen, Heidi (Niels Bohr Institute)

Rapid rotation enhances the dynamo operating in stars, and thus also introduces significantly stronger magnetic activity than is seen in the slower rotators, like our Sun. Many young cool stars are rapid rotators, because they have the primordial rotation rates induced by the interstellar molecular cloud from which they were formed. Also older stars in close binary systems are rapid rotators. These types of stars can show strong magnetic activity and large starspots. Photometric monitoring spanning decades has allowed studying the long-term magnetic activity in these stars revealing complicated activity cycles. The development of observing and analysis techniques that has occurred during the past two decades has also enabled us to study the detailed starspot and magnetic field configurations on them. In this talk I will review the state-of-the-art observing techniques and recent results on studying stellar magnetism and activity cycles in active stars.

Observations of magnetic activity on young solar type stars

Lehtinen, Jyri (University of Helsinki), L. Jetsu, T. Hackman, P. Kajatkari, G.W. Henry, H. Korhonen

Among the longest time scale observing programmes dedicated for studying the magnetic activity of individual stars are photometric monitoring programmes carried out with automated photoelectric telescopes. Decade spanning nightly photometry of stars displaying spot activity can reveal a lot from the magnetic processes underlying the spot generation including detection and characterisation of activity cycles, active longitudes and surface differential rotation. Here I will talk about results of analysing such photometry of young solar type stars as well as limitations of interpretation of the results. I will also discuss using spectroscopic measurements of chromospheric emission in conjunction with photometric observations.

Spot activity of rapidly rotating late-type stars

Lindborg, Marjaana (University of Helsinki), Mantere, M.J., Hackman, T., Pelt, J., Korhonen, H., Ilyin, I., Kochukhov, O., Piskunov, N., Olspert, N., Henry, G.W., Jetsu, L., Strassmeier, K.G.

Rapidly rotating late-type stars can be seen as analogues to the young Sun. Due to the rapid rotation, they exhibit strong magnetic activity. Doppler imaging is a very commonly used tool for investigating temperature spots on the stellar surfaces.

DI Pisces is one of the lithium rich giant stars, whose stellar parameters and activity cycle are all but well-known. The Coriolis number characterizing the strength of rotational influence on the turbulent motions in the stellar convection zone makes it possible to theoretically predict activity cycle lengths in rapid rotators.

The estimated Coriolis number of roughly 35 places DI Psc on the high-Coriolis number edge on the active branch, on which stars systematically show magnetic cycles of the order of ten years. On this branch, the magnetic activity cycle length decreases as function of rotation rate. We've recently published temperature maps for 2004-2006, which show that the relatively large variations seen in the spot coverage fraction during only a few years can be at least considered to rule out the possibility of DI Psc exhibiting very long magnetic cycle characteristic for the superactive branch or stars transiting towards it.

For II Pegasi we have one of the longest sets of observations, covering the years 1994-2010. According to earlier Doppler images of II Peg, the surface of the star was dominated by one single active longitude that was clearly drifting in the rotational frame of the binary system during 1994-2002; later imaging for 2004-2010, showed decreased and chaotic spot activity, with no signs of the drift pattern. We have combined all collected photometric data into one single data set, and analyze it with the Carrier Fit method. As a result, we confirm the earlier results of the spot activity having been dominated by one primary spotted region almost through the entire data set, and the existence of a persistent, nearly linear drift.

Active longitudes and their role for dynamos

Mantere, Maarit (Aalto University)

The spectroscopic time series obtained for rapidly rotating late-type stars, analyzed with Doppler imaging methods, have revealed huge high-latitude temperature anomalies unevenly distributed over the stellar longitudes. The analysis of photometric time series have in many cases confirmed the spectroscopic results, and allowed the follow-up of the evolution of the light curve minima for longer time extents and with better time sampling. From these investigations it seems clear that in many stars the magnetic activity manifests itself as active longitude(s) that undergo apparently quite irregular phase jumps, sometimes called flip-flops, and drifts in the rotational frame of reference. In terms of dynamo theory, a change from the solar-type mostly axisymmetric and quite regular oscillatory solution to a non-axisymmetric non-stationary one occurs as the rotation rate is increasing.

Some of the phenomena related to these active longitudes can rather straightforwardly be understood from mean-field dynamo theory. The change from axi- to nonaxisymmetric solutions with increasing rotation rate, for instance, is a prediction dating back to simple linear dynamo solutions, that has been later confirmed by more complex non-linear modelling. Oscillatory solutions emerge if e.g. anisotropic turbulent transport coefficients are allowed for.

Severe challenges, however, remain. From theoretical point of view it is quite poorly understood how the dynamo-generated sub-surface fields transform themselves into sun- or starspots, and whether the same mechanisms are at play in all the objects under study. Here we review different scenarios, ranging from the rising flux tubes models, turbulent effects causing negative magnetic pressure leading into instability (NEMPI), and purely hydrodynamic instability leading into the formation of large vortices with significant temperature anomalies.

Competition of rotation and stratification in flux concentrations

R. Losada, Illa (Nordita), A. Brandenburg, I. Rogachevskii, N. Kleeorin

In a strongly stratified turbulent layer, a uniform horizontal magnetic field can become unstable to form spontaneously local flux concentrations due to a negative contribution of turbulence to the large-scale (mean-field) magnetic pressure. This mechanism is of interest in connection with dynamo scenarios in which most of the magnetic field resides in the bulk of the convection zone, and not at the bottom, as is usually assumed. Recent work using the mean-field hydromagnetic equations has shown that this negative effective magnetic pressure instability (NEMPI) becomes suppressed at rather low rotation rates with Coriolis numbers as low as 0.1. Here we extend these earlier investigations by studying the effects of rotation both on the development of NEMPI and on the effective magnetic pressure (turbulent and non-turbulent contributions). We quantify the kinetic helicity resulting from rotation and stratification and compare with earlier work at smaller scale-separation ratios. We also determine the sensitivity of surface diagnostics of magnetic helicity. We use direct numerical simulations (DNS) and mean-field calculations of the three-dimensional hydromagnetic equations in a Cartesian domain and analytical studies using the τ approach. We find that the growth rates of NEMPI in earlier mean-field calculations are well reproduced with DNS and that the rotational effect on the effective magnetic pressure is negligible as long as the production of flux concentrations is not inhibited by rotation. In that case, kinetic and magnetic helicity are also found to be weak. Production of magnetic flux concentrations through the suppression of turbulent pressure appears to be possible only in the upper-most layers of the Sun,

where the convective turnover time is less than 2 hours.

Relaxation-type second order closure models in astrophysical hydrodynamics

Snellman, Jan (University of Helsinki)

A brief introduction to the closure models in astrophysical settings is given focusing on two recently proposed closures: The minimal tau-approximation and the model of Ogilvie et al. Both of these models are based on replacing third order correlations in the Reynolds stress equations by relaxation terms. The validity of these models can be tested by compering their results to the direct numerical simulations in the same parameter regimes. Some results from these tests are presented.

Solar magnetic cycle in light of dynamo theory: a message for stellar activity studies

Sokoloff, Dmitry (Moscow State University)

Recent archive findings concerning solar activity variations over several last centuries and efforts of astronomers to get observational information concerning solar dynamo governing parameters resulted in a substantial progress in understanding of this spectacular phenomenon. In particular, various local deviations from a standard scenario of solar cycle isolated in these studies shows a lot of options for dynamo activities in stellar convective envelopes. We present these options in context of stellar activity studies.

Discovery of optical sub-second spikes in UV Ceti giant flare

STEPANOV, Alexander (Pulkovo Observatory), G.Beskin, S.Karpov, V.Plokhotnichenko, Yu.Tsap

Sub-second spike events in giant flare of UV Ceti on December 12, 2008 were detected in observations with 6 m telescope of the Special Astrophysical Observatory in U band using panoramic photometer with time resolution of 1 microsecond. Such a short bursts were firstly observed in the flare maximum. They have triangular form with duration of both fronts about 0.3-0.6 s. We consider flare site as a set coronal magnetic loops. Possible mechanisms of sub-second spikes driven by accelerated flaring electrons are discussed. Synchrotron emission requires electrons with Lorentz-factor $\gamma \approx 700$ and energy spectrum power index less than 2.5 in the magnetic field B $\approx$ 1000 G. Inverse Compton needs $\gamma > 10^3$. We discussed also bremsstrahlung emission from the photosphere loop footpoints driven by precipitating >20 keV electrons with power index more than 3. It is shown that high energy electrons can accelerate effectively by the electric field in a flare loop.

Observational techniques: measuring, detecting and quantifying stellar magnetic fields

Thorsten, A. Carroll (-)

I will give a short overview over currently existing methods for detecting and quantifying magnetic fields on stellar surfaces. In particular Doppler-Imaging and Zeeman-Doppler Imaging are powerful methods to reveal the surface distribution of the temperature and/or the magnetic field from phase resolved spectro-polarimetric data. However there are limitations, and we can not and we should not expect to obtain a complete picture by theses techniques. Moreover, even when the field as well as the temperature distribution can be correctly reconstructed the interpretation of the results in terms of the underlying process that generates these surface fields is far from straight forward.

Solar-like differential rotation in a convective dynamo with a coronal envelope

Warnecke, Joern (Nordita), Petri Kapyla, Maarit Mantere, Axel Brandenburg

We report on the results of three convective dynamo simulations with an outer coronal layer. The magnetic field is self-consistently generated by the convective motions beneath the surface. Above the convection zone we include a polytropic layer that extends to 1.6 solar radii. The temperature increases in this region to $\approx$ 8 times the value at the surface, corresponding to $\approx$ 1.2 times the value at the bottom of the spherical shell. We associate this region with the solar corona. We find a solar-like differential rotation with radial contours of constant rotation rate, together with a solar-like meridional circulation and a near-surface shear layer. This spoke-like rotation profile is caused by a non-zero latitudinal entropy gradient which violates the

Taylor-Proudman balance via the baroclinic term. The lower density stratification compared with the Sun leads to an equatorward return flow above the surface. The mean magnetic field is in most of the cases oscillatory with equatorward migration in one case. In other cases the equatorward migration is overlaid by stationary or even poleward migrating mean fields.

2 Posters

The interacting binary system OO Aql

ICLI, TUGCE (Ege University Department of Astronomy and Space Sciences), G.Cisem Boz , Dolunay Kocak

In this study we present photometric and spectroscopic variation analysis and orbital period study of an interacting system OO Aql. Simultaneous solution of the light and radial velocity curves provide us a determination of new set of stellar physical parameters for the primary and the secondary companions. Analyses of the mid-eclipse times indicate a period increase of $\frac{P}{\dot{P}} = 4 \times 10^7$ yr that can be interpreted in terms of the mass transfer $\frac{dM}{dt} = 5 \times 10^{-8}$ $M_\odot$/yr from the less massive component to the more massive component. Our new solution confirmed that OO Aql is a multiple system in the form of AB + C + D.

Statistics of Stellar Magnetic Fields

KHOLTYGIN, ALEXANDER (Saint Petersburg State University), S.Hubrig, N.A.Drake, N.P.Sudnik, V.V.Dushin

We review the magnetic fields measurements for OBA stars. The distribution functions for magnetic fields and magnetic quasi-fluxes of these stars are obtained. We find that magnetic fields are distributed according to a power law with an index of about 2.5. The connection between the existence of the magnetic field of a star with its enrichment of the atmosphere with nitrogen and silicon is investigated. We consider the possibility that OBA stars have the local spots with the strong magnetic fields in addition to general global magnetic field. We also study the connection of the stellar magnetic field and the line profile variations in spectra of the early-type stars.

Unusual binary system HD83058: orbital parameters, atmospheric models and line profile variabilities

POGODIN, M. A. (Pulkovo Astronomical Observatory, Saint Petersburg, Russia), N.A. Drake, E.G. Jilinski, C.B. Pereira

We present the results of detailed analysis of the binary system HD83058 based on high-resolution spectra obtained with the FEROS echelle spectrograph and the 2.2m telescope at ESO, Chile. The orbital elements were determined. Disentangling of the observed composite spectra permitted us to determine fundamental parameters and construct atmospheric models of primary and secondary components. We present also analysis of the line profiles variabilities in the spectra of both components and discuss their origin which could be connected with the presence of magnetically active zones on the stellar surface.

Symposium S8

Deaths of massive stars as supernovae and gamma-ray bursts

1 Oral contributions

SN rate in the local Universe

Botticella, Maria Teresa (Capodimonte Observatory, INAF-Napoli)

The core collapse supernova rate provides a strong lower limit for the star formation rate. Progress in using it as a cosmic star formation rate tracer requires some confidence that it is consistent with more conventional star formation rate diagnostics in the nearby Universe. Complete and volume-limited SN and galaxy samples are crucial to perform a

statistically meaningful analysis and the advent of large sets of multi-wavelength observations of nearby galaxies provide us the opportunity to compare SFRs based on CC SN rate and more established tracers in the same galaxy sample. The data are complete enough that we can take into account the different uncertainties and biases that affect these SFR diagnostics. Multi-wavelength data also allow us to study the effect of dust extinction, to constraint the fraction of missed SNe in optical SN searches and to compare the spatial distribution of CC SNe with that of the SFR.

The progenitors of grbSNe

Cano, Zach (University of Iceland)

It is now accepted that a long-duration gamma-ray burst (GRB) is generated during the violent demise of a massive star whose properties are quite atypical to those of the general core-collapse supernova (ccSN) population. Determining the properties of the progenitor stars of gamma-ray burst supernovae (grbSNe) is of great interest within the GRB and SN communities. Why do only a tiny fraction of massive stars create a GRB? What are the special properties that the progenitor star must possess

to produce a GRB Solving this puzzle requires a clever combination of observations and theory, with results from each helping to drive the state

of the field forward. In this talk I will discuss the general properties of grbSNe in relation to other ccSNe, and describe how these observations are helping to constrain and differentiate between the leading theoretical

progenitor models for grbSN production.

What fraction of CCSNe give rise to GRBs ?

Della Valle, Massimo (Capodimonte Observatory, INAF-Napoli)

Several lines of evidence suggest that long duration Gamma-ray Bursts and SNe are coeval events within less than ∼0.1 days. Current estimates of SN and GRB rates yield a ratio GRB/SNe-Ibc less (or much less) than -3%. However observations of GRB 060614 puzzled this scenario, pointing out the existence of long-duration Gamma-ray Burst not accompanied by bright supernovae.

SN 2011dh - Current state of research.

Ergon, Mattias (Stockholm University, Department of Astronomy)

I will discuss the current state of research on the Type IIb SN 2011dh focusing on the results presented by our group in Maund et al. (2011), Bersten et al. (2012) and Ergon et al. (2013) as well as preliminary results

from Jerkstrand et al. (in preparation) and Ergon et al. (in preparation). The observations published in these and other papers are among the best obtained ever, covering a wavelength range from radio to X-rays and two years later monitoring is still ongoing. I will mainly discuss the UV to MIR observations and the results we have obtained from these, in particular on the nature of the progenitor star. The luminosity of the SN is now considerably fainter than the yellow supergiant coincident with the SN confirming this star to be the progenitor. Several independent methods using both SN and progenitor observations gives consistent results regarding the nature of the progenitor and HST imaging in the year to come might confirm or rule out the presence of a companion star.

Observations and progenitor scenarios of Type IIn SNe

Fransson, Claes (Stockholm University)

I will discuss recent multi-wavelength observations of Type IIn SNe, in particular SN 2005ip, 2006jd, 2009ip and in most detail SN 2010jl, and what these observations tell us about the SN environment and progenitor.

New frontiers in transient science from PTF and iPTF

Gal-Yam, Avishay (Weizmann Institute of Science)

The wide-field Palomar Transient Factory (PTF) survey has been scanning the sky for optical transients since 2009, discovering thousands of events. I will present science highlights from this survey, as well as new results from its ongoing extension, the intermediate PTF (iPTF), as well as prospects for near-future ground- and space-based wide-field transient surveys. An emerging theme is the real-time study of optical transients. For example, iPTF can currently study supernova explosions during the first hours post-explosion; future surveys will be able to move on to minute timescales. This real-time capability opens new scientific windows to study numerous optical transients, in ways previously only possible for much rarer high-energy (X- and Gamma-ray) transients.

Predicting the look of massive stars before death

Groh, Jose (Geneva Observatory, Switzerland)

Stars more massive than about 8 $M_\odot$ end their lives as a supernova (SN), an event of fundamental importance Universe-wide. The morphological appearance of massive stars before the SN event is very uncertain, both from a theoretical and observational perspective. In this talk, I will present coupled stellar evolution and atmospheric modeling of stars done with the Geneva and CMFGEN codes, for initial masses between 9 and 120 $M_\odot$. We are able to predict the high-resolution spectrum and broadband photometry, which can then be directly compared to the observations of SN progenitors. I will discuss the surprising predictions of spectral types of massive stars before death. Our models indicate that massive stars die as RSGs, LBVs, WNs, or WOs, depending on the initial mass and rotation. I will also discuss the detectability of SN progenitors.

Observations of the IGC process in some GRBs-SNe and applications to cosmology

Izzo, Luca (Sapienza University of Rome and ICRANet), Izzo, L.; Bianco, C. L.; Muccino, M.; Penacchioni, A. V.; Pisani, G. B.; Rueda, J. A.; Ruffini, R.; Wang, Y.

The Induced Gravitational Collapse scenario was proposed recently to explain the connection between Gamma Ray Bursts and the related Supernovae Ib/c. We present the phenomenology of this mechanism in the prototype GRB 090618, and in an other good example, GRB 970828, explaining all the observational evidences and deriving the parameters of the NS and progenitor system. Moreover, we found a standard luminosity light curve behavior in the late-time X-ray emission of this subclass of GRBs, which implies the possibility to estimate the distance of GRB-SN-IGC event without an observed redshift. This method was successfully applied to other GRBs, which will be presented and discussed.

Nebular phase spectral modeling of core-collapse supernovae

Jerkstrand, Anders (Queens University Belfast)

Nebular phase supernova observations and modeling allows an analysis of the nucleosynthesis in the deep

interior of massive stars. By computing the transformation of radioactive decay energy to emission lines from the various nuclear burning zones, observed spectra can be interpreted to yield constraints on the hydrostatic and explosive evolution of the star. I present results of such modeling for both hydrogen-rich (Type IIP) and hydrogen-poor (Type IIb) supernovae, from which several interesting conclusions on the progenitor masses, nucleosynthesis, and explosive mixing have emerged.

Spatial distributions of core-collapse supernovae in actively star-forming galaxies

Kangas, Tuomas (Tuorla Observatory), Seppo Mattila, FINCA/Tuorla Observatory Erkki Kankare, FINCA/Tuorla Observatory

Using pixel statistics, we investigate the correlation between locations of core-collapse supernovae (CCSNe) and Hα, near-UV, R- and Ks-band light, to constrain the progenitors of CCSNe in a sample of 57 actively star-forming galaxies and the 86 CCSNe detected in them since 1990. We also analyse the radial distribution of the CCSNe in these galaxies, and determine an exponential fit to surface densities of CCSNe at different distances from the host galaxy core. We draw the following conclusions: (1) Type Ic SNe are more strongly correlated with H II regions (Hα) and NUV- and Ks-bright regions than types II and Ib. These correlations are consistent with previous studies and indicate that type Ic progenitors may mostly be massive WR stars, while most type Ib progenitors may be stars of similar mass as those of type II, located in interacting binaries. (2) Type II SNe occur further away from the host galaxy core than stripped-envelope SNe, in agreement with previous studies. This may be due to a top-heavy IMF in regions of enhanced SF, combined with many SNe being missed in the central regions of actively star-forming galaxies. (3) We obtain a scale length of 0.23 R_25 for the surface density of CCSNe in actively star-forming galaxies. This is less than that observed for CCSNe in normal spiral galaxies (0.29). The centralisation of the SN population we see in our galaxies is mostly due to a central excess of type Ibc/IIb SNe (scale length 0.19) compared to normal galaxies.

Core-collapse supernovae in luminous infrared galaxies

Kankare, Erkki (University of Turku), Seppo Mattila (University of Turku), Stuart Ryder (AAO)

We have conducted a four year study of searching for core-collapse supernovae (CCSNe) in a sample of eight luminous ($L_{\rm IR} > 10^{11} L_{\odot}$) infrared (IR) galaxies (LIRGs) using the Gemini-North Telescope with ALTAIR/NIRI laser guide star adaptive optics system. The high resolution and the usage of near-IR wavelengths are crucial for the discovery and follow-up of the obscured CCSNe in these dusty and actively star forming galaxies. The improved statistics of SNe discovered in LIRGs can be used as useful tools to independently trace and study the star formation, extinction distribution and supernova population in these galaxies. Furthermore, we were recently able to expand the results from studies of CCSNe in LIRGs in the local Universe also into higher redshift ($z \gtrsim 1$) where the LIRGs become the dominating source of star formation. This work has provided new correction factors for the 'missing' SNe for studies of CCSN rates as a function of redshift.

Light Echoes of Core-Collapse Supernovae

Krause, Oliver (Max-Planck-Institut für Astronomie)

Young Galactic supernova remnants are unique laboratories for supernova physics. Due to their proximity they provide us with the most detailed view of the outcome of a supernova. However, the exact spectroscopic types

of their original explosions have been undetermined so far - hindering to link the wealth of multi-wavelength knowledge about their remnants with the diverse population of supernovae. Light echoes, reflections of the brilliant supernova burst of light by interstellar dust, provide a unique opportunity to re-observe today - with powerful scientific instruments of the 21st century - historic supernova explosions even after hundreds of years and to conclude on their nature. We review optical light-echo spectroscopy of historical core-collapse supernovae, in particular the youngest known CC SN Cas A. These observations finally recovered the missing spectroscopic classifications and provide new constraints on explosion models for future studies.

Super-luminous supernovae and their host galaxies

Leloudas, Giorgos (Oskar Klein Centre)

In the recent years we have witnessed the discovery of a class of very luminous explosions, a.k.a. super-luminous supernovae. In the first part of the talk I will give a short overview of this booming field. I will try to cover some historical aspects, the observational properties and diversity of SLSNe and the proposed mechanisms explaining their luminosities. In addition, their potential for probing the high-z universe, the ISM and the IMF of dwarf galaxies. In the second part, I will present a large effort to study the host galaxies of super-luminous supernovae. Our team is using a number of telescopes, including the VLT, GTC, Magellan and smaller facilities, in order to obtain multi-wavelength imaging data and spectra of these hosts. Our purpose is to build their SEDs, determine their properties and measure their metallicities. These monstrous explosions seem to occur in very special environments.

The absolute magnitudes of GRB-SNe

Li, Xue (Dark Cosmology Centre, Niels Bohr Institute), Jens Hjorth

We report the light curves in the rest frame V band derived for fourteen GRB-SNe with redshift z up to 1, using multi-band K corrections, and suitably corrected for the foreground extinction. These light curves indicate that the GRB-SNe have small intrinsic dispersion: 0.384 mag, in the absolute magnitudes in the rest frame V band. The dispersions of the absolute magnitudes of 70 Type Ia supernovae (z $\sim$ 0.08) are also estimated as a comparison. The dispersion is 0.453 mag. This result can be interpreted that GRB-SNe show a good property of constant intrinsic luminosities. Moreover, the absolute magnitudes appear to be correlated with the decline rate of the light curve in V band similar to Type Ia supernovae. Considering the wide application of Type Ia supernovae in the measurement of cosmological distance, it is possible that the GRB-SNe can also be used as cosmological standard candles.

Measuring cosmological parameters with GRBs: status and perspectives

Lorenzo, Amati (INAF - IASF Bologna), M. della Valle, F. Frontera, C. Guidorzi

Given their huge isotropic-equivalent radiated energies, up to more than 10^{54} erg, and their redshift distribution extending up to more than z = 8, Gamma-Ray Bursts (GRB) are in principle a powerful tool for measuring the geometry and expansion rate of the Universe. However, they are not standard candles given that their luminosities span several orders of magnitude, even when considering possible collimation angles. In the recent years, several attempts to exploit the correlation between the photon energy at which the nuFnu spectrum peaks ("peak energy") and the radiated energy (or luminosity) for "standardizing" GRBs and using them as tools, complementary to other probes like SN Ia, BAO and the CMB, for the estimate of cosmological parameters have been made. These studies show that already with the present data set GRBs can provide a significant and independent confirmation of Omega_M < 1 (and around 0.25) for a flat LambdaCDM universe and that the measurements expected from present and next GRB experiments (e.g. Swift, Fermi/GBM, SVOM, UFFO) will allow us to constrain Omega_M, Omega_Lambda, and, in particular, to get clues on dark energy properties and evolution.

What we know for sure: most long GRBs come from exploding massive stars

Malesani, Daniele (Dark Cosmology Centre)

That long-duration GRBs are produced in the explosion of massive stars is an observationally well-established fact. This in turn enables the use of long GRBs as cosmological probes of star formation at all redshifts. It is less certain which kind of stars do explode as GRBs. A similar SN explosion (properties comparable to a factor of few) is observed for GRBs with extremely different energetics (spanning a factor of 10^6), as showcased by the recent low-redshift, high-power GRB 130427A. Constraining quantitatively the properties of GRB stellar progenitors is the next necessary step to pursue further the use of GRBs as cosmic probes.

The Progenitors of Core-collapse Supernovae

Maund, Justyn (Queen's University Belfast)

All stars with initial mass $> 8M_\odot$ are expected to end their lives as core-collapse supernovae. I will review the latest results from efforts to directly identify the progenitor stars of core-collapse supernovae in fortuitous pre-explosion images. Of particular importance to this field is our evolving understanding of the uncertainties in our analysis of the pre-explosion observations, and I will discuss the benefits that may be achieved by acquiring late-time observations of the sites of these explosions.

Core-collapse supernovae - rates and host galaxy properties

Melinder, Jens (Stockholm University), G. Östlin, T. Dahlen, S. Mattila, C. Fransson, M. Hayes, J. Sollerman, L. Mencia-Trinchant, E. Zackrisson

Supernova surveys have been used successfully to measure both cosmological parameters and the cosmic star formation history. I will give a brief review over the current status of surveys trying to estimate the core collapse supernova rate at intermediate redshift. Among these surveys is the SVISS (Stockholm VIMOS Supernova Survey) which targeted both Ia and core-collapse SNe and discovered 16 SNe at $0.1<z<1.4$, nine core collapse SNe and seven Ia SNe. Recently we obtained optical spectra for most of the host galaxies using the VIMOS instrument on the VLT. With the VIMOS spectroscopy we are able to characterise the host galaxies of both SN types in terms of star formation, metallicities and extinction, but also put further constraints on the SNe themselves through the addition of accurate redshifts. At the EWASS 2013 we will present the first result of this study.

Impostors and interacting supernovae connection.

Pastorello, Andrea (INAF-Padova Observatory)

Supernova impostors are transient events that mimic the observables of weak type IIn supernovae, showing narrow spectral lines that indicate relatively low ejecta velocities (a few hundreds km/s) and having absolute magnitudes of -11 to -15. During the outbursts, the luminosity of the star, usually a Luminous Blue Variable, exceed by several magnitudes the magnitude of the quiescent star. What triggers the outbursts is unclear, but it is generally accepted that these massive stars violate the Eddington luminosity limit, initiating major mass loss episodes. The interest towards these transients has mounted up because there are claims that some interacting supernovae (of type IIn or type Ibn) have been heralded by pre-SN eruptions. In this talk I will discuss a few representative examples of SN impostors and review observational evidences of a connection between them and genuine, interacting supernovae.

Optical photometric and spectroscopic follow-up observations of the luminous Supernova 2012aa

Roy, Rupak (Aryabhatta Research Institute of observational sciencES (ARIES), Nainital, India), A. J. Drake, J. M. Silverman, S. Benetti, R. Martin, S. Bose, E. Cappellaro, E. Kankare, A. Pastorello, Brajesh Kumar, A. V. Filippenko, D. Garcia-Alvarez, Brijesh Kumar, L. Tomasella, M. Turatto, S. Valenti

A few dedicated surveys like CRTS, LOSS, ROTSE, PTF, PanSTARRS, and LSQ discovered several stellar explosions which have an average absolute V-band peak magnitude of about -21, more than 2 mag brighter than normal stripped-envelope SNe. SN 2012aa, which was discovered on 29.6 January 2012 UT by the LOSS, has similar characteristics. From optical spectra it was characterized as a Type Ic SN. The event was also detected by the CRTS during its rising phase, with peak apparent unfiltered magnitude $\sim$18. It was also observed in the BVRI bands along with good spectroscopic coverage over a time span of 100 days using different telescopes throughout the world. The SN is in a relatively distant (redshift $z\sim0.08$) host galaxy, with a line-of-sight reddening E(B-V)$\sim$0.2 mag. This value is comparable to the Galactic reddening ($\sim$0.1 mag). The derived absolute V-band peak magnitude is roughly -20.5 mag, a very luminous SN. The post-maximum decay rate is roughly 0.012 mag/day. This is much lower than that of normal stripped-envelope CCSNe ($\sim$0.06 mag/day) and comparable to the decay rate of overluminous events like CSS100217 and SN 2007bi. The preliminary derived mass of radioactive Ni is $\sim$2.1 solar masses, which is a little less than that of CSS100217 and SN 2007bi, but significantly higher than that of normal stripped-envelope events. Here, we present the optical photometric and spectroscopic follow-up observations of this event, along with detailed modeling of the light curve and spectra.

Host galaxies of long gamma-ray bursts

Savaglio, Sandra (Max Planck Institute for Extraterrestrial Physics), Sandra Savaglio

The investigation of galaxies hosting long gamma-ray bursts (GRBs) offers the opportunity to explore regions of the universe which are observationally very hostile for traditional means, due to gas and dust absorption. A decade of GRB detections and research has brought to "light" a galaxy population that was not expected before. For instance, the cosmic chemical enrichment revealed by GRBs over billions of years is found to be much milder than what previously thought. One main unclear issue is whether the typical GRB host

at low redshift is different from the high-z counterpart. The answer to this question may be closely related to the sharp decline of the cosmic rate of star formation, to the gas consumption and to the change in the galaxy merger rate, for z < 1. Another crucial issue is the recent discovery of several hosts at intermediate redshift with red color (some related to dark hosts), which can help to unveil the role of dust in our detection capabilities of the brightest objects in the universe. Finally, very distant GRB hosts (z > 5) have given so far elusive results, indicating very small galaxies, smaller than what is reached today with typical NIR deep surveys.

Carnegie Supernova Project: Observations of Type IIn supernovae

Taddia, Francesco (Stockholm University, Astronomy)

Carnegie Supernova Project (CSP) optical and near-infrared light curves and visual-wavelength spectroscopy of the Type IIn SNe 2005kj, 2006aa, 2006bo, 2006qq, and 2008fq are presented. Combined with previously published observations of the Type IIn SNe 2005ip and 2006jd, the full CSP sample is used to derive physical parameters that describe the nature of the interaction between the expanding SN ejecta and the circumstellar material (CSM). For each SN of our sample, we find counterparts, identifying objects similar to SNe 1994W (SN 2006bo), 1998S (SN 2008fq), and 1988Z (SN 2006qq). We present the unprecedented initial u-band plateau of SN 2006aa, and its peculiar late-time luminosity and temperature evolution. For each SN, mass-loss rates of 10^{-4}–10^{-2} $M_\odot$ yr^{-1} are derived, assuming the CSM was formed by steady winds. Typically wind velocities of a few hundred km s^{-1} are also computed. The CSP SN IIn sample seems to be divided into subcategories rather than to have exhibited a continuum of observational properties. The wind and mass-loss parameters would favor a luminous blue variable progenitor scenario. However the assumptions made to derive those parameters strongly influence the results, and therefore, other progenitor channels behind SNe IIn cannot be excluded at this time.

The origin of soft X-ray absorption in gamma-ray burst afterglows

Watson, Darach (University of Copenhagen), Zafar, Tayyaba; Andersen, Anja C.; Fynbo, Johan P. U.; Gorosabel, Javier; Hjorth, Jens; Jakobsson, Páll; Krühler, Thomas; Laursen, Peter; Leloudas, Giorgos; Malesani, Daniele

Gamma-ray burst (GRB) afterglows are potentially valuable probes of both their immediate star-forming environments and the galaxies in which they explode. Soft X-ray absorption in excess of Galactic is observed in the afterglows of most GRBs, but the correct solution to its origin has not been arrived at after more than a decade of work, preventing its use as a powerful diagnostic tool. We resolve this long-standing problem and find that absorption by He in the GRB's host H II region is responsible for most of the absorption. We show that the X-ray absorbing column density ($N_{\rm H_X}$) is correlated with both the neutral gas column density and with the optical afterglow's dust extinction (A_V). We find that the correlation with the dust column has a strong redshift evolution, whereas the correlation with the neutral gas does not. From this we conclude that the column density of the X-ray absorption is correlated with the *total gas* column density in the host galaxy rather than the metal column density. The strong redshift evolution of $N_{\rm H_X}/A_V$ is thus a reflection of the cosmic metallicity evolution of star-forming galaxies and we find it to be consistent with measurements of the redshift evolution of metallicities for GRB host galaxies. We conclude that the absorption of X-rays in GRB afterglows is caused by He in the H II region hosting the GRB. While dust is destroyed and metals are stripped of all of their electrons by the GRB to great distances, the abundance of He saturates the He-ionising UV continuum much closer to the GRB, allowing it to remain in the neutral or singly-ionised state. Helium X-ray absorption explains the correlation with total gas, the lack of strong evolution with redshift as well as the absence of dust, metal or hydrogen absorption features in the optical-UV spectra.

2 Posters

SNRs and CRs: new challenges after a breakthrough.

Cardillo, Martina (Università di Roma Tor Vergata & INAF-IAPS), Andrea Giuliani, Marco Tavani

In the last few years, SNR study showed an increasingly complex scenario with a continuous elaboration of theoretical models; until now, providing an experimental unambiguous proof of the CR origin has been elusive. In this context the AGILE and Fermi gamma-ray satellites had a significant role. One year ago, AGILE found, for the first time, the proof of CR acceleration in the SNR W44. After this discovery, Fermi published new gamma-ray data of W44 confirming the AGILE results. In spite of this, theoretical interpretation of the SNR W44 features is still being debated. Here we will discuss new Fermi and new AGILE data, in the light of new CO data from NANTEN2 telescope, with the purpose to understand physics beyond observations in the context of DSA linear and nonlinear models.

Host galaxy environments of the super-luminous supernovae

Chen, Ting-Wan (Astrophysics Research Centre, Queen's University Belfast), S. Smartt, F. Bresolin (on behalf of a larger collaboration)

Super-luminous supernovae have a tendency to occur in faint host galaxies which are likely to have low mass and low metallicity. While these extremely luminous explosions have been observed from z = 0.1 to 4, the closest explosions allow more detailed investigations of their host galaxies. We present detailed analysis of the host galaxies of SN 2010gx (z = 0.23) and PTF-12dam (z = 0.107). SN 2010gx was classified as a super-luminous stripped-envelope supernova, and we found its host is a dwarf galaxy (Mg = -17.42 ± 0.17) with a high specific star formation rate. It has a remarkably low metallicity of 12 + log (O/H) = 7.5 ± 0.1 dex as determined from the detection of the [O III] λ4363 line. PS1-12arh is a 2007bi-like supernova, with a slowly fading light curve. It also occurred in a small galaxy (physical size = 2.34 kpc), which is similar with the host of SN 2010gx, but its absolute magnitude (Mg = -19.42 ± 0.10) is much brighter. The host galaxy has extremely strong emission lines, and we detect a wealth of emission lines such as [OIII] 4363, [OI] 6300/6364, [SIII] 9069/9532. Careful calibration of the emission line fluxes indicate a metallicity of 12 + log (O/H) = 8.0 ± 0.2 dex (using the direct method). In this poster, we show the comparison of the differences of the host galaxy from two super-luminous supernovae, and establish how the environment (i.e stellar progenitor metallicity) could help to explain the low volumetric rates ($\sim 10^{-4}$ of the core-collapse population) of the super-luminous supernova. We propose that these SNe are magnetar driven, and that this mechanism may be causally linked to low metallicity progenitor stars.

Photometric and spectroscopic monitoring of the type IIn supernova 2011ap

Harmanen, Jussi (Tuorla Observatory), Mattila Seppo, Kankare Erkki

We have observed the light curves of supernova (SN) 2011ap in the spectral bands of U,B,V,R,I,J,H,K. The SN was discovered in type Sc D galaxy IC 1277 (z$\sim$0.024) in 16 February 2011. The SN was identified to be type IIn. They are characterized by narrow emission lines emerging from strong interaction with the interstellar medium surrounding the SN at the time of explosion. The observations begun two weeks before the maximum and continued about four months. In addition to the photometric observations also ten optical spectra were taken. Observations were made with several telescopes including New Technology Telescope in La Silla, William Herschel Telescope and Nordic Optical Telescope in La Palma.

The interacting binary system OO Aql

kocak, Dolunay (ege university department of astronomy and space sciences), Tugce İcli, G.Cisem Boz

In this study we present photometric and spectroscopic variation analysis and orbital period study of an interacting system OO Aql. Simultaneous solution of the light and radial velocity curves provide us a determination of new set of stellar physical parameters for the primary and the secondary companions. Analyses of the mid-eclipse times indicate a period increase of $\frac{P}{\dot{P}} = 4 \times 10^7$ yr that can be interpreted in terms of the mass transfer $\frac{dM}{dt} = 5 \times 10^{-8}$ $M_\odot$/yr from the less massive component to the more massive component. Our new solution confirmed that OO Aql is a multiple system in the form of AB + C + D.

Time evolution of emission lines from inner ring of SN 1987A

Migotto, Katia (Department of Astronomy, Stockholm University), Claes Fransson, Peter Lundqvist, Jason Spyromilio, Josefine Larsson, Seppo Mattila, Bruno Leibundgut, Robert Kirshner, Per Gröningsson

We present preliminary results from high resolution VLT/UVES spectra of the inner circumstellar ring in SN 1987A at different epochs, as well as an analysis of the time evolution of the emission lines from the aforementioned region. Furthermore, the optical light curves are compared to the time evolution of X-ray emission, in addition to HST narrow and broad band imaging. The line emission and time evolution are discussed in the context of the interaction between the ejecta and the ring. The evolution of the radiative shocks resulting from this interaction can from these observations be studied in real time.

GRB 090227B, a genuine short burst, and GRB 090510, a disguised short burst in the highest CircumBurst Medium ever inferred.

Muccino, Marco (Sapienza), Carlo Luciano Bianco, Luca Izzo, Ana Virginia Penacchioni, Giovanni Battista Pisani, Remo Ruffini

GRB 090227B and GRB 090510, both detected by Fermi satellite, are two Gamma-Ray Bursts (GRBs) classified as short bursts. The major outcome of our analysis is that they originate from different systems. The clear detection of their thermal components and the determination of the corresponding energetics have allowed us to infer the main theoretical parameters of the Fireshell model: the energy of e+e- plasma, Ee+e-, the amount of baryons engulfed, B, as well as the density profile of the CircumBurst Medium (CBM). In the case of GRB 090227B, from the inferred values of Ee+e-=$(2.83\pm0.15)\times10^{53}$ erg and of B=$(4.13\pm0.05)\times10^{-5}$), as well as of the average density of the CircumBurst Medium (CBM), $\langle n\rangle$=$(1.90\pm0.20)\times10^{-5}$ cm^{-3}, we assume the progenitor of this burst to be a symmetric binary neutron stars with masses m=1.34 Msun, radii R=12.24 km, and thickness of their crusts 0.47 km. For GRB 090510, the plasma energy Ee+e-= $(1.10\pm0.06)\times10^{53}$ erg is constrained by the isotropic energy Eiso, and we derive a Baryon load B=$(1.45\pm0.28)\times10^{-3}$ and a Lorentz factor at transparency Gamma=$(6.7\pm1.7)\times10^{2}$, which are characteristic of the long GRB class, and a very high CBM density, $\langle n\rangle$=(1.85 ± 0.14) $\times10^{3}$ cm^{-3}. The joint effect of the high values of Gamma and of $\langle n\rangle$ compresses in time and "inflates" in intensity the extended afterglow, making appear GRB 090510 as a short burst, which we here define as "disguised short GRB by excess" occurring in an overdense region with 10^3 cm^{-3}.

Simulations of gamma-ray burst afterglows

Pennanen, Tuulia (University of Oulu), Indrek Vurm, Juri Poutanen

Gamma-ray burst (GRB) afterglows are the result of the interaction between the relativistic jet emanating from the central object and the surrounding medium. We have developed a numerical code to simulate the afterglow radiation, which is emitted mainly via the synchrotron and inverse Compton mechanisms by shock-accelerated electrons. The code solves the full kinetic equations describing the temporal evolution of the photon and electron distributions in the emission region. Our simulations suggest that a luminous high-energy component may arise in the GRB spectrum due to the scattering of the prompt GRB photons against the afterglow-emitting electrons. We have also compared the difference between the afterglow in a wind environment and a constant-density medium, and found that the low-energy end of a power-law electron distribution can be thermalized by synchrotron self-absorption heating in a wind-type medium.

A SEARCH FOR GAMMA RAY BURST REMNANT CANDIDATE IN SPIRAL GALAXY M101

Sonbas, Eda (University of Adiyaman), E. SONBAS, A. AKYUZ, S. TOPAL, U. TEMIZ

Gamma Ray Bursts (GRBs) are expected to leave behind GRB remnants, similar to how standard supernovae (SNe) leave behind SN remnants. The identification of these remnants in nearby galaxies would allow having knowledge about their birth sides and progenitors. It would also provide independent constraints on GRB rates and energetics (Perna et al. 2000). In this work, we present the preliminary results of an optical search for Gamma Ray Burst Remnants (GRBR) in the spiral galaxy M101. Photometrical and spectroscopical observations were performed with the 1.5m Russian-Turkish and 6-m BTA Telescopes. According to high line flux ratio (like as; OIII/Hbeta, HeII/Hbeta ve OIII/OII) in photoinozied regions, we identified 15 emission nebulae as GRBR. Knowing the positions of the GRBRs, we can compare their distributions relative to other emission nebulae (e.g. Supernova Remnants, Planetary Nebulae, HII regions).

Supernova detection efficiency inside starburst and luminous infrared galaxies

Takalo, Ari (University of Turku), Seppo Mattila Jens Melinder Erkki Kankare

We have developed methods for estimating supernova detection efficiencies inside starburst and luminous infrared galaxies (LIRGs). These methods were developed for estimating completeness corrected supernova rates from near-infrared supernova searches. We have carried-out both under natural seeing conditions and using adaptive optics correction. The method is based on simulating artificial supernovae on observed images of the target galaxies and utilising a detection algorhitm to search for these simulated sources in subtracted images. The search method uses optimal image subtraction from the ISIS 2.2 package to find variability in the observed images and combines SExtractor and aperture photometry statistics for finding objects in the subtracted images. We show initial result for data obtained using the NACO instrument on the ESO VLT.

Symposium S9

Extreme physics of neutron stars

1 Oral contributions

session 2

The mechanism of flame propagation in Type I Bursts

Cavecchi, Yuri (A. Pannekoek - University of Amsterdam), A. L. Watts, J. Braithwaite, Y. Levin

Many accreting Neutron Stars (NSs) show the extraordinary thermonuclear explosions known as Type I Bursts. During the bursts the accreted matter is ignited in one spot and then a burning flame propagates along the NS ocean: that produces a bright burst of X-ray on top of the persistent accretion-powered emission. Burst spectra and lightcurves encode information about NS parameters and the burning material. More over, many bursts show intensity fluctuations in their lightcurves, known as burst oscillations, which are thought to be due to some kind of asymmetry in the emission pattern of the burning ocean and can be used to measure the spin rate of the star.

However, before the bursts and their oscillations can be effectively used as probes of NS properties, we need to firmly understand the different mechanisms behind their diverse phenomenology. As well as nuclear reaction rates and spectra formation, the very flame spreading mechanism is of key importance. Despite the long efforts put in the past years in tackling the problem, both theoretical and numerical, the problem has yet to be resolved. One specific problem is that the flame is expected to be propagating by deflagration, but simulations could not meet such expectations and only obtained detonations.

I will present the first results of numerical simulations which actually show a deflagrating flame front, the speed of which is in good agreement with the observations. These simulations highlight the role of different physical aspects of the NS and the accreted material, such as the spin frequency of the star, through Coriolis force and nearly geostrophic balance, and conduction across the front.

session 6

Baryon superfluidity and neutron-star dynamics

Gusakov, Mikhail (Ioffe Institute)

Baryons in the internal layers of not too hot neutron stars are likely to be in the superfluid state. Superfluidity has a dramatic effect on the microscopic and macroscopic properties of superdense matter and thus affects the neutron-star evolution in many ways. In my talk I will discuss various aspects related to theoretical modeling of superfluid neutron stars and analyse possible observational signatures of baryon superfluidity (such as glitches, neutron-star cooling and oscillations).

session 1

Equation of state, masses, and radii of neutron stars

Haensel, Pawel (N. Copernicus Astronomical Center (Warsaw, Poland))

Equation of state (EOS) of neutron stars (NS) will be reviewed, with particular emphasis on the importance of the various segments of the EOS for the NS masses and radii. The implications of existence of two two-solar-mass pulsars will be discussed. The problems related with hyperonic cores will be reviewed and the proposed solutions of the "hyperon puzzle" will be described. Constraints on the quark core in NS (if any) will be rewiewed. Implications of the strange cores in NS for the NS radii will be described.

session 2

Observations of X-ray bursts and accreting millisecond pulsars

in 't Zand, Jean (SRON)

Thermonuclear shell flashes on neutron stars, that are abundantly detected as bright X-ray bursts since the advent of X-ray astronomy four decades ago, are interesting for particularly two reasons. First, they can provide valuable constraints on the elusive nature of neutron stars and their immediate surroundings, and, second, they entail nuclear reactions seen nowhere else in the universe. We will review the observational characteristics of this phenomenon, concentrating on recent developments and what hopes there are for the near and far future with current and future instrumentation. One development concerns burst oscillations, which comprise are a unique timing feature emanating directly from the surfaces of neutron stars. Thanks to their occurrence on several accreting millisecond pulsars, their diagnostic power is enhanced.

session 4

Modeling thermal structure of magnetars: heating versus cooling

Kaminker, Alexander (Ioffe Physical Technical Institute), A.A. Kaurov. University of Chicago, Chicago, USAA.Y. Potekhin, Ioffe Physical Technical Institute, St. Petersburg, RussiaD.G. Yakovlev, Ioffe Physical Technical Institute, St. Petersburg, Russia

We model thermal structure of magnetars as highly magnetized warm neutron stars with internal heat sources in the neutron star crust. We analyze spreading of heat from the heat source for different heat source locations, geometries and heat intensities using two and one dimensional cooling codes. We formulate the conditions under which the generated heat can be efficiently transported to the surface and emitted there as intense X-ray radiation (rather than emitted by neutrinos from the stellar interior without heating the surface). We apply these results to build a realistic model for the heat sources and for energy budget of magnetars.

session 6

New instability windows and evolution scenario for rotatingneutron stars in LMXBs

Kantor, Elena (Ioffe Institute), M. Gusakov, A. Chugunov

We reanalyze the r-mode instability in rotating superfluid neutron stars. To this aim we develop a model of resonance interaction of normal $m = 2$ r-mode with superfluid modes. We show that this interaction dramatically modifies the instability window, that is the region of stellar spin frequencies and temperatures in which a neutron star becomes unstable with respect to radiation of gravitational waves. This modification allows us to formulate an evolution scenario for neutron stars in LMXBs that can explain all rapidly rotating neutron stars observed in LMXBs. We demonstrate that neutron star rotation frequency is limited by the instability of $m = 3$ r-mode rather than $m = 2$ r-mode, as is usually believed. This result agrees with the predicted value of the cutoff spin frequency ~ 730 Hz, derived from statistical analysis of the accreting millisecond X-ray pulsars. Confronting our scenario with observations opens a new possibility to put stringent constraints on the properties of superdense matter.

This study was supported by RF Presidential Programme (grants MK-857.2012.2 and NSh-4035.2012.2), RFBR (grants 11-02-00253-a and 12-02-31270-mol-a), and by Ministry of Education and Science of Russian Federation (Agreement No. 8409, 2012).

session 3

The soft gamma-ray pulsar population and its link to the Fermi LAT pulsar population: a full high-energy picture

Kuiper, Lucien (SRON-Utrecht), W. Hermsen

While at high-energy gamma-rays (>100 MeV) the Fermi LAT already detected more than 120 pulsars since its launch in June 2008, the number of pulsars seen at soft gamma-rays (20 keV - 30 MeV) is still very limited, though steadily growing.

Namely, in recent years targeted deep radio and/or X-ray observations of Supernova remnants, GeV and TeV sources and newly discovered INTEGRAL sources revealed the presence of young and energetic pulsars, surrounded by bright pulsar wind nebulae (PWN).

Currently, the total number of detected soft gamma-ray pulsars counts 16 secure members. The average characteristics of these soft gamma-ray pulsars differ from those of the LAT detected pulsars, e.g. the Fermi LAT pulsar population typically reaches its peak luminosity at GeV energies, the soft gamma-ray pulsar

population does so at MeV energies. In this presentation I will discuss the characteristics of this soft gamma-ray pulsar population in comparison with the Fermi LAT findings in order to obtain a full high-energy picture of the pulsar population.

session 5

Accreting Magnetars

Kylafis, Nikolaos (University of Crete), Joachim Truemper

It is well known that accretion onto magnetic neutron stars, with magnetic fields in the range of 10^{12}–10^{13} G, results in the formation of a radiative shock in the accretion column. For luminosities of Anomalous X-ray Pulsars (AXPs) and Soft Gamma-ray Repeaters (SGRs), which are in the range 10^{34}–10^{36} erg/s, the transverse optical depth of the accretion column at the shock is relatively small compared to that of normal X-ray pulsars like Her X-1. Assuming that AXPs and SGRs have normal (10^{12}–10^{13} G) dipole fields and accrete from a fall-back disk, we have studied by Monte Carlo the upscattering of soft X-ray photons by allowing them to crisscross the radiative shock as many times as the optical depth dictates. We have found that the resulting X-ray spectrum reproduces the persistent and transient X-ray spectra, both soft and hard, observed from AXPs and SGRs. In particular, one can obtain a high-energy power-law spectrum, with photon number spectral index $\Gamma \sim 1$ and a cutoff around 100 keV, with a transverse Thomson optical depth of ~ 5. In our model, the outbursts with super-Eddington luminosities are produced in localized super-strong (10^{14}–10^{15} G) multipole fields.

session 5

Magnetar seismology and the physics of neutron-star interiors

Levin, Yuri (Monash University)

Among neutron stars, magnetars are distinguished by their super-strong magnetic fields, with 10^{13} - 10^{15} Gauss on the outside and possibly even higher on the inside. Part of their magnetic energy is released in bright flares that are observed with x-ray and gamma-ray telescopes.

In this talk I will present a theoretical investigation into the mechanism of the flare energy release, and the subsequent shaking of the star. I will make connection with the quasi-periodic oscillations that have been observed in the x-ray lightcurves of some giant flares.

session 2

Thermonuclear bursts from slowly and rapidly accreting neutron stars

Linares, Manuel (IAC), Chakrabarty, Cumming, Keek, Altamirano, van der Klis, Connaughton, Jenke, et al.

Models of thermonuclear burning on accreting neutron stars predict different ignition regimes, depending mainly on the mass accretion rate per unit area. For more than three decades, testing these regimes observationally has met with only partial success. I will present recent results from the Fermi-GBM all-sky X-ray burst monitor, which is yielding robust measurements of recurrence time of rare and highly energetic thermonuclear bursts at the lowest mass accretion rates. I will also present RXTE observations of thermonuclear bursts at high mass accretion rates, including the discovery of millihertz quasi-periodic oscillations and several bursting regimes in a neutron star transient and 11 Hz X-ray pulsar. This unusual neutron star, with higher magnetic field and slower rotation than any other known burster, showed copious bursting activity when the mass accretion rate varied between 10% and 50% of the Eddington rate. I will discuss the role of fuel composition and neutron star spin in setting the burst properties of this system, and the possible implications for the rest of thermonuclear bursters.

session 3

A reflection model for the cyclotron lines in the spectra of X-ray pulsars

Mushtukov, Alexander (University of Oulu), Juri Poutanen, Valery Suleimanov, Sergey Tsygankov, Dmitrij Nagirner, Victor Doroshenko, and Alexander Lutovinov

Cyclotron resonance scattering features observed in the spectra of some X-ray pulsars show a significant changes of the line energy with the pulsar luminosity. At high luminosities, these variations are often associated with the onset and growth of the accretion column, which is believed to be the origin of the observed emission and of the cyclotron lines. However, this scenario inevitably implies large gradient of the magnetic field strength within the line-forming region, which makes the formation of the observed line-like features problematic.

Moreover, the observed variation of the cyclotron line energy is much smaller than could be anticipated for the corresponding luminosity changes. We argue here that a more physically realistic situation is that the cyclotron line forms when the radiation emitted by the accretion column is reflected from the neutron star atmosphere, where the gradient of the magnetic field strength is significantly smaller. We develop the reflection model and apply it to explain the observed variations of the cyclotron line energy in a bright X-ray pulsar V 0332+53 over a wide range of luminosities.

session 2

Influence of accretion flow on the cooling of neutron star atmospheres after X-ray bursts: implications for mass and radius determination

Nättilä, Joonas (University of Oulu), Juri Poutanen, Jari J.E. Kajava, Outi-Marja Latvala, Duncan Galloway and Valery Suleimanov

Thermonuclear (type-I) X-ray bursts from low mass X-ray binaries (LMXB) can be used to study properties of neutron stars (NS). Some bursts can be so energetic that they cause the whole photosphere of the NS to expand. These photospheric radius expansion bursts (PRE-bursts) can be used to measure NS masses and radii simultaneously.

A common problem encountered using this method is that different bursts from a given system can yield completely different mass and radius measurements. This fact casts a doubt on the robustness of the entire method. We study the PRE burst emission from 4U 1608–52 at various persistent fluxes.

We find a strong dependence of the burst properties on the flux before burst. Bursts that happen during the hard state at low accretion rate show strong evolution of the apparent black body radius which is consistent with the theoretical predictions of the neutron star atmosphere models. On the other hand, bursts occurring during the soft state at a higher accretion rate show constant apparent radius, which is inconsistent with the theory. We then use the hard-state bursts to constrain the neutron star radius and mass in 4U 1608–52. For a NS with mass $M > 1M_{\odot}$ a lower limit on radius of 13 km is obtained.

session 5

Magnetospheric models of magnetar flares

Parfrey, Kyle (Princeton University), Andrei Beloborodov, Lam Hui

Giant flares from soft gamma repeaters are characterised by millisecond rise times, indicating a magnetospheric origin. I will discuss two models for producing the flares, differentiated by whether, before being released by a magnetospheric instability, the flare energy is stored inside the star or in a twisted magnetosphere. To illustrate the latter scenario, I will show results of relativistic force-free MHD simulations in which surface shearing of the stellar crust slowly twists the magnetosphere, leading to inflation of the magnetic field lines away from the star and the formation of a thin current layer. At some critical twist angle this current layer becomes unstable to the tearing instability, triggering rapid large-scale reconnection and dissipating a significant fraction of the free energy stored in the magnetosphere. This behaviour leads to spikes in the spindown torque applied to the star, on timescales anywhere from the long twisting timescale to the stellar spin period. I will compare the torque changes seen in simulations to observations of SGR 1900+14 and SGR 1806-20, and discuss how spindown rate measurements can inform flare models.

session 6

The force-free neutron star magnetosphere linked to its wind.

Petri, Jerome (Observatoire Astronomique)

We present new solutions to the nearly stationary force-free neutron star magnetosphere and its link to the striped wind for arbitrary obliquities. To this end, the time-dependent Maxwell equations are solved in spherical geometry in the force-free approximation using a vector spherical harmonic expansion of the electromagnetic field. An exact analytical enforcement of the divergencelessness of the magnetic part is obtained by a projection method. Special care has been given to design an algorithm able to look deeply into the magnetosphere with physically realistic ratios of stellar R to light-cylinder r_L radius. We checked our code against several analytical solutions, like the Deutsch vacuum rotator solution and the Michel monopole field. We also retrieve energy losses comparable to the magneto-dipole radiation formula and consistent with previous similar works. Finally, for arbitrary obliquity, we give an expression for the total electric charge of the system. It does not vanish except for the perpendicular rotator. This is due to the often ignored point charge located at the centre of the neutron star. It is questionable if such solutions with huge electric charges could exist in reality except for configurations close to an orthogonal rotator.

session 1

Advances in X-ray burst modelling

Poutanen, Juri (University of Oulu), Valery Suleimanov

Thermal emission during X-ray bursts is a powerful tool to determine neutron star masses and radii, if the Eddington flux and the apparent radius in the cooling tail can be measured accurately, and distances to the sources are known. I discuss here a novel method of determining the basic stellar parameters using the data from the cooling phase of long, photospheric radius expansion bursts covering a large range of luminosities. For this purpose, we computed a large set of atmosphere models for burst luminosities varying by two orders of magnitude and for various chemical compositions and surface gravities. We show that the variation of the inverse square root of the apparent blackbody radius with the flux, observed during the photospheric radius expansion bursts from a number of sources at low accretion rate is entirely consistent with the theoretical expectations of the color-correction factor evolution. However, for bursts happening at higher accretion rates the observed evolution is inconsistent with theory, implying that accretion strongly disturbs the neutron star atmosphere. These findings have profound implications for the recent claims on determination of the neutron star radii and masses from such bursts. Our method allows us to determine both the Eddington flux and the ratio of the stellar apparent radius to the distance much more reliably. For 4U 1724-307, we find a lower limit on the neutron star radius of 13 km, independently of the chemical composition. These results suggest that the matter inside neutron stars is characterized by a stiff equation of state.

In this talk, I will also discuss the potential of Astro-H to make a progress in understanding the physics of X-ray bursts.

session 3

Multiwavelength Studies of the Black Widow and Redback Population

Roberts, Mallory (Eureka Scientific/NYU Abu Dhabi), Maura McLaughlin, Jason Hessels, Scott Ransom, Paul Ray, Pete Gentile, Rene Breton, Fernando Camilo, Matthew Kerr, Ester Aliu

Since 2009, the numbers of Black Widows (eclipsing millisecond pulsars with $\sim$0.01-0.04 $M_\odot$ companions) and Redbacks (eclipsing millisecond pulsars with $\sim$0.1-0.4 $M_\odot$ companions) in the Galactic field has increased enormously. We have been systematically studying many of these newly discovered systems at multiple wavelengths. Typically, the companion is nearly Roche-lobe filling and heated by the pulsar which drives mass loss from the companion. The pulsar wind shocks with this material just above the surface of the companion. We will discuss various observational properties of these systems including radio eclipses, orbitally modulated X-ray emission, reprocessed optical emission, and the potential for γ-ray emission. As a class, Redbacks, which have larger, likely non-degenerate companions, generally seem to have more luminous shocks than black widows which have very low mass companions. This is expected since the more massive redback companions intercept a greater fraction of the pulsar wind. This might make them better targets for TeV studies. We will also compare these systems to accreting millisecond pulsars in quiescence, which may represent a redback or black widow like phase with the radio pulsations eclipsed throughout their orbit.

session 4

Neutron star cooling theory

Shternin, Peter (Ioffe Physical-Technical Institute), Yakovlev Dmitrii

We review the current status of theories of thermal evolution of neutron stars. The main focus is made on young and middle-aged isolated neutron stars which cool predominately via neutrino emission from their interiors. Predictions of theoretical models are confronted with observations of the thermal emission from neutron star surfaces. Constrains on the properties of superdense matter which can be inferred from the observations are discussed.

session 4

Carbon atmosphere models for neutron stars.

Suleimanov, Valery (IAAT), D. Klochkov, G.G. Pavlov, G. Pühlhofer, B. Posselt, S. Simon, K. Werner and A. Santangelo

We present an extended grid of neutron star carbon .atmosphere models. The grid contains 549 model atmospheres for 9 values of surface gravity $\log g$, from 13.7 to 14.9 with a step of 0.15, and 61 values of effective temperature $T_{\rm eff}$, from 1 to 4 MK with a step of 0.05 MK. The computed photon spectra were used as an input to XSPEC. We describe the basic properties of the models and their usage to fit the X-ray spectra of central compact objects (CCOs) in some supernova remnants. A carbon atmosphere was recently suggested for the CCO in Cas A to bring its size in accordance with the canonical neutron star radii (Ho & Heinke 2009). A similar non-pusatting CCO in the center of supernova remnant HESS J1731−347 / G353.6−0.7 has been

discovered with XMM-Newton. Fitting the XMM-Newton spectrum of the CCO with our models, we obtained $M = 1.5^{+0.4}_{-0.6}\ M_\odot$, $R = 12.6^{+2.1}_{-5.3}$ km, and $T_{\rm eff} = 2.2^{+1.2}_{-0.2}$ MK for the neutron star at the adopted distance of 3.2 kpc.

session 3

Power spectra of transient X-ray pulsars: estimation of the neutron stars magnetic field

Tsygankov, Sergey (FINCA)

We report the results of studies of power density spectra (PDS) of the X-ray flux variability in accreting X-ray pulsars. PDS of X-ray pulsars fed from an accretion disk have a distinct break/cutoff at the neutron star spin frequency in the case of corotation (Revnivtsev et al., 2009). This break is a manifestation of the transition from the disk to the magnetospheric flow at the frequency which is characteristic for the truncation radius of the accretion disk (magnetospheric radius). Suggesting that the PDS break frequency is directly related to the magnetospheric radius for a given value of the mass accretion rate, the method for estimate the magnetic moment of accreting compact stars is proposed. Comparison of magnetic field's values derived by this method and using the position of the cyclotron absorption line for a number of sources is presented.

session 5

Magnetar bursts

Watts, Anna (University of Amsterdam)

Magnetars are highly active, with regular spectacular outbursts of gamma-ray bursts powered by decay of the magnetic field. The largest bursts (the so-called giant flares) are so powerful that they trigger long-lived seismic vibrations of the neutron star. This has led to the emergence of the new field of neutron star asteroseismology. More generally, burst light curves allow us to explore not only strong magnetic field effects but also the various instabilities that might be involved in the trigger mechanism. In this talk I will review some recent developments in our efforts to understand the burst emission process, motivated in part by high quality burst lightcurve data from the Fermi Gamma-ray Burst Monitor. I will discuss the trapped fireball model, how emission might be modulated by seismic vibrations, and the processes involved when burst luminosities exceed the Eddington limit.

session 6

Selfsimilarity relations for cooling superfluid neutron stars

Yakovlev, Dmitry (Ioffe Physical Technical Institute), P.S. Shternin, Ioffe Physical Technical Institute

We discuss models of cooling neutron stars with nucleon cores which possess moderately strong triplet-state superfluidity of neutrons. When the internal temperature drops below the maximum of the critical temperature, this superfluidity sets in, producing a neutrino outburst due to Cooper pairing of neutrons and greatly accelerating the cooling. We formulate selfsimilarity relations which describe the cooling at this stage and apply them to interpret the observations of the neutron star in the Cassiopeia A supernova remnant.

2 Posters

S9_poster

Noise Strength Estimates of magnetars AXP 4U 0142+61, Swift J1822.3-1606, SGR J1833-0832 and Swift J1834.9-0846.

Cerri, Danjela (Middle East Technical University), Prof. Altan Baykal; S.Cagdas Inam; M.Mirac Serim

We aim to represent in detail the timing properties of Anomalous X-Ray Pulsar AXP 4U 0142+61 together with X-ray timing and spectral features of Soft Gamma Repeaters SGR J1833-0832, SWIFT J1822.3-1606 and SWIFT J1834.9-0846. The study of pulse frequency evolution, pulse profile geometry and flux decay time scales of this sources using the RXTE and SWIFT satellite observations will be included as well. According to what we have calculated so far, except AXP 4U 0142+61, timing noise of these neutron stars are linked with their spin down rates, leading us to think that the magnetic field may rupture the neutron star's crust in micro scale which would in return causes delay in pulse arrival times. Our future plans consist of further investigation of this relation.

S9_poster

Thermal g-modes in superfluid neutron stars

Kantor, Elena (Ioffe Institute), M. Gusakov

It is well known that the nonsuperfluid matter of neutron stars supports the so-called composition g-modes. At the same time it is generally believed that g-modes cannot propagate in superfluid neutron star matter. Here we demonstrate that proper account for the finite stellar temperatures gives rise to the peculiar thermal g-modes in superfluid neutron stars. We calculate the eigenfrequencies and e-folding times for these modes and demonstrate, that at certain temperature gradients they can be convectively unstable.

This study was supported by RF Presidential Programme (grants MK-857.2012.2 and NSh-4035.2012.2), RFBR (grants 11-02-00253-a and 12-02-31270-mol-a), and by Ministry of Education and Science of Russian Federation (Agreement No. 8409, 2012).

Symposium S10

The co-evolution of black holes and galaxies

1 Oral contributions

Occupation of X-ray selected Galaxy Groups by X-ray AGN in COSMOS

Allevato, Viola (University of Helsinki), A. Finoguenov, G. Hasinger, T. Miyaji, N. Cappelluti, M. Salvato, G. Zamorani, R. Gilli, M. R. George, M. Tanaka, M. Brusa, J. Silverman, F. Civano, M. Elvis and F. Shankar

I'll present the first direct measurement of the mean halo occupation distribution (HOD) of X-ray-selected AGNs in the COSMOS field at z $\leq$ 1, based on the association of 41 XMM and 17 C-COSMOS AGNs with member galaxies of 189 X-ray-detected galaxy groups from XMM-Newton and Chandra data. I'll show that the mean HOD of AGNs among central galaxies is modeled by a softened step function at log M_h > log M_min = 12.75(12.10, 12.95) M_sun while the satellite AGN HOD shows a preference for an increasing AGN fraction with M_h , suggesting that the average number of AGNs in satellite galaxies grows slower ($\alpha < 0.6$) than the linear proportion ($\alpha = 1$) observed for the satellite HOD of samples of galaxies.

Compact Massive Objects in galaxies: the sequence from massive black holes to Nuclear Star Clusters

Arca-Sedda, Manuel (Dep. of Physics, Sapienza, Univ. of Roma, Italy), Roberto Capuzzo-Dolcetta

There is evidence of the presence of Compact Massive Objects (CMOs) in galaxies over the whole Hubble sequence. Very massive galaxies harbor massive and supermassive black holes (SMBHs), i.e. superdense states of matter, while fainter galaxies show the presence of looser "objects", like resolved stellar nuclei (in ellipticals) and Nuclear Star Clusters (NSCs, mainly in spirals). The origin of these different mass aggregations is still uncertain. An ascertained point is the existence of some correlation among the small space-time scales of the central condensation and those, larger, of the hosting galaxy. Actually, it has been convincingly shown that scaling relations exist between NSCs and their hosts; it is still unclear, however, how these relations are connected with those between SMBHs and the hosts. In this talk we will show how the hypothesis of formation of NSCs by mean of "migration" of massive globular clusters to the cenrte of the host galaxy by mean of the dynamical friction effect fits observational scaling laws, accounting for the observed NSCs masses and properties, in the direction of an interpretation of the link between the total host galaxy luminosity and the type of CMO contained.

The environments of z$\sim$5 QSOs

Bremer, Malcolm (University of Bristol), Kate Husband, Luke Davies, Elizabeth Stanway, Matt Lehnert

Much theoretical work has suggested or assumed that the most distant luminous QSOs are found at the peaks of the high redshift density field, in the most clustered and overdense regions. These regions will have undergone the strongest early evolution and growth enabling the supermassive black holes and their relatively

massive host galaxies to form in the limited time available since the Big Bang. Until now observational studies of z∼5 and higher QSO environments have had mixed and ambiguous results, often because of the techniques used and because they have attempted to explore QSOs at too high a redshift:- even significant clustering could be missed. We present results of a new study of z∼5 QSO environments where overdensities of Lyman break galaxies around them are searched for photometrically and then crucially followed up spectroscopically. Importantly, we use the same techniques as those used in our previous field LBG survey that clearly identified a range of clustering behaviours, and so can be used as a control and for comparison:- we know what the clustering signal should look like in our data. We show that luminous z∼5 QSOs are found in overdense environments, but not necessarily the most overdense at that redshift (the field can show stronger clustering). For the QSO found in the strongest overdensity, a likely protocluster, we consider which characteristics of the QSO and host are the best predictors for a strongly clustered environment.

The host galaxies properties of z∼2 obscured AGN: evidence for AGN feedback and outflows

Brusa, Marcella (DIFA Bologna)

Quasar feedback on host galaxies in the form of powerful outflows is invoked as a key mechanism to quench star formation in massive galaxies, but direct observational evidences are still scarce, and the debate on the physical origin of the observed outflows is still open. I will review the most recent results on AGN-galaxy co-evolution on this topic, obtained from large area and deep X-ray surveys and discuss the expected contribution of near-infrared and millimeter follow-up observations towards a better understanding of the co-eval AGN-galaxy growth.

Revealing the AGN Feedback through Broad Wings of CO Emission Lines

Cicone, Claudia (University of Cambridge)

Negative feedback from AGNs is invoked by theoretical models to explain the red-and-dead properties of nearby massive galaxies and the local "M_BH-sigma" relationship. Finding observational evidence of such feedback in action is one of the main challenges of current extragalactic astronomy. The recent observations of massive molecular outflows in nearby quasar host galaxies constitute a major breakthrough in this field. However, so far, these outflows have been found and studied only in few, exceptional galaxies, and little is known about their origin and physics. I will present new detections of powerful molecular winds in a sample of AGNs and ULIRGs, traced by broad wings of the CO(1-0) emission line, observed with IRAM PdBI. By including data from the literature, I have assembled a total of 16 molecular outflows detections in local galaxies, spanning a wide range of AGN and starburst activity. I have found that outflow rates are significantly "boosted" in AGNs. I have discovered, for the first time, a tight correlation between outflow rate and AGN luminosity. Outflow kinetic power and AGN power are also correlated, and their ratio is very close to the expectations of models of AGN feedback (i.e. 5%). Interestingly, my results show that only in a few of the starburst-dominated sources the outflow energetics are fully consistent with entirely star-formation driven winds.

An observational outlook on massive black holes and host galaxies

Decarli, Roberto (Max Planck Institue for Astronomy)

Over the last 15 years, the correlation between the mass of massive black holes and some large-scale properties (luminosity, mass, velocity dispersion of stars) of their host galaxies has become an observational cornerstone for our models of galaxy formation and evolution. Here I review the status of the observational efforts and their future perspective. Concerning the local Universe, the main goals nowadays are the extension of the scaling relations towards intermediate black hole masses ($< 10^6 M_\odot$) and the census of outliers, especially at high black hole masses ($> 10^{10} M_\odot$). At high redshift, the challenges are the self-consistency of the tracers, especially when compared with low-z studies. Here the advent of the Atacama Large Millimeter Array and of the James Webb Space Telescope will allow us to make a transformational step forwards in our insight of galaxy evolution.

Supermassive black hole growth at z>4.75 in cosmological hydrodynamic simulations

DeGraf, Colin (Hebrew University of Jerusalem), Tiziana Di Matteo

Supermassive black holes have been shown to reside at the center of most galaxies, with strong evidence

for significant interaction between growth of the black hole and evolution of the host galaxy. Cosmological simulations provide an ideal means of probing the growth of these black holes in the context of galaxy evolution and gas inflow/outflow. I will discuss an extremely large (0.75 Gpc)^3 hydrodynamic simulation which directly incorporates black hole growth (through accretion and mergers) and feedback, showing it is able to well-reproduce the high-z quasar populations. I will use this simulation to demonstrate how black holes grow in the early (z>4.75) universe, in particular how high density cold streams can fuel accretion to produce black holes of 10^9 solar masses by z=6-7, while lower-mass black holes follow a well-defined growth pattern set by local gas density. Additionally, I will discuss how these black holes evolve along the M-sigma relation at z≤5, and how galaxy mergers impact their evolutionary tracks along the M-sigma plane.

Measuring the Masses of Supermassive Black Holes: Methods, Challenges, and Recent Advances

Denney, Kelly (DARK Cosomology Centre - Denmark)

I will review the four common dynamical methods with which we can measure the masses of supermassive black holes at the centers of galaxies - stellar and gas kinematics in quiescent galaxies and megamaser dynamics and reverberation mapping in active galaxies - and present the impetus for why we are interested in such measurements in the context of galaxy evolution. I will then highlight important advances that we are making in determining reverberation-based BH masses and discuss recent work to improve single-epoch black hole masses estimates based on AGN scaling relationships used for high-redshift BH mass measurements.

AGN feedback in hydro cosmological simulations of galaxy formation

Dubois, Yohan (IAP, France)

Feedback processes are thought to solve some of the long-standing issues of the numerical modeling of massive galaxies: over-cooling, low angular momentum, massive blue galaxies, extra-galactic enrichment, etc. The accretion of gas onto super-massive black holes in the centre of massive galaxies can release tremendous amounts of energy to the surrounding medium. I will show, with cosmological Adaptive Mesh Refinement simulations, how the growth of black holes is regulated by the feedback from Active Galactic Nuclei. I will discuss how this large amount of feedback is able to modify the mass content of galaxies and the consequences on their morphological properties.

Stellar populations and star formation rates of X-rays selected AGN at z∼1

Hernán-Caballero, Antonio (Instituto de Física de Cantabria), Almudena Alonso-Herrero, Pablo Pérez-González, Nicolás Cardiel, Antonio Cava and the SHARDS team

We report on results from the analysis of the stellar populations and star formation rates in the host galaxies of X-rays selected optically faint AGN at 0.65<z<1.1 with ultra-deep ($m_{AB} < 26.5$) optical medium-band (R∼50) photometry from the Survey for High-z Absorption Red and Dead Sources (SHARDS). The spectral resolution of SHARDS allows us to consistently measure the strength of the 4000 Å spectral break, while deep mid- and far-infrared photometry from Spitzer and Herschel provide strong constraints on the contributions of the AGN and star formation to the infrared output of these galaxies. We confirm that most X-ray selected AGN are hosted by massive galaxies (typically $M_* > 10^{10.5}$ $M_\odot$) and that the fraction of galaxies hosting an AGN increases with the stellar mass. AGN-hosts have light-weighted average stellar ages comparable to those of a control sample of non-AGN galaxies with the same mass distribution, but there is a deficit of AGN among the massive galaxies with the youngest and oldest stellar populations. The star formation rate of z∼1 AGN hosts is on average slightly above the main sequence of star-forming galaxies. However, the specific star formation rate of AGN hosts spans 3 orders of magnitude from quiescent to starburst, and the fraction of galaxies hosting an AGN increases steeply with the specific star formation rate.

Co-evolution: Do black holes actually matter for galaxy evolution?

Jahnke, Knud (MPIA, Heidelberg)

Overall stellar and black hole mass densities in the Universe show a qualitatively similar function over cosmic time. It is notably similar but not identical. At the same time cosmic averaging has been identified as one or

even the major driver for BH-galaxy scaling relations. So the obvious question is: is there any causal physical coupling at all between the growth of black holes and the growth of stars in galaxies? If yes, at which epoch, mass scale, environment and, most interesting, in what is cause and what is effect? Could it be that for the bulk of galaxies both BH and stars are simply subject to the same streams of gas flowing into galaxies, and are both simply subject to the ever-decaying reservoirs of available gas?

I will attempt to sort our knowledge and ignorance and try to sketch out which 'knowledge' is actual solid and which might is not actually based on evidence. This will automatically lead to where progress could be made in the intermediate future.

Equal and Unequal-mass mergers of galaxies with thermal and kinetic feedback from black holes

Johansson, Peter (University of Helsinki), Ena Choi, Thorsten Naab, Jeremiah P. Ostriker

Observations in the last decade have shown that supermassive black holes (SMBHs) reside in the centers of all massive galaxies. The properties of the SMBHs and their host galaxies are correlated in a number of ways, with more massive black holes being found in general in more massive galaxies. Using numerical simulations of binary galaxy merger simulations of both gas-rich disk galaxies and gas-poor elliptical galaxies including radiative cooling, star formation and black hole accretion we demonstrate that the observed M_BH-sigma and M_BH-M_bulge relations can be reproduced in numerical simulations.

In addition, we study the impact of feedback from SMBHs on the properties of galaxies. In particular we attempt to constrain the energy input mechanism of the black holes. In typical feedback models the energy extracted from the SMBH is inputted thermally heating the gas, whereas a more realistic case would involve a mixture of thermal heating and kinetic feedback, resulting in mass outflows on galactic scales, in agreement with observed active galaxies.

Properties of the quasar environments in the nearby Universe

Karhunen, Kalle (University of Turku), Kotilainen, J., Falomo, R., Bettoni, D.

We present a photometrical study of the properties of the environments of low redshift ($z < 0.5$) quasars based on a large and homogeneous dataset from the Stripe 82 subsection of SDSS DR7. For this sky region, deep (r $\sim$23.5) u,g,r,i,z band images reach up to 2 magnitudes deeper than the rest of the survey. Our sample consists of 416 quasars, greatly outnumbering previous studies of low redshift quasars. The < 1 Mpc scale environments of the quasars in the i-band were compared to those of 580 passive early-type control galaxies, selected from Stripe 82 to have similar redshift and galaxy luminosity distributions to the quasar sample.

We find the galaxy number density of the quasar environments to be comparable to that of the control galaxies, both showing significant excess compared to the background galaxy density at distances < 400 kpc. There is no significant dependence of the galaxy density in the quasar environments on either redshift or quasar luminosity.

In the near future, we shall analyze the data in all the five SDSS filters, to study the colours of the galaxies in the quasar environments as evidence for recent star formation. We shall also compare the environments with the black hole mass and host galaxy luminosity and mass of the quasars, and study the role of their very close environments in igniting the nuclear activity.

The host galaxies of low-redshift quasars in the SDSS Stripe 82

Kotilainen, Jari (FINCA, University of Turku)

We present a study of the host galaxies of low redshift ($z < 0.6$) quasars, based on a large homogeneous dataset from the Stripe 82 subsection of SDSS. In this region, SDSS imaging reaches up to 2 mag deeper than DR7. Our sample consists of $\sim$400 quasars, greatly outnumbering all previous studies of low redshift quasars. The host galaxy is resolved in $\sim$80% of the quasars. The hosts are practically all very luminous galaxies, between M*-3 and M*. For well resolved quasars, the morphologies of the host galaxies turn out to be more complex than found in previous studies. Quasars are hosted in a variety of galaxies from pure ellipticals to composite morphologies with spheroids, disks, lenses and halos. The black hole masses of the quasars, estimated from their spectral properties, are significantly correlated with the bulge, but not the total luminosity of the host galaxy.

Is the $M_\bullet - L_{\rm bul}$ relation really fundamental ?

Läsker, Ronald (MPIA Heidelberg), Laura Ferrarese Glenn van de Ven Francesco Shankar

I present a re-calibration of the $M_\bullet - L_{\rm bul}$ relation at NIR wavelengths, based on a dedicated set of wide-field imaging data that we obtained on CFHT/WIRCam. After deriving bulge ($L_{\rm bul}$) as well as *total* host luminosities ($L_{\rm tot}$) from these data, and relating them to dynamically measured (published) masses ($M_\bullet$) of 35 BH host galaxies of all Hubble types, we arrive at three significant conclusions: First, the log-slope of the $M_\bullet - L_{\rm bul}$ relation has been overestimated previously and now, at the updated value of 0.77 ± 0.10, it strongly implies a disproportionality of BH and host bulge mass. Second, this observed slope depends systematically on the detail of the decomposition, i.e. whether or not nuclei, bars, spiral arms and inner disks are identified and accounted for, while notably the intrinsic scatter is almost unaffected. In contrast, the relation of $M_\bullet$ with $L_{\rm tot}$ is consistent with a direct proportionality, and its characterization robust with respect to the photometric method. Third, *the intrinsic scatter of both relations is consistent.* In combination, these results question the widely-held view that the $M_\bullet - L_{\rm bul}$ relation is "fundamental", both from an observational as well as a theoretical point of view. We stress that the quality of our data was instrumental in obtaining these results: surpassing the resolution and depth of any imaging repository previously available for these objects, it enabled us to perform detailed and reliable two-dimensional decompositions, and to derive unbiased bulge parameters. I also briefly describe the specialized strategy of NIR background subtraction that we applied, discuss the role of pseudobulges, and take a look at statistical aspects of characterizing the BH scaling relations.

Non-evolution of the dependence of black hole masses on bolometric luminosities for QSOs

López-Corredoira, Martín (Instituto de Astrofísica de Canarias), Carlos M. Gutiérrez

There are extremely luminous quasi stellar objects (QSOs) at high redshift which are absent at low redshift. The lower luminosities at low redshifts can be understood as the external manifestation of either a lower Eddington ratio or a lower mass. To distinguish between both effects, we determine the possible dependence of masses and Eddington ratios of QSOs with a fixed luminosity as a function of redshifts; this avoids the Malmquist bias or any other selection effect. For the masses and Eddington ratios derived for a sample of QSOs in the Sloan Digital Sky Survey, we model their evolution by a double linear fit separating the dependence on redshifts and luminosities. The validity of the fits and possible systematic effects were tested by the use of different estimators of masses or bolometric luminosities, and possible intergalactic extinction effects.

The results do not show any significant evolution of black hole masses or Eddington ratios for equal luminosity QSOs. The black hole mass only depends on the bolometric luminosity without significant dependence on the redshift as on average for z$\leq$ 5. This must not be confused with the possible evolution in the formation of black holes in QSOs. The variations of the environment might influence the formation of the black holes but not their subsequent accretion. It also leaves a question to be solved: Why are there not QSOs with very high mass at low redshift? A brief discussion of the possible reasons for this is tentatively pointed out.

The strong environmental dependence of black hole scaling relations

McGee, Sean (Leiden Observatory)

I will discuss how the scaling relations between central black hole mass (Mbh) and host galaxy properties (velocity dispersion, bulge stellar mass and bulge luminosity) depend on the large scale environment. For each of a sample of 69 galaxies with dynamical black hole measurements we compile four environmental measures (nearest neighbor distance, fixed aperture number density, total halo mass, and central/satellite). We find that central and satellite galaxies follow distinctly separate scalings in each of the three relations we have examined. The Mbh - sigma relation of central galaxies is significantly steeper than that of satellite galaxies, but has a similar intercept. This behavior remains even after restricting to a sample of only early type galaxies or after removing the 8 brightest cluster galaxies. The Mbh - sigma relation shows more modest differences when splitting the sample based on the other environmental indicators, suggesting that they are driven by the underlying satellite/central fractions. Separate relations for centrals and satellites are also seen in the power law scaling between black hole mass and bulge stellar mass or bulge luminosity. We suggest that gas rich, low mass galaxies undergo a period of rapid black hole growth in the process of becoming satellites. If central galaxies on the current Mbh - sigma relation are representative progenitors of the satellite population, the observations imply that a sigma = 120 km/s galaxy must nearly triple its central black hole mass. The

elevated black hole masses of massive central galaxies are then a natural consequence of the accretion of satellites.

The many manifestations of AGN feedback: is the galaxy/BH relation a result of self-regulation?

Monaco, Pierluigi (Universita' di Trieste)

Accretion of gas on supermassive black holes hosted in the potential wells of galaxies can generate huge amounts of energy. However, the efficiency with which this energy is given to the interstellar medium can be very low. Feedback from active galactic nuclei (AGN) has been proposed as a mechanism to (1) suppress star formation in the host galaxy and thus self-regulate black hole and galaxy growth, (2) suppress cooling in massive halos (galaxy groups and clusters) and thus avoid late star formation in massive elliptical galaxies. These two suppression schemes are connected with different accretion regimes. Winds or radiation pressure from radiatively efficient AGNs (quasars), possibly triggered by mergers, may self-regulate the galaxy/black hole relation; however, this may be due to the same mechanism that regulates the accretion of gas, if not to stochastic mergers. Jets from radiatively inefficient AGNs (radio galaxies) are usually held responsible for the suppression of cooling in galaxy clusters, though many details of this proposed mechanism are not yet understood. I will review how the two feedback schemes are commonly implemented in semi-analytical models and numerical codes of galaxy formation, and the main results that have been obtained with the two techniques. I will finally highlight the connection between the downsizing trends observed in galaxies and in AGNs.

Cold gas in the life of radio sources: status and future perspectives

Morganti, Raffaella (ASTRON & Kapteyn Institute)

Massive gas outflows are considered a key component in the process of galaxy formation and evolution. I will present recent results obtained from HI and CO observations of a number of objects where the AGN - and in particular the radio jet - is playing a major role in producing large and fast gas outflows. The results are reinforcing the conclusion that gas outflows have a complex and multiphase structure and that cold gas in different phases (atomic and molecular) represents a major component. High-spatial resolution observations have allowed, in a number of sources, to locate the region where the outflow originates as well as to derive more accurate estimates of the mass outflow rate and the associated energy. Therefore, these results provide important constraints for understanding the mechanisms that lie at the origin of the outflows. A possible link between the evolutionary stage of the radio source and the presence of outflow will also be discussed. All these topics will be further investigated in the near future by a number of new telescopes available to the European community: ALMA (with time already allocated for one of the objects), LOFAR and Apertif, the upgrade of the Westerbork radio telescope. I will comment on what these instruments will do for us.

Star formation in the host galaxies of AGN up to $z \approx 3$

Pannella, Maurilio (CEA-Saclay), James Mullaney, Emanuele Daddi, David Elbaz and the GOODS-Herschel collaboration

We present a study of the infrared properties of X-ray selected, moderate luminosity (i.e, Lx=10^{42}-10^{44} ergs/s) active galactic nuclei (AGNs) up to z$\sim$3, in order to explore the links between star formation in galaxies and accretion onto their central black holes. We use the deepest survey yet undertaken by the Herschel telescope and show that in the vast majority of cases (i.e., more than 94%) the FIR fluxes are dominated by emission from the host galaxy. As such, these far-infrared bands provide an uncontaminated view of star formation in the AGN host galaxies. The main results of our work are: i) we confirm that the star formation rates of AGN hosts increase strongly with redshift, and in a way entirely consistent with the normal population of star-forming galaxies (Main Sequence); ii) we estimate that most ($\approx$80%) of moderate luminosity AGNs are hosted in main-sequence galaxies, $\approx$15% per cent in quiescent galaxies and only less than 10% in strongly starbursting galaxies; iii) we find that the fractions of star forming galaxies that are experiencing a period of moderate nuclear activity is dependent on galaxy stellar mass; rising from just a few per cent at Mgal 10^{10}Msun to $>\sim$20 per cent at Mgal$\leq 10^{11}$Msun. Finally, we argue that the majority of moderate nuclear activity is fuelled by internal mechanisms rather than violent merger events, which suggests that high redshift disk instabilities could be an important AGN feeding mechanism.

Co-evolution of Black Holes and Galaxies : The role of observational biases

Portinari, Laura (Tuorla Observatory, Dept. of Physics and Astronomy, University of Turku), Jari Kotilainen, Renato Falomo, Roberto Decarli

Quasars are useful tracers of the cosmological evolution of the BH mass–galaxy relation. Their host galaxies appear to obey the same BH mass–host luminosity relation as local galaxies. As stellar populations were much younger and brighter at high redshift, this implies that the BH/host mass ratio was much larger (up to a factor of 10) in the past.

However, since quasars preferentially trace very massive black holes ($10^9 - 10^{10}\ M_\odot$) at the steep end of the luminosity and mass function, a careful comparison to semi-analytical models reveals that selection effects and statistical biases dominate the interpretation of the observational results. Current data are, ultimately, still compatible with the idea that BH and galaxies co-evolved with a constant mass ratio since early epochs.

We discuss the various biases involved in the interpretation of the data, and our prospects for a better quantitative understanding of their effects.

The key role of angular momentum on the black hole accretion rate and on the galaxy mass function.

Rosas Guevara, Yetli (Durham University), Yetli M Rosas-Guevara, Richard Bower, Michelle Furlong, Carlos Frenk, Craig Booth, Rob Crain, Joop Schaye, Matthieu Schaller, Tom Theuns, Claudio Dalla Vecchia, Volker Springel , Simon White

A fundamental open question in galaxy formation is the role that the black holes play in shaping the galaxy around them. The observed black hole scaling relations indicate that there is an intimate connection between the growth of the central black hole and the growth of the bulge. Moreover, galaxy formation models are only able to create the break in the galaxy mass function when the feedback produced by the black hole accretion is invoked. Unfortunately, hydrodynamical simulations have not been able to demonstrate that this compelling idea works so far. We will show that this failure arises simply because the current black hole accretion models do not consider angular momentum. A simple modification of the Bondi accretion formula makes possible to reproduce the break in the galaxy mass function. Furthermore, with this model, the early black hole growth is dominated by violent episodes of Eddington limited accretion strongly resembling quasars, while feedback at late times is dominated by more frequent sub-Eddington outburst that look remarkably similar to radio galaxies.

Accretion, feedback, and gas excitation in nearby AGN host galaxies

Scharwächter, Julia (Observatoire de Paris, LERMA), P. McGregor, M. Dopita, T. Beck, P. Shastri, F. Combes

A detailed knowledge of the properties of the host galaxy ISM is crucial for constraining models of AGN accretion and feedback. The ISM plays an important role as a possible fuel reservoir for AGN accretion. Furthermore, it is a probe of AGN feedback interacting with the ISM through jets, winds and outflows, and/or photoionisation. I will present integral field spectroscopy of the ISM in individual nearby AGN host galaxies, including a high-resolution near-infrared study of the R<50 pc molecular hydrogen accretion disk in Perseus A and optical wide-field spectroscopy of ionised gas in Seyfert galaxies. I will interpret the data in view of accretion and feedback scenarios and discuss physical parameters of the narrow-line region and the ionising AGN.

Local Scaling Relation of Super-Massive Black Holes: Origin, Evolution, Consequences

Shankar, Francesco (GEPI-Observatoire de Paris)

In this talk I will start by reviewing our current knowledge of local scaling relations between super-massive Black holes (SMBHs) and their host galaxies, with a particular emphasis on scatters, slopes, and possible breaks. I will then discuss the most up-to-date theoretical proposals put forward to explain their origin, exact shape, and redshift evolution. I will insert the theoretical review in the more general framework of the co-evolution of SMBHs and galaxies, developing the link with merger and monolithic models of spheroid

formation and the size evolution of massive galaxies. I will finally show how these scaling relations help us inserting SMBHs in a coherent cosmological context, by illustrating their potential in defining the total SMBH mass function, their accretion history, and their Clustering properties.

Cosmic warming: global self-regulation of the growth of massive black holes in the early Universe

Tanaka, Takamitsu (Max Planck Institute for Astrophysics), Rosalba Perna, Zoltan Haiman

Regardless of whether they began their existence as the remnants of massive stars or the catastrophic collapse of massive atomic gas, the supermassive black holes we observe as quasars above redshift 6 must have gained the vast majority of their mass via gas accretion. Such prolific accretion would have released a large amount of X-rays in a short amount of time. Since X-rays can escape the host galaxies and propagate for gigaparsecs before being absorbed in the intergalactic medium, they can globally warm the early IGM to hundreds or even thousands of Kelvin. By reducing the number of halos containing cool gas, X-rays from the growth of the first massive black holes may have globally stunted the growth of nuclear black holes at later times.

Timing the starburst-AGN connection

Wild, Vivienne (School of Physics and Astronomy, University of St. Andrews)

There are many theories successful in explaining the observed scaling relations between black holes and their host galaxies. In turn, these theories play a crucial role in explaining other observed aspects of the galaxy population, such as the red/blue bimodality. Since the advent of large, high quality, spectroscopic galaxy surveys, there has been a rapid increase in research that identifies correlations between host galaxy properties and black hole/AGN properties. However, identifying causation out of all these correlations remains a major challenge. I will review some of the recent literature on the host-galaxy AGN connection at low redshift, and take a look towards upcoming results from new galaxy surveys.

2 Posters

A new class of obese black hole galaxies at z>6

Agarwal, Bhaskar (Max Planck for Extraterrestrial Physics), Andrew Davis, Sadegh Khochfar, Priyamvada Natarajan, Jarrett Johnson, Claudio Dalla Vecchia, James Dunlop

The focus of the talk would be on whether or not there could be galaxies where the central black hole (BH) forms first, followed by the accumulation of the stellar component. There is a scenario where a high level of Lyman-Werner radiation (11.2 -13.6 eV) is able to dissociate H2 molecules in pristine gas, thereby raising the Jeans mass required for collapse and leading the gas directly to the formation of a black hole of mass 104-5 Msun i.e. via the direct collapse (DC) channel. We explore the physical conditions (DM haloes) where this could occur, using our model that treats the LW radiation field locally and globally in our cosmological simulation volume and uses the spin and virial temperature of the dark matter (DM) halo to determine whether it could host a DCBH. We find that at z∼6, there could be as many as 0.03 Mpc-3 objects where the DCBH forms first, which leads these galaxies to have an over-massive black hole, at least initially, and we call these galaxies obese-black hole-galaxies (OBGs). OBGs can be characterized by the absence of a UV-Balmer break and the fact that they would appear as unresolved objects with magnitudes equal to or larger than the galaxies that JWST is expected to observe at z>6. Their abundance also leads to the question of whether or not these OBGs could play a role in reionizing the universe, which I will also briefly glance upon.

Exploring the dusty environs of Active Galactic Nuclei: dusty tori and nuclear star formation

Alonso-Herrero, Almudena (IFCA, CSIC-Universidad de Cantabria)

The fueling of black holes occurring in active galactic nuclei (AGN) is fundamental to the evolution of galaxies. AGN themselves are largely explained in the context of a unified theory, by which a geometrically and optically thick torus of gas and dust obscures the AGN central engine. The exact properties of the torus still remain uncertain. We are conducting a mid-infrared survey of local AGN using the CanariCam instrument on the

10.4m Gran Telescopio Canarias (GTC). The imaging and spectroscopic mid-IR observations are diffraction limited (angular resolution 0.3-0.5") and are part of an ESO/GTC large programme and CanariCam guaranteed time. We complemented the CanariCam sample with mid-infrared imaging and spectroscopy of AGN obtained with other mid-IR instruments (T-ReCS, Michelle, and VISIR) on 8m-class telescopes. The sample is composed of approximately 125 local AGN covering nearly six orders of magnitude in AGN luminosity and including different types of AGN: LINERs, Seyfert 1s, Seyfert 2s, QSO, radio galaxies, and (U)LIRGs. This poster focuses on two main open questions regarding the AGN dusty torus: (1) Do the properties of the dusty torus depend on the AGN type and luminosity, and (2) What is the role of nuclear (<100pc) star formation activity in feeding AGNs.

Orbital resonances and anisotropy around a massive central black hole

Boily, Christian (Strasbourg), T. Padmanabhan, N. Gaudin

A massive black hole will drag stars effectively out to a radius which includes a mass in stars comparable to its own. The impact of small-amplitude BH motion can thus be felt by streams of stars on a scale easily resolvable in the Milky Way and M31. Resonances will alter the profile of the velocity field, which can lead to 'hot' shells of stars seen in projection. The impact these shells may have on the BH evolution will be explored with self-consistent N-body calculations performed on GPU cards to determine the rate at the BH recoils and the likelihood of this recoil being detected.

(submitted as Oral or poster presentation, or both.)

Host galaxy properties of radio selected AGN.

Bonzini, Margherita (ESO), V. Mainieri, P. Padovani, P. Rosati, N. Miller, K. I. Kellermann, P. Tozzi, S.Vattakunnel

Deep radio surveys are an important tool to investigate the evolution of star forming galaxies (SFG) and active galactic nuclei (AGN), since the radio band is much less affected by dust extinction as compared to the optical and soft X-ray frequencies. We are studying a sample of $\sim$ 900 radio sources detected at 1.4 GHz in a VLA survey of the Extended Chandra Deep Field South (E-CDFS) down to $\sim$ 30μJy. Thanks to the wealth of data available in this field, we use a multi-wavelength approach to differentiate AGN from SFG using the ratio between their mid-infrared and radio emission, their IRAC color, and the level of X-ray luminosity. The μJy sensitivity of our survey allows us to explore the faint end of the radio population and to detect not only radio loud AGN, but also a significant population of radio quiet objects. We compare the host galaxies properties (stellar masses optical colors, and morphology) for these radio selected sources. Based on our analysis, the radio emission detected in the radio-quiet AGN is produced by star-formation activity rather than accretion on the central black hole. We have therefore the remarkable opportunity to use the radio emission itself to estimate the star-formation level in the host galaxy and compare it to the star formation rate derived from Herschel observations. Our characterization of the faint radio sky is very relevant for the upcoming radio surveys, which will be soon generated by the Square Kilometre Array (SKA) and its pathfinders.

The Dynamics near Centers of Galaxies with Supermassive Binary Black Holes

Jiang, Ing-Guey (National Tsing Hua University, Taiwan), Li-Chin Yeh

The correlation between the bulges and black holes is constructed under the usual assumption that there is one single supermassive black hole. This is partially due to the difficulties in detecting two black holes at galactic centers. We propose that it is equally important to study the centers of galaxies with supermassive binary black holes. We study the equilibrium points, stellar orbits, and the effect on central density profiles of galaxies in these kind of galactic systems. We find that their properties can be determined through some important and useful conditions.

Radio Sources, Quasars, AGN, and Star Formation

Kellermann, Kenneth (NRAO)

Radio surveys as well as targeted radio observations made with the NRAO Very Large Array with sensitivity as good as 1 microJy/beam rms define the radio emission resulting from accretion onto SMBHs(AGN) and that due to star formation. Surveys of the Chandra Deep field South and the Lockman hole, along with targeted

and survey observations which include QSOs from the SDSS suggest that the sub-milliJy radio sources are due to a combination of star formation and AGN, and that the weak radio emission observed from optically highly luminous but radio quiet quasars is due to star formation from the underlying galaxy and is not from the AGN. Confusion limited VLA observations at 3 GHz show no evidence for a new population of weak radio sources suggested by the high extragalactic non thermal background radiation reported by the ARCADE2 balloon experiment. If due to discrete sources, they cannot be stronger than about 30 nanoJy, and cannot be related to galaxies brighter than 29th magnitude.

Simultaneous SEDs of Nearby Seyferts

KILERCI ESER, ECE (DARK/NBI Copenhagen University), Marianne Vestergaard, Kelly Denney, Bradley Peterson

Active Galactic Nuclei (AGN) are powered by the interaction between the supermassive black hole residing at their centers and the surrounding accretion. The optical to X-rays continuum luminosity is generated by the accretion disk. AGNs show variations in flux at all wavelengths, which affect the spectral energy distributions (SEDs) and the bolometric luminosities. The details of the SED and its shape provide important constraints to theoretical accretion disk models and to the accretion processes that control the growth and evolution of the central black hole and its host galaxy. We construct simultaneous SEDs for 7 nearby Seyfert 1 galaxies using contemporaneous optical, ultraviolet (UV) and X –ray data at multiple epochs and we investigate the time dependence of these SED-related parameters in individual objects.

AGN as standardizable candles and the importance of high redshift standard candles for cosmological constraints

King, Anthea (University of Copenhagen/University of Queensland), Davis, T. M., Delley, K., Watson D., Vestergaard, M.

AGN have recently been proposed as accurate distance indicators through reverberation mapping techniques (Watson et al 2011). Reverberation mapping is a method for determining the size of the broad line region (BLR) through the correlation between the light curves of the accretion disk flux and broad emission line fluxes. It has been found empirically that there is a direct relationship between the size of the BLR and the luminosity of the central source (Kaspi et al 2000, Bentz et al 2009). This method has primarily been used in determining the mass of the central black hole but has the potential to be used for cosmological distance measurement. Due to their high luminosity AGN can be used to probe unexplored regions in the expansion history of the universe. I will discuss the potential for AGN as useful dark energy probes when used in conjunction with current and predicted future measurements of type Ia supernovae, baryon acoustic oscillations, and the cosmic microwave background. We find that it is optimal when studying dark energy to have a combination of high and low redshift measurements. Low redshift measurements act as an anchor and help reduce degeneracies in dark energy characterisation, while a large redshift range allow time evolution to be more recognisable. Therefore, a large scale AGN reverberation mapping survey has the potential to give great insight into galaxy black-hole co-evolution and also dark energy constraints.

Black hole mass dependence of the scale length of cross-correlation between AGNs and galaxies

Komiya, Yutaka (National Astronomical Observatory of Japan), Yuji Shirasaki Masatoshi Ohishi Yoshihiko Mizumoto

We present results of study about galaxy clustering around active galactic nuclei (AGNs) at z=0.1-1. For the cross-correlation analysis, we use data of ∼10,000 SDSS AGNs for which the virialmass (M_{BH}) of the central supermassive black hole (SMBH) were estimated and galaxy data in the UKIDSS Large Area Survey catalog. The observational data is obtained using Virtual Observatory. We found an indication that the clustering amplitude increases as BH mass increases at $M_{BH} > 10^8 M_{solar}$. This suggests that the mass growth of SMBHs is mainly driven by the interactions with the surrounding environment for $M_{BH} > 10^8 M_{solar}$. On the other hand, we found no dependence of clustering amplitude on BH mass at $M_{BH} \lesssim 10^8 M_{solar}$. This may imply that evolution mechanisms of lower mass SMBHs are different from higher mass SMBHs.

Analyzing the first optically selected BL Lac sample

Kügler, Dennis (Landessternwarte, Heidelberg), J. Heidt, K. Nilsson, T. Schultz, J. Esser

We present and discuss an analysis of the optical properties of 182/240 probable BL Lac candidates from the SDSS catalog by Collinge et al (2005). This sample is the first well selected sample of optically selected BL Lac objects based on featureless spectra and the absence of proper motions alone.

Properties targeted are optical polarization (corrected for host galaxy contamination), variability, host galaxy fitting, high SNR spectroscopy as well as NIR-optical broad-band SEDs. This allows to rule out possible sample contamination, by e.g. galaxies with weak absorption lines or cold DC white dwarfs. An investigation of the possible intrinsically difference between high-energy peaked (HBL) and low-energy peaked (LBL) BL Lacs which are discussed in the literature was performed by including radio (NVSS/FIRST) and X-ray (RASS) data.

According to our classification scheme we confirm **114/182** as **BL Lac objects** highlighting the effectiveness of the original sample selection. 51 objects remain in the candidate class and 11/6 could be excluded as other objects with stellar/extragalactic origin. Since the X-ray data available are shallow for most of the targets, any intrinsic differences between LBL and HBL remain speculative. High SNR spectroscopy (in order to obtain more redshifts) as well as a deep X-ray survey are required to optimize the selection further and to finally rule out or confirm intrinsic differences of LBL and HBL.

The testing of the unified model for sources with steep radio spectrum

Miroshnichenko, Alla (Institute of Radio Astronomy of the NAS of Ukraine)

Based on the catalogue of extragalactic sources obtained in Grakovo observatory with the radio telescope UTR-2 at the decameter band we have formed samples of sources with steep radio spectra of two types - with linear steep spectrum (S) and with low-frequency steepness after a break (C+). Note, that the values of spectral indices of examined sources are greater 1. At the frame of LambdaCDM-model of the Universe the sample's galaxies and quasars with steep spectrum of both types (S and C+) posses the very extent radio structure ($\sim$ Mpc) and the great luminosity ($\sim$ 10E28 W/Hz ster at the frequency 25 MHz). A number of considered objects are also the sources of X-ray and infrared radiation. We have determined the ratio of corresponding flux densities (the ratio of corresponding monochromatic luminosities) of sample sources at the decameter, centimeter, infrared, optical, X-ray bands. These values may be the testing for the unified model of sources. It turned out, that the mean values of corresponding ratios of monochromatic luminosities for quasars and galaxies in the sample have enough close quantities. We conclude that the obtained characteristics of radio sources with steep spectrum are in concordance with the unified model of sources. Besides, the values of ratios of monochromatic luminosities display the dependence on redshifts and linear sizes of considered objects.

Investigating the SMBH to spheroidal stellar mass ratio in z$\sim$3 QSOs using the Subaru Telescope

Saito, Yuriko (The Graduate University for Advanced Studies(SOKENDAI)), Tomoki Morokuma, Toshihiro Kawaguchi, Masatoshi Imanishi, Yosuke Minowa, Takeo Minezaki, Nozomu Kawakatu, Tohru Nagao, Kenta Matsuoka, Nagisa Oi

The tight correlation between the masses of super massive black holes (SMBHs) and spheroidal stars in the local universe suggests that their formation is physically closely related. However, various theories predict the redshift evolution of SMBH to spheroidal stellar mass ratio in a different manner, and it is observationally unclear whether (1) SMBHs grow first, or (2) spheroidal stars grow first, or (3) both SMBHs and spheroidal stars grow in the same way.

To address this issue, we have embarked on (1) systematic near-infrared spectroscopy of z=3-3.5 QSOs, to derive the SMBH masses, based on the well-calibrated Balmer beta emission line method, and (2) Subaru LGS-AO near-infrared multi-color imaging observations, to estimate spheroidal stellar masses in the host galaxies of these QSOs in a reliable manner.

So far we obtained spectroscopic data for 41 objects, and estimated their BH masses. We have also obtained Subaru LGS-AO imaging data of 8 QSOs, and detected the emission from QSO host galaxies in 2 sources. We present our strategy and initial results.

A Novel Approach to the Seeding of Black Holes in Cosmological Simulations

Taylor, Philip (University of Hertfordshire)

I present a new method for creating black holes (BH) in cosmological simulations. Any pristine gas particle whose density exceeds a specified threshold density, spawns a BH. We have performed a suite of chemodynamical simulations using a version of the GADGET code augmented with star and BH formation, energy feedback from BHs, energy and chemical feedback from AGB stars, Type II and Ia supernovae and hypernovae, and radiative cooling. Simulation volumes in the range $10 - 100 Mpch^{-1}$ are used, with spatial resolutions as small as $1 kpch^{-1}$. I present the results of these simulations, which show that this model is able to reproduce the observed $M_{BH} - \sigma$ relation, and quenches star formation at late times.

Estimation of central black hole‘s masses of the isolated 2MIG AGNs of the Northern hemisphere

Vavilova, Irina (MAO NAS of Ukraine), Pulatova Nadiya

This work is the part of our investigation related to the studying internal properties of 2MIG isolated host galaxies connected with its nuclear activity. For this goal we used the sample of isolated AGNs, which was obtained through a cross-correlation of 2MIG catalog (Karachentseva et al., 2010) and Catalogue of Quasars and AGNs (Veron-Cetty, 2010). The sample of 2MIG selected AGNs of the Northern hemisphere consists of 37 galaxies (limited by the declination > -15 degree, K_s < 12.0^m, radial velocity <15000 km/s ($z < 0.05$)). To determine preliminary the AGN black hole masses we used the archival data from HyperLeda (stellar velocity dispersion, maximum rotational velocity of the gas) as well as SDSS DR9 spectra. Such estimations have been possible for 30 2MIG isolated AGNs of the Northern hemisphere. We found that the isolated AGNs contain a smaller black hole by mass as comparing with other Seyfert galaxies with a known black hole mass. This result and the observational program, which is in progress for the more correct central black hole mass estimations by reverberation-mapping method for several AGNs from our sample, are discussed in detail.

AGN in duet with their neighbours: who plays the viola?

Villarroel, Beatriz (Uppsala Universitet)

We have used the Sloan Digital Sky Survey and Galaxy Zoo to study a large number galaxy neighbours to Type-1 and Type-2 AGN. Our aim was to test the AGN unification (Antonucci 1993), and we have found results more supportive of a evolutionary sequence between the two classes of objects (type-1 vs type-2 AGN). With our data, we can so far only reject the geometric model of AGN unification. From morphology constraints, we see that the AGN appear to interact very differently with their neighbours. Also, both they influence their neighbours star-formation in very disparate ways, but also it seems from our data that Type-2 AGN are very "fragile" states that do not survive subsequent merger and transform into something else. But into what? We will also discuss a zone-of-avoidance around AGN found in our data.

The Link Between Ejected Stars And Eccentricity Growth of Super Massive Black Hole s In Galactic Nuclei

Wang, Long (Kavli Institute of Astronomy and Astrophysics in Peking Univerisity), Rainer Spurzem, Peter Berczik

The hierarchical galaxy formation picture suggests super massive black hole (SMBH) in galactic center observed today formed from two massive black holes coalescence during galaxy merging. The strong three body encounters between the massive black holes binary (MBHB) and neighbor stars remove energy and angular momentum from the MBHB and results in eccentricity growth. In this paper, we do direct N-body simulations of rotating galaxy nuclei with 10^6 stars and two massive black holes unbound initially. We analyze the properties of ejected stars due to *slingshot* effects of the MBHB in detail. Our results provide the direct relation between the eccentricity growth of the MBHB and energy and angular momentum removed by ejected stars. The stellar system rotation will also influence the MBHB eccentricity evolution.

Symposium S11

Gaia research for European astronomy training

1 Oral contributions

Massive stars in the Gaia-ESO Survey

Blomme, Ronny (Royal Observatory of Belgium)

We report on the preliminary analysis of GES data from two massive-star clusters. We determine stellar parameters for the B-type stars in NGC 3293 and compare the A-type stars population between the two clusters. We also use a repeat observation to study binarity and use the radial velocity information to study cluster membership in NGC 3293.

Gaia-DPAC (Data Processing & Analysis Consortium)

Brown, Anthony (University of Leiden)

This presentation will describe the current status of the Gaia Data Processing and Analysis Consortium, highlighting preparations for final end to end testing in advance of Gaia launch, and the subsequent early phase science analysis operations.

Open clusters as tracers of the external disk

Cantat, Tristan (Astronomical Observatory of Padova, IT)

The chemical gradient of the disk provides important contrains on the formation and evolution of the disk. Here we discuss the chemical gradient of the external disk using open clusters as tracers. High resolution archive data on several clusters located in the external regions of the disk are analysed in an homogeneous way using the same methods of the Gaia-ESO Survey.

The importance of Gaia spectro-photometric data for asteroid science:

Cellino, Alberto (INAF - Osservatorio Astrofisico di Torino)

Gaia spectro-photometric data obtained by the BP/RP detectors are expected to be an essential complement to Gaia astrometric and photometric data in G light. For each object and at each transit on the focal plane, it will be possible to derive a reflectance spectrum in the spectral interval between 0.3 and 1 micron. This will allow us to produce eventually a very big catalog of asteroid reflectance spectra, including several tens of thousands objects. The importance of this catalog will not be limited to the number of entries, but it will be due also to the fact that the spectra will include the blue region, which has been essentially lost in the most modern spectroscopic survey carried out from the ground. The blue region is extremely important to distinguish among different sub-classes of the population of low-albedo, primitive asteroids. In particular, some of these sub-classes, like the old F taxonomic class defined may years ago when only UBVRI data were available, seems to be extremely important, and might possibly represent a "bridge" between the asteroid and comet populations. More in general, the Gaia taxonomic classification will be an essential tool for the overall physical interpretation of asteroid properties based on Gaia data. As an example, the number of about 150 asteroids for which the mass and bulk density will be determined by Gaia data, include objects belonging to a

large variety of taxonomic classes. We will have at disposal for the first time the possibility to make an analysis of the relation between density and taxonomic classification, laying a bridge between surface properties and internal structure of the objects.

Stellar populations in disks and bulge in chemodynamical simulations

Chiaki, Kobayashi (University of Hertfordshire)

Using self-consistent chemodynamical simulations of a Milky Way-type galaxy, we predict the frequency distribution of elemental abundance ratios from Carbon to Zinc as a functions of time and location, which can be directly compared with GAIA-ESO survey. The bulge have formed from the assembly of subgalaxies at z>2, and have higher [Hα/Fe] ratios because of the lack of contribution of Type Ia Supernovae. The disk have formed with a constant star formation over 13 Gyr, and shows a decreasing trend of [Hα/Fe] and increasing trends of [(Na,Al,Cu,Mn)/Fe]. However, the thick disk stars tend to have higher [Hα/Fe] and lower [Mn/Fe] than thin disk stars, and lower [(Na,Al,Cu)/Fe] than bulge because of the metallicity dependent yields of core-collapse supernovae.

MOONS: a new multi-object spectrograph for the VLT

Cirasuolo, Michele (Royal Observatory Edinburgh), MOONS Consortium

I will present a science and technical overview of MOONS, a new Multi-Object Optical and Near-infrared Spectrograph, selected by ESO as a third generation instrument for the Very Large Telescope.

MOONS will provide the crucial spectroscopic follow-up for the ESA Gaia mission and other ground-based surveys with VISTA, UKIDSS and LSST. Given the spectral resolutions (R$\sim$8,000 and R$\sim$20,000) and the capability of observing in the near-IR, MOONS will allow us to clarify the nature of the heavily-obscured regions of the Bulge, but also to assess the chemo-dynamical structure of the Thin and Thick Discs, and to understand the importance of satellites and streams in the Halo. MOONS will provide accurate radial velocities and detailed chemical abundances (Fe, Se, Ca, Ti, Mg, Cr, Mn, CNO etc) for several million stars, down to the very faint limits of the Gaia catalogue.

I will highlight the main Galactic science cases, the surveys envisaged and briefly also the overall technical design.

The Besançon Galaxy Model renewed. I. Constraints on the Galactic thin disc evolution from Tycho data

Czekaj, Maria Anna (University of Barcelona), A. C. Robin, F. Figueras, X. Luri, M. Haywood

The construction of a dynamical model of the Milky Way from the upcoming Gaia data will require a complex comparison between models and data in the space of the observables. To be ready for this challenge this work is dedicated to improve the Besançon Galaxy Model by comparing the simulations to real data in order to study the process of Galaxy evolution. Thanks to the improvement of the algorithm for star generation the IMF, SFR and evolutionary tracks are now free parameters and can be changed at will. Furthermore, we have also implemented the simulation of stellar binarity, absent in the old model. We present a new version of the Besançon Galaxy Model where ingredients as critical as the IMF, the SFR, the binary fraction, the age-metallicity relation and the age-kinematic relation are constrained using Tycho-2 data and the local luminosity function. The optimization includes also the use of most updated evolutionary tracks and atmosphere models. The extinction model turns out to be a very important ingredient of a Galaxy model and in our work we compare the performance of two different extinction models. In total, thirteen different ingredients of the model were under study.

WEAVE: A new wide-field multi-object spectrograph for the William Herschel Telescope

Dalton, Gavin (Oxford University, UK)

WEAVE will provide full Northern Hemisphere access for follow-up of the Gaia survey at medium (R=5000) resolution and high (R=20000) resolution to provide radial velocities, stellar parameters and detailed chemical abundances. I will describe the current status of the WEAVE instrument programme, the schedule for first

observations and the path to a survey consortium.

Reconstructing asteroid shapes from sparse-in-time photometry

Durech, Josef (Charles University in Prague, Astronomical Institute), J. Hanus, D. Oszkiewicz, E. Bowell

Asteroid physical parameters - the shape, the sidereal rotation period, and the spin axis orientation - can be reconstructed from disk-integrated photometry that is either dense (classical lightcurves) or sparse in time. Because Gaia asteroid photometry will be sparse in time, it is necessary to develop fast and reliable algorithms that will be used to Gaia data with the aim of deriving asteroid physical properties.

We will review our recent progress in asteroid shape reconstruction from sparse photometry. In particular, we will show the results based on Lowell photometric data processed in the framework of the BOINC distributed computing project Asteroids@home. We will show that our methods produce reliable asteroid models with very low rate of false solutions and that the pipelines and codes can be directly used either to Gaia data alone or - preferably - to Gaia data combined with all other photometric data available.

Detecting temporarily-captured natural Earth satellites with Gaia

Granvik, Mikael (University of Helsinki), R. Jedicke, B. Bolin

Granvik et al. (2012, Icarus 218) predict that the Earth is surrounded by a cloud of meter-sized and smaller asteroids. These asteroids are temporarily captured from the much larger near-Earth-asteroid (NEA) population. In order to get captured, an NEA must approach the Earth-Sun L1 or L2 points with a speed less than 2 km s^{-1}, which requires that the NEA orbit prior to the capture is very Earth-like. An average natural Earth satellite (NES) is captured for 9 months during which the object makes 3 revolutions around the Earth. The model by Granvik et al. (2012) predict the observed characteristics (such as size, length of capture, number of revolutions, etc.) of the only known NES to date, 2006 RH_{120}.

The typically extremely low *Delta*v make NESs very desirable targets for the highly topical plans for asteroid return missions. However, detecting and discovering NESs has turned up to be a major challenge for planning space missions. Discovering NES with a ground-based survey requires an all-sky coverage to a limiting magnitude of $V \gtrsim 23$. Although Gaia's all-sky survey has a limiting magnitude of only $V = 20$, it will be located in the vicinity of L2. As roughly 50% of all NESs enter through this region the proximity to L2 may be enough to counteract the brighter limiting magnitude and thus making Gaia the best NES discovery tool available. We will present the expected NES detection rate based on a simulated Gaia survey and discuss the possibility of NES discoveries.

Chemodynamical evolution of the extended solar neighbourhood

Just, Andreas (ARI at ZAH)

Radial and vertical scalelength and abundance gradients are linked to the kinematic properties of the stellar subpopulations in the Milky Way disc. The star formation history, the element enrichment history and the dynamical evolution are the main ingredients in a consistent physical model of the Milky Way. I will discuss the impact of observed abundances and their gradients in the extended solar neighbourhood on our self-consistent analytic disc model. The model is based on laws for the star formation history, the dynamical evolution and chemical enrichment. The model reproduces the local kinematics of main sequence stars, SDSS star counts towards the North Galactic Pole, and the metallicity distribution of G dwarfs very well. Including radial gradients and abundance ratios allow more constraints on the evolution history of the Milky Way disc. Large spectral surveys like SEGUE, RAVE and Gaia-Eso, can be combined with proper motions and distances to provide powerful tests of any Milky Way model.

Structure of the second Galactic quadrant based on homogeneous distances of O and B type stars

Kaltcheva, Nadia (University of Wisconsin, USA)

Intermediate-band uvby-beta photometry is used to derive precise homogeneous photometric distances for a large sample of OB-associations and young open clusters. The implication of various calibrations in terms of fundamental stellar parameters on the overall delineation of the spiral structure in the second Galactic

quadrant is discussed.

Extragalactic Gaia data

Kontizas, Mary (National and Kapodistrian University of Athens)

a) Stellar content in nearby galaxies detected by Gaia, b) Gaia data of various unresolved Galaxy types

Canis Major overdensity and Monoceros ring explained in terms of pure Milky Way structure

Lopez Corredoira , Martín (Instituto de Astrofísica de Canarias, ES)

We present arguments to think that the Canis Major overdensity and Monoceros ring are just a part of the Galactic warped+flared stellar disc, instead of a dwarf galaxy with its tidal stream.

The Gaia Data System (CU9)

Luri, Xavier (Department d' Astronomia i Meteorologia, University of Barcelona)

This talk will describe the DPAC CU9 - developing the Gaia Data Access System.

Determining the Galactic potential with Gaia

McMillan, Paul (University of Oxford, UK)

What's the best way to determine the Galactic potential from Gaia data? I'll show that methods based on orbit libraries are ill-suited to the task, but that an alternative method holds great promise.

Kinematic signatures in the outskirts of barred discs

Molloy, Matthew (Kavli Institute, Peking University)

We investigate the kinematic landscape in the outskirts of a barred disc using the N-body simulation of Shen et al. (2010). The simulation is in qualitative and quantitative agreement with observations of the kinematics, photometry and structure of the Milky Way bulge and suggests that the Milky Way evolved from a pure disc galaxy with no significant classical bulge. Being the major perturbation in the disc, the bar affects even the outermost regions in the disc. Resonant orbits beyond co-rotation provide a wealth of structure in phase-space and understanding the effects of non-axisymmetric disc components will be of great importance in the era of LAMOST and Gaia. Observations of red clump stars towards the anti-centre (Liu et al., 2012) and some preliminary results from the LAMOST anti-centre survey show some striking similarities to the kinematics seen in the simulation and gaining a better understanding of their origin will be vital in reconstructing the evolutionary history of the Milky Way.

Asteroid lightcurve inversion using virtual-observation MCMC methods

Muinonen, Karri (University of Helsinki & Finnish Geodetic Institute), Xiaobin Wang, Yibo Wang

Novel virtual-observation Markov-chain Monte Carlo methods (MCMC) are presented for the asteroid spin and shape inversion problem posed by photometric lightcurve observations. In the method, the proposal probability density is chosen to mimic the convolution of the a posteriori density by itself: first, random errors are simulated for each photometric observation, resulting in a set of virtual observations; second, least-squares spin and shape solutions are derived for the virtual observations using the Nelder–Mead downhill simplex method (triaxial ellipsoid models) or the Levenberg-Marquardt method (convex models); third, repeating the procedure gives a difference between two sets of what can be called virtual least-squares solutions; and, fourth, the difference obtained constitutes a symmetric proposal in a random-walk Metropolis–Hastings algorithm, avoiding the explicit computation of the proposal density. In practice, the proposals are based on a large number of pre-computed sets of spin and shape solutions. Virtual-observation MCMC is thus based on the characterization of the phase-space volume of solutions before the actual MCMC sampling. For validation, the novel MCMC methods are applied to the extensive photometry of asteroid (171) Ophelia and to the scarce photometry of asteroid (1028) Lydina. Finally, the methods are applied to sparse photometric observations of asteroids simulated for the Gaia mission.

Towards a simple approximation of the local phase space distribution function

Nardin, Alberto (Astronomisches Rechen-Institut)

The aim of our group is to construct an analytical evolution model of the Milky Way disc starting with a dynamical model of the extended solar neighbourhood. One important aspect is to find a handy approximation of the phase-space distribution function depending on the three integrals of motion. My short-term work will regard the approximation of the third integral looking on the "known" solutions and their limitation, like the epicycle theory and the Staeckel potential. We want to understand what is the link between the inclination of the velocity ellipsoid and third integral of motion and the relation with the gravitational potential of the Milky Way. For my long term work I want to apply this model to stellar subpopulations with different alpha-enhancement and metallicity combining extensive data sets like SEGUE, RAVE, Gaia-ESO, which are suitable for kinematical studies of the Milky Way disc.

The ESA Gaia Data Archive

Osuna, Pedro (European Space Agency)

This talk will describe the ESAC Gaia Archive.

Lowell photometric and astrometric databases as precursors to Gaia

Oszkiewicz, Dagmara (Adam Mickiewicz University), E. Bowell, L. Wasserman, K. Muinonen, A. Penttilä,
S. Breiter, T. Michałowski, P. Bartczak, T. Santana-Ros, J. Durech, J. Hanus, O. Wilkman

The Lowell observatory photometric database contains recalibrated photometric data from the Minor Planet Center for about half a milion asteroids and the astrometric database contains orbital parameters for all the numbered asteroids. The photometric data are of very low precission and accuracy, but in many respects share the same characteristics with the upcoming data from the Gaia mission. The photometric database is very large and contains sparse data spread over a number of years. The average number of photometric data points per object is on the order of few hundrets of points per object (for most of the numbered asteroids).

We compare the Lowell Observatory data with the forthcomming astreoid photometric data from the Gaia mission. We present the potential of large photometric datasets based on the example of the Lowell Observatory databases. In particular, we present the results of our scientific exploration of the Lowell Observatory data, including asteroid absolute magnitudes, overall phase curves and their connection to asteroid taxonomy, asteroids spin and shape characteristics.

The large datasets provide a window to the overall characteristics of the different populations of asteroids and therefore are key to understanding of the current state and evolution of the asteroid belt. In particular the Gaia mission due to its high precission and accurancy and the number of asteroids observed will contribute significantly to all areas of the planetary science. The Gaia photometric data could be processed in a simar manner to the Lowell Observatory data, for example the shapes could be computed in the framework of Asteroids@home and the phase curves using the Asteroid Phase Curve Analyser.

Exploring the Variable Sky with LINEAR

Palaversa, Lovro (Geneva Observatory), Željko Ivezić, Sarah Loebman, Domagoj Ruždjak, Davor Sudar, Mario Galin, Andrea Kroflin, Martina Mesarić, Petra Munk, Dijana Vrbanec, Hrvoje Božić, Laurent Eyer, Nicholas Hunt-Walker, Jacob VanderPlas, David Westman, J. Scott Stuart, Branimir Sesar, Andrew C. Becker, Gregor Srdoč, Przemyslav Wozniak, Hakeem Oluseyi

We describe the construction of a highly reliable sample of ∼7,000 optically faint periodic variable stars with light curves obtained by the asteroid survey LINEAR across 10,000 deg^2 of sky. The majority of these variables have not been catalogued yet. The sample flux limit is several magnitudes fainter than for most other wide-angle surveys. Light curves include on average 250 data points, collected over about a decade. Using SDSS-based photometric recalibration of the LINEAR data for about 25 million objects, we selected ∼200,000 most probable candidate variables with $r < 17$ and visually confirmed and classified ∼7,000 periodic variables using phased light curves. The reliability and uniformity of visual classification across eight human classifiers was calibrated and tested using a catalogue of variable stars from the SDSS Stripe 82, and verified using

unsupervised machine learning approach. The resulting sample of periodic LINEAR variables is dominated by 3,900 RR Lyrae stars and 2,700 eclipsing binary stars of all subtypes, and includes small fractions of relatively rare populations such as asymptotic giant branch stars and SX Phoenicis stars. We discuss the distribution of these mostly uncatalogued variables in various diagrams constructed with optical-to-infrared SDSS, 2MASS and WISE photometry, and with LINEAR light curve features. We find that combination of light curve features and colours enables classification schemes much more powerful than when colours or light curves are each used separately. An interesting side result is a robust and precise quantitative description of a strong correlation between the light-curve period and colour/spectral type for close and contact eclipsing binary stars (β Lyrae and W UMa). These large samples of robustly classified variable stars will enable detailed statistical studies of Galactic structure and physics of binary and other stars, and we make them publicly available.

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Palaversa, Lovro (UNIGE, University of Geneva, CH)

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Simulation method for realistic asteroid spectra for Gaia

Penttilä, Antti (University of Helsinki), Hanna Pentikäinen, Karri Muinonen, Marco Delbó, Alberto Cellino

Gaia will observe the photometry of hundreds of thousands of asteroids, producing a large database of asteroid spectra in the visual and near-infrared wavelength bands. This will enable us to estimate asteroid taxonomic classifications for a huge number of new objects and revise existing classifications. The taxonomic class of an asteroid is tightly linked up with the properties of the asteroid's surface composition, and therefore also to its origin and evolution. It might be even possible to derive a new, Gaia based taxonomy of asteroids.

To prepare for the classification task of the data observed by Gaia we need to test classification approaches with existing data. Since the amount of the existing observational data will not meet the Gaia observations, a method to simulate realistic data is needed. Also, Gaia will observe the blue and UV ranges that are commonly not observable from ground based spectroscopy due to the absorption of the atmosphere. We have developed a simulation method based on tailored statistical techniques for this purpose. Our approach includes the B-spline fit to the observed spectra, the principal component transform to a new coordinate basis and data compressing with only the first few principal components, and finally a simulation method based on the kernel distribution fit in the new coordinate system of the observations. Using this method, we will produce continuous spectra and can further sample these with the Gaia wavelength filters and add realistic observational noise.

Matching Coronal Mass Ejections with their effects, an automated method.

Perez-Suarez, David (Finnish Meteorological Institute), Gabriele Pierantoni (Trinity College Dublin)

The HELiophysics Integrated Observatory (HELIO), a project funded under the EC's 7th Framework Pro-

gramme (FP7), developed a set of web services to facilitate data discovery and event matching throughout the entire heliosphere. In order to do this, events that can be related are found by querying catalogues of events and features and a simple propagation model (Solar–Heliospheric Event Ballistic Algorithm – SHEBA) is executed to ascertain whether the events can be related. However, although the propagation model is simple it requires scientists to define certain parameters that may not easily known, forcing the scientist to guess them based on her/his experience. This problem is tackled with the advanced propagation model developed in the SCI-BUS project, an FP7 project that offer a seamless access to different computing architectures like clouds, grids and clusters. This advanced propagation model runs the propagation model as a parameter sweep job covering all parameters that are not known "a priori" and it validates the results by checking matching events on the event catalogues on Earth.

This talk will give an overview of the services built by HELIO and how the advanced propagation model uses them. The talk will also cover future work of interest for the heliophysics community that arises at the convergence of Infrastructure Projects such as SCI-BUS and ER-FLOW and Heliophysics specific projects such as HELIO.

Gaia-ESA

Prusti, Timo (ESTEC, ESA)

Gaia is heading toward launch in September 2013. All subsystems have been delivered and the assembly, integration and testing are in full swing. The presentation will outline the current status of the spacecraft and payload. The scientific performance estimates will be presented in view of the latest test results and the scenario for intermediate data releases will be presented.

The 4MOST Facility

Schnurr, Olivier (Leibniz Institute for Astrophysics, DE)

This presentation will provide an update as to the status of the 4MOST project.

Gaia as a tool for exoplanet detection and characterization in the Solar neighborhood of the Milky Way

Sozzetti, Alessandro (Astronomical Observatory of Torino, IT)

I will review the expectations for exoplanet detection an characterization with Gaia astrometry based on the present day understanding of planet frequencies as a function of the host stars' physical parameters. I will then outline some of the important synergies between Gaia and other planet detection and characterization programs, with a particular focus on space-borne observatories such as TESS, CHEOPS, PLATO, and EChO.

The Solar System as seen by Gaia

Tanga, Paolo (Observatoire de la Côte d'Azur)

Gaia is expected to produce one of the largest samples of homogeneous asteroid data, including astrometric, photometric and spectro-photometric observations. A total of about 3.5e5 objects will be observed over 5 years, with a limiting magnitude V=20. A few months before the launch of Gaia, we will review the expected outcome for Solar Systeme objects. The highly optimized astrometric performance opens new perpectives to the determination of the dynamical properties of the Solar System. Orbit accuracy will strongly increase and several asteroid masses will be precisely determined. Physical properties for all the observed objects, including overall shapes, directions of the rotation axis and spin, will be available. Eventually we will describe the role of current and future ground-based observations as a source of data complementary to those obtained by Gaia.

Open clusters in the Gaia ESO survey

Vallenari , Antonella (Astronomical Observatory of Padova, IT)

Open clusters are an important part of the Gaia-ESO Survey. Here the target selection, the observational strategy, the data quality are presented. The old objects are discussed in detail, and their importance for the stellar evolution is presented.

Gaia-GREAT

Walton, Nicholas (IoA, Cambridge, UK)

The status of the GREAT network programme will be described including reports on activities carried out

through the GREAT ESF Research Network Programme and the EU FP7 GREAT Initial Training Network. In addition activities initiated as a result of GREAT support activities will be mentioned. The presentation will close with an update of upcoming opportunities for the communtity.

Effects of scattering laws on asteroid lightcurves and astrometry

Wilkman, Olli (University of Helsinki), Muinonen, Karri

When modelling asteroid photometry, some assumptions must be made of the surface scattering properties. These usually take the form of a scattering law, which relates the observational geometry and the reflectivity of the surface. A common choice of scattering law for asteroids is the Lommel-Seeliger law, possibly combined with the Lambertian law. We have studied the effects of various scattering laws on asteroid photometry. The main comparison is made between the Lommel-Seeliger law and a semi-numerical scattering law that is known to fit lunar photometry well. The choice of scattering law affects both the phase-amplitude effect and the rotational phase of asteroid lightcurves. The scattering law also affects the location of the photocentre of the asteroid in disk- resolved imaging. However, this effect is too slight to affect astrometry in the foreseeable future.

2 Posters

Physical parameters from Stromgren photometry of NGC6705

Balaguer-Nuñez, Lola (Universsity of Barcelona - ICCUB/IEEC), Laia Casamiquela, Carme Jordi, Eduard Masana

The systematic study of selected open clusters by our team, has lead to the production of the best set of Strömgren photometry ever obtained for the rich open cluster NGC6705. We discuss the results of our INT WFC CCD uvby-Hbeta intermediate-band photometry, covering an area of about 34'x34' down to V$\sim$20. The stars of the area selected as cluster members are classified into photometric regions and their physical parameters determined, using uvby-Hbeta photometry and standard relations among colour indices for each of the photometric regions of the HR diagram. That allows us to determine reddening, distances, absolute magnitudes, spectral types, effective temperatures, gravities and metallicities, thus providing a preliminary astrophysical characterization. Our aim is to investigate their comparison with the GES results to assess the quality of the photometric determinations.

THE KINEMATICS OF THE GALAXY FROM DATA ON YOUNG MASSIVE STARS

Bobylev, Vadim (Central (Pulkovo) Astronomical Observatory), Anisa Bajkova

On the basis of published sources the kinematic data base of the massive (>10 solar masses) young galactic stellar systems, located within a radius of $\leq$3 kpc from the Sun, including 220 objects, is created. About 100 objects from this sample represent the spectral-double and multiple stellar systems, the components of which are massive OB stars, the rest ones are the massive B-star from the HIPPARCOS catalogue with errors of parallaxes of not more than 10%. From the entire sample the rotation curve of the Galaxy has been constructed. The value of the circular velocity of the Solar neighborhood rotation was determined as V0 = 259$\pm$16 km/s for galactocentric distance of the Sun R0 = 8 kpc. There were determined the parameters of the spiral density wave, namely: the amplitude of the perturbation of the radial and azimuthal velocities fR = -10.8$\pm$1.2 km/s and fθ = 7.9$\pm$1.3 km/s respectively; the pitch angle of two-armed spiral pattern i = -6.0$\pm$ 0.4 degrees, the length of the spiral density waves in the near-sun distance λ = 2.6$\pm$ 0.2 kpc; the value of radial phase of the Sun in the spiral wave χ0 = -120$\pm$ 4 degrees. It is shown that in frame of the theory of spiral density wave such features of the Gould Belt, as a local effect of the expansion of the system, the deviation of the vertices of an ellipsoid speeds and a significant additional rotation can be explained. All of these effects decrease significantly after accounting in speeds of nearby stars the impact of the spiral density wave. It was also revealed the influence of the stars of the Gould Belt on the estimates of the parameters of the Galaxy. Their exclusion from the kinematic equations led to the following new values of the parameters of the spiral density wave: fθ = 2.9$\pm$2.1 km/s and χ0 = -104$\pm$6 degrees.

The interacting binary system OO Aql.

Boz, Gulberk Cisem (Ege university department of astronomy and space sciences), Tugce Icli,Dolunay Kocak

In this study we present photometric and spectroscopic variation analysis and orbital period study of an interacting system OO Aql. Simultaneous solution of the light and radial velocity curves provide us a determination of new set of stellar physical parameters for the primary and the secondary companions. Analyses of the mid-eclipse times indicate a period increase of $\frac{P}{P} = 4 \times 10^7$ yr that can be interpreted in terms of the mass transfer $\frac{dM}{dt} = 5 \times 10^{-8}$ $M_\odot$/yr from the less massive component to the more massive component. Our new solution confirmed that OO Aql is a multiple system in the form of AB + C + D.

Period and shape determination for the slowly rotating Hungaria asteroid (39420)

Fedorets, Grigori (University of Helsinki), Mikael Granvik, Karri Muinonen, Joseph Masiero, Jana Pittichova, Robert Jedicke

The majority of rotation periods of asteroids solved from photometric lightcurves belong to fast rotators. The time required for obtaining an accurate period estimate is substantially longer for a slowly rotating asteroid than a for a rapidly rotating asteroid. Therefore, lightcurve surveys with limited observation time which allocate the same amount of time for all asteroids, are expected to only produce accurate periods for asteroids with short rotation periods.

The Thousand Asteroid Lightcurve Survey (TALCS; Masiero et al. 2009, Icarus 204, 145-171) carried out with the Canada-France-Hawaii Telescope was one of the first systematic asteroid lightcurve surveys. The main outcome of TALCS was a debiased rotation period distribution for the main-belt asteroids but, due to above-mentioned reasons, the accuracy of the period distribution is poor for long periods. In order to determine a more accurate periods for slow rotators and thus assess the validity of the debiased rotation-period distribution at the long-period end, we have obtained photometric follow-up observations of a selected sample of TALCS slow rotators with the U. Hawaii 2.2-m telescope.

One of the TALCS slow rotators selected for follow-up is Hungaria asteroid (39420). Masiero et al. (2009) quoted a rotation period of 105 ± 21 h which is a relatively inaccurate solution, especially compared to the solutions for the fast rotators. In this work we present an updated period fit as well as a convex shape solution (Kaasalainen & Torppa, 2001, Icarus, 153, 24-36 and Kaasalainen et al. 2001, Icarus, 153, 37-51) for the asteroid. We will also discuss the possibility that the investigated asteroid is a close binary or a non-primary-axis rotator.

Gaia photometry for White Dwarfs

Jordi, Carme (Universitat de Barcelona), J.M. Carrasco, S. Catalán, P.-E. Tremblay, R. Napiwotzki, X. Luri, A. Robin, P. Kowalski

Gaia, through its 5–6 years survey of the whole sky up to magnitude 20–25 (depending on the colour of the source), will drastically increase the sample of known white dwarfs. As most of the stars end their lives as white dwarfs, they can be used to study the structure and evolution of the Galaxy. Among them, the very cool WDs provide the information for the oldest members of each population.

We provide a characterisation of *Gaia* photometry for the case of white dwarfs. Transformations between some of the most common photometric systems and *Gaia* passbands are derived to allow predictions of how white dwarfs will be seen by this mission. We also give estimations of the number of white dwarfs of the different galactic populations that will be observed. These estimations will allow to better prepare for the analysis of the scientific output of *Gaia* mission.

Different relationships have to be considered for different white dwarf compositions. Pure-He white dwarfs show a unique behaviour valid at different temperatures. Pure-H white dwarfs, instead, need to be analysed in two different temperature regimes, as around T_{eff} = 5000 K their spectra change because of formation of molecular hydrogen.

Estimations of the number of observed WDs are provided using two different WD galactic models. According to these simulations, *Gaia* will be able to observe thousands of very cool white dwarfs for the first time, which will greatly improve our knowledge of these stars.

NEAR INFRARED STUDY OF GALACTIC OPEN CLUSTERS WITH CARBON STARS PROJECTED IN THEIR RADIUS FOR THE ESO-GAIA PROJECT

MAVRIKIS, DIMITRIS (UNIVERSITY OF ATHENS), Hatzidimitriou, D. Dapergolas, A Gavas, Th. Kontiza, M.

We use JHK photometry from the 2MASS catalog to construct color-magnitude diagrams and derive accurate ages and radial extents of intermediate age open clusters that appear to contain carbon stars within their radius. The ultimate purpose is to select cases of open clusters for which the carbon stars are probable members (based on photometric criteria). These clusters will be proposed for inclusion in the observing list of the ESO-GAIA project

Asteroid initial orbital inversion in the Gaia space mission

Pentikäinen, Hanna (University of Helsinki), Karri Muinonen, Mikael Granvik, Dagmara Oszkiewicz, and Tuomo Pieniluoma

In the Gaia Data Processing and Analysis Consortium pipeline, initial asteroid orbital inversion is carried out using MCMC methods by the development unit DU456. The function of the module is to perform daily successful orbital inversion on accurate but short observations of new solar system objects (SSO) found by Gaia.

The main algorithm implemented in the module is Markov Chain Monte Carlo (MCMC) Ranging (Oszkiewicz et al., MAPS 2009), a random-walk Metropolis-Hastings algorithm. Proposal orbits for an observed object used in the MCMC chain are created by randomizing the position of the object in Gaia's field of view while staying within the error margins. The result is a collection of orbital element sets with corresponding weights, which represent the solution probability of a particular set of orbital elements.

Computation could slow down significantly if the module were to receive observations from a time period of more than a few days. The novel virtual-observation MCMC method (Muinonen et al., PSS 2012) could guarantee a thorough examination of the possible orbital element phase space. The initialization of our implementation of the virtual-observation MCMC method in the module includes adding random error into observations, and then optimizing orbits created by MCMC Ranging during its burn-in phase with the Nelder and Mead Downhill Simplex Method against the virtual observations. The addition of the difference of two randomly selected optimized orbits with the previous orbit in the MCMC chain forms the proposal orbit.

We will present both MCMC algorithms together with orbital element sets resulting from the utilization of the algorithms by DU456. Simulated observations of main-belt and near-Earth Objects will be employed as input.

From embedded to open clusters: structure and mass segregation

Schmeja, Stefan (Zentrum für Astronomie der Universität Heidelberg)

Embedded clusters seem to evolve from a hierarchical structure, often consisting of several subclusters, to a centrally concentrated state. Many of them show signs of mass segregation already after a few Myr. Only a small fraction of embedded clusters may survive the emergence from the parental molecular cloud to become gravitationally bound open clusters. These open clusters are usually mass segregated. Sometimes they show substructure, which is probably a result of dynamical evolution rather than a relict from the formation process. I analyse a large sample of embedded and open clusters, in order to study differences and similarities and possible evolutionary links.

Symposium S12

The gamma-ray sky in the era of Fermi and Cherenkov telescopes

1 Oral contributions

Ext I3

Modeling and Theory of Gamma-Ray Emitting Blazars

Boettcher, Markus (North-West University)

This talk will present a review of the current status of models for the broadband emission from gamma-ray emitting blazars. Recent advances and current challenges for both leptonic and hadronic models will be discussed.

Ext C

Gamma-ray flaring activity from the gravitationally lensed blazar PKS 1830-211 observed by Fermi LAT

Ciprini, Stefano (ASI Science Data Center & INAF Observatory of Rome, Italy), (on behalf of the Fermi LAT Collaboration)

The Fermi Large Area Telescope (LAT) routinely detects the highly dust-absorbed, reddened, MeV-peaked flat spectrum radio quasar (FSRQ) PKS 1830-211 (z=2.507). Its apparent isotropic gamma-ray luminosity is among the largest ever observed in Fermi LAT blazars, peaking at the outburst of October 2010. PKS 1830-211 is a rather complicated gravitationally lensed system, and one expects to observe time-delayed flux variability events from the lens image of the source. Three main flaring events were detected by the LAT in the first three years of the Fermi survey, and contrary to previous published claims we find no statistical evidence for delayed gamma-ray activity. Implications of the LAT results both for blazar emission models and lensing structure are illustrated.

Ext C

Gamma-ray emitting Narrow-Line Seyfert 1 galaxies. New discoveries and open questions

D'Ammando, Filippo (INAF-IRA Bologna), M. Orienti, J. Finke, J. Larsson, M. Giroletti on behalf of the Fermi LAT Collaboration

Before the launch of the Fermi satellite only two classes of AGNs were known to generate relativistic jets and thus emit up to the gamma-ray energy range: blazars and radio galaxies, both hosted in giant elliptical galaxies. The first two years of observations by the Large Area Telescope on board Fermi confirmed that these two are the most numerous classes of identified sources in the extragalactic gamma-ray sky, but the discovery of variable gamma-ray emission from 5 radio-loud Narrow-Line Seyfert 1 galaxies revealed the presence of a possible emerging third class of AGNs with relativistic jets. Considering that Narrow-Line Seyfert 1 are typically hosted in spiral galaxy, this finding poses intriguing questions about the nature of these objects, the onset of production of relativistic jets, and the cosmological evolution of radio-loud AGN. Here, we discuss the radio-to-gamma-rays properties of the gamma-ray emitting Narrow-Line Seyfert 1 galaxies in the context of the blazar scenario and the unification of relativistic jets at different scales, in particular focusing on PKS 1502+036 and the two flaring sources SBS 0846+513 and PMN J0948+0022.

Gal I

Pulsar Wind Nebulae at VHE gamma-rays

de Ona, Emma (IEEC-CSIC)

Pulsar Wind Nebulae (PWNe) represent the most numerous population of TeV Galactic Sources. More than 20 PWNe have been detected at very-high-energies by Cherenkov telescopes, mainly in the H.E.S.S. Galactic Plane Survey, which covers the inner part of the Galaxy where the majority of these objects are located. Very-high-energy gamma-rays are believe to be originated by particles accelerated along their propagation into pulsars surroundings or at the shocks produced in collisions of the winds with the surrounding medium. As a result of the interactions of relativistic leptons with the magnetic field and low energy radiation (of synchrotron origin, thermal, or microwave background), non-thermal radiation is produced from the lowest possible energies up to ∼100 TeV. Typically, only pulsars with high spin-down energy (∼1033 erg s-1) produce prominent PWNe. I will review the most important discoveries and discuss the main advances in our knowledge of these sources based in the recent observations.

Ext C

Gamma-ray Emission from the Brightest Cluster Galaxy NCG 1275 – A Multiwavelength Perspective

Dutson, Kate (University of Leicester), A. C. Edge M. T. Hogan J. A. Hinton

The active galaxy NGC 1275 is a complex and intriguing local, non-thermal source. The system hosts a misaligned blazar, whose central engine is capable of inflating bubbles of radio-bright, relativistic plasma tens of kiloparsecs into the intracluster medium. These synchrotron features are seen to anti-correlate with the observed bremsstrahlung emission of X-rays. On larger scales ($\sim 10^2$kpc) the cooling-core cluster Perseus, of which NGC 1275 is the dominant member, exhibits a centralised region of diffuse radio-synchrotron emission *mixed* with the thermal gas, known as a mini-halo. NGC 1275 is a bright and highly-variable source in gamma rays, detected using the Fermi Gamma-ray Space Telescope's LAT instrument after its launch in 2008, and more recently at very-high energies using the MAGIC Cherenkov telescopes, during a flaring event.

A temporal and spectral investigation of the high-energy (HE) emission from NGC 1275 over the past four years will be presented, and a simultaneous study at submillimetre wavelengths with the SCUBA-2 camera of the James Clerk Maxwell Telescope at the Mauna Kea Observatory, will be discussed, in the context of the historical non-thermal activity of the source. Such multiwavelength reviews of the data are the key to disentangling the HE emission components, of particular importance when probing the various scales on which we might expect gamma rays to be produced, from the inner jet of the active nucleus, through to the Perseus mini-halo.

Ext C

The Gamma-ray Spectrum of the Most Distant TeV-Emitting Blazar PKS 1424+240

Furniss, Amy (University of California Santa Cruz), on behalf of the VERITAS and Fermi Collaborations

PKS 1424+240 has been determined to reside at a redshift of 0.6035 or beyond through the detection of Lyman forest absorption in far-ultraviolet spectra from the Hubble Space Telescope/Cosmic Origins Spectrograph, making it the most distant VHE-detected blazar to date. Thus, archival VERITAS observations sample historically large gamma-ray opacity values; the application of absorption corrections to these observations results in an unexpected spectral shape not well described by a power law or log parabola. The flux of the lowest energy VERITAS points lie significantly below the extrapolation of the contemporaneous Fermi Large Area Telescope (LAT) power-law fit while the highest energy VERITAS point recovers to show agreement with this extrapolation. We expand upon this puzzling result with deeper VERITAS observations and contemporaneous LAT and Swift X-ray Telescope (XRT) data. We show the particularly soft X-ray spectrum of the blazar, and explore possible mechanisms which might produce the unusual gamma-ray spectral shape.

Gal C

Modeling the Dynamical and Broadband Spectral Properties of a Pulsar Wind Nebula inside a Supernova Remnant

Gelfand, Joseph (NYU Abu Dhabi), Patrick Slane (Harvard-Smithsonian Center for Astrophysics)

Pulsar wind nebulae (PWNe), the nebula powered the spin-down luminosity of the central neutron star, are a significant fraction of Galactic γ-ray sources. This is particularly true for PWNe powered by young neutron

stars, likely to be inside the remnant produced by their progenitor supernova. I will demonstrate that, by applying this model to particular systems, it is possible to measure the birth properties of the central neutron star, the energetics of the progenitor supernova, and the spectrum of accelerated particles. I will also discuss how this model can potentially disentangle the γ-ray emission from the pulsar, PWN, and SNR – a significant complication at GeV energies.

Gal I

Gamma-ray pulsars as seen with the Fermi LAT

Guillemot, Lucas (Max-Planck-Institut fuer Radioastronomie), on behalf of the Fermi LAT Collaboration

Gamma-ray observations of pulsars with the Large Area Telescope (LAT) on the Fermi satellite have revolutionized our view of the gamma-ray pulsar population. Since the LAT began operating in 2008, the number of pulsars known to emit gamma rays has increased from fewer than ten to over 120, split into three sub-classes of comparable size: normal radio-loud pulsars, normal radio-quiet pulsars and millisecond pulsars. In this presentation I will give an overview of the main results from pulsar observations with the Fermi LAT and from multi-wavelength studies of unassociated LAT sources likely to contain pulsars. I will also discuss some of the implications of the results in terms of emission properties and population statistics.

Gal I

Binary systems as seen by Fermi-LAT

Hill, Adam (SLAC), on behalf of the Fermi LAT collaboration

The Large Area Telescope on-board the Fermi Gamma-ray Space Telescope has been surveying the sky above 100 MeV for 5 years. The high-energy source population is dominated by the variable, flaring AGN and the steady, persistent rotation-powered pulsars. Hidden amidst these sources is a small population of gamma-ray binary systems. Of the hundreds of known X-ray binaries within our galaxy only five have been identified to emit at energies above 100 MeV. These binaries exhibit a wide range of behaviours and are still not well understood; indeed the nature of the compact object is only known in one of the systems, PSR B1259-63. Additionally the LAT has discovered high-energy emission from a number of other binary systems including microquasars and classical novae. We present the latest high-energy Fermi observations of this object class in the context of our current understanding of this mysterious population of natural particle accelerators.

Ext I

Observational View on AGN

Hovatta, Talvikki (California Institute of Technology)

Active galactic nuclei dominate the extragalactic gamma-ray sky. These highly variable objects emit brightly over the entire electromagnetic spectrum. Current gamma-ray instruments cannot resolve the emission site and therefore it is unclear whether the gamma-ray emission originates very close to the black hole within the broad line emitting clouds or further downstream in the relativistic jet. Recent studies combining data from the Fermi Gamma-ray Space Telescope and other wavebands show evidence for both types of behavior suggesting that there may be multiple gamma-ray emission sites. I will review how multiwavelength observations can be used to study the location of the gamma-ray emission site and show examples of recent studies.

Quasi-star jets as unidentified gamma ray sources

Janiuk, Agnieszka (Center for Theoretical Physics, Polish Academy of Sciences), Bozena Czerny, Marek Sikora, Jean-Pierre Lasota

Gamma-ray catalogs contain a considerable amount of unidentified sources. Many of these are located out of the Galactic plane and therefore may have extragalactic origin. Here we assume that the formation of massive black holes in galactic nuclei proceeds through a quasi-star stage and consider the possibility of jet production by such objects. Those jets would be the sources of collimated synchrotron and Compton emission, extending from radio to gamma rays. The expected lifetimes of quasi-stars are of the order of million of years while the jet luminosities, somewhat smaller than that of quasar jets, are sufficient to account for the unidentified gamma-ray sources. The jet emission dominates over the thermal emission of a quasi-star in all energy bands, except when the jet is not directed towards an observer. The predicted synchrotron emission peaks in the IR band, with the flux close to the limits of the available IR all sky surveys. The ratio of the γ-ray flux to the IR flux is found to be very large (~ 60), much larger than in BL Lac objects but reached by some radio-loud quasars. On the other hand, radio-loud quasars show broad emission lines while no such lines are expected from quasi-stars. Broad band colors in the infra-red are predicted to cover a narrow range, since the synchrotron peak in the model is above 1.5 microns. Therefore the differentiation between various scenarios accounting for the unidentified gamma-ray sources will be possible at the basis of the photometry and spectroscopy of the

IR/optical counterparts. Currently, we are investigating a range of the luminosity ratios between the Fermi and WISE bands, expected from the model, including evolutionary trends and possible correlations with WISE colors.

Gal I5

Interstellar Galactic gamma-ray emission

Johannesson, Gudlaugur (Science Institute, University of Iceland)

The interstellar Galactic gamma-ray emission originates from high-energy cosmic rays (CRs) interacting with the interstellar matter and radiation. It is a unique tracer of CR density outside of the solar system and provides valuable information on the properties of the interstellar gas and radiation fields. Detailed observations of the interstellar Galactic emission with the Large Area Telescope (LAT) aboard the Fermi Gamma-Ray Space Telescope provide wealth of information on the CR environment throughout the Galaxy. Here I will discuss how these observations combined with radio and CR data are improving our understanding of the origin of CRs and their propagation in the Galaxy.

Ext C

The Fermi-LAT view of blazar variability and multiwavelength correlations

Larsson, Stefan (Stockholm University), Lars Fuhrmann and Benoit Lott for the Fermi-LAT and F-GAMMA Collaborations

The Fermi Large Area Telescope (LAT) is providing an unprecedented opportunity to study AGNs in the GeV energy range. Using 44 months of data for about 90 blazars we have investigated and characterized their gamma-ray variability properties. This includes power density spectra, duty cycles, the flares' rise and fall times and correlations between flux and spectral hardness. For a set of 56 sources we have also studied the correlation between gamma-ray and 11 different radio bands as obtained by the F-GAMMA radio monitoring program. Using a stacking analysis we obtain the first highly significant measurement of gamma-ray vs radio correlation properties. In addition we are able to describe systematic differences between FSRQs and BL Lacs, in terms of how correlation strength and time lag vary, when gamma-rays are correlated with increasingly longer radio wavelengths, from the sub-mm to cm bands.

Ext C

VHE gamma-ray emission from the Flat Spectrum radio quasars

Lindfors, Elina (Finnish Centre for Astronomy with ESO, University of Turku), Fabrizio Tavecchio,Ulisses Barres de Almeida, Gessica de Ganeva, Kari Nilsson, Koji Saito, Cornelia Schultz, Julian Sitarek on behalf of the MAGIC Collaboration Sara Buson, Filippo D'Ammando and Masaaki Hayashida on behalf of the Fermi-LAT collaboration

The detection of Flat Spectrum Radio Quasars (FSRQs) in the Very High Energy (VHE, E>100 GeV) range is challenging, mainly because of their steep soft spectra, that could be due to internal and external absorption. MAGIC telescopes have observed and detected all the three FSRQs known to be VHE emitters and found that they exhibit very different behavior. We present two recent multiwavelength campaigns led by MAGIC in which 3C279 and PKS 1510-089 have been observed from radio to VHE gamma rays. 3C279, which was discovered as VHE emitter by MAGIC in 2006 and re-detected in 2007, was again observed in 2011, first during a monitoring campaign and later triggered by a flare detected with *Fermi*-LAT. We find that the observed broad-band SED can be described by a multi-zone emission model where the GeV gamma-ray flare takes place inside the broad line region. The model can also explain the non-detection by MAGIC. PKS 1510-089, first detected by HESS in 2009, was observed and detected by MAGIC in spring 2012 during a high gamma-ray state as observed by *Fermi*-LAT and AGILE. The source was found in high state also in radio and optical bands. The MAGIC data show no significant variability, but connects smoothly with the *Fermi*-LAT spectrum. We find that the data are best described with a model where the emission region is located outside the broad line region.

Gal C

SNRs interacting with molecular clouds as seen with H.E.S.S. and Fermi-LAT

Mehault, Jeremie (CNRS-IN2P3-CENBG), Francois Brun, Armand Fiasson, Diane Fernandez, Marie-Helene Grondin, Marianne Lemoine-Goumard, Vincent Marandon, Matthieu Renaud, Romain Rousseau on behalf of the Fermi-LAT and H.E.S.S. collaborations

More than 30 Galactic Supernova Remnants (SNRs) are thought to be interacting with Molecular Clouds (MC). These sources are prime GeV-TeV source candidates as the accelerated and/or escaped particles from shock fronts collide with the surrounding high-density medium and emit gamma-ray emission from hadronic interactions. H.E.S.S. and Fermi-LAT observations revealed about ten sources coincident with Galactic SNRs interacting with MCs and this population is growing.

Most of these sources exhibit a softening of their spectra from GeV to TeV energies (e.g. W28, W51C, W49B), implying a spectral break at intervening energies. The morphological study of such SNR-MC system provides significant information to understand cosmic ray acceleration and diffusion.

In this contribution, we will discuss the advantage of studying interacting SNRs in GeV and TeV energy ranges together. We will present new results of SNR W41 study and perspectives on interacting SNRs using H.E.S.S. II.

Search for ultra-high energy photons at the Pierre Auger Observatory

Middendorf, Lukas (RWTH Aachen University, III. Physikalisches Institut A, Aachen, Germany), for the Pierre Auger Collaboration (Pierre Auger Observatory, Av. San Martín Norte 304, 5613 Malargüe, Argentina; Full author list: http://www.auger.org/archive/authors_2013_03.html)

Searches for ultra-high energy (UHE) photons in the EeV range ($\geq 10^{18}$ eV), leading to observations or upper limits on their fluxes, are particularly interesting, allowing conclusions on cosmology, and sources, acceleration mechanisms and propagation of UHE cosmic rays. The Pierre Auger Observatory, located in Argentina, is currently the largest ground based observatory for cosmic rays at energies above 10^{17} eV. The detection of extensive air showers is used for the observation of cosmic rays from the southern sky, employing a hybrid approach with 27 air fluorescence telescopes in addition to 1600 water-Cherenkov detectors distributed on a regular grid over an area of 3000 km^2.

Both detection techniques provide shower observables that are sensitive to the type of the primary particle. Combinations of these observables in multivariate analyses are used to discriminate photons in the EeV range from the hadronic background. Analyses searching for a diffuse photon flux as well as studies taking directional information into account have been performed on data recorded by the Pierre Auger Observatory and are presented in this contribution.

Searching for gamma ray emission in massive star-forming regions

Munar-Adrover, Pere (Universitat de Barcelona), Josep Maria Paredes, Valentí Bosch-Ramon, Josep Martí

Star-forming regions and massive protostars have been proposed to be sources of gamma-ray emission. Some of these sources have shown non-thermal radio emission associated with the jets, indicating relativistic particle acceleration. It is expected that strong shocks form at the jet-termination region leading to gamma-ray emission. We have studied IRAS 16547- 4247, an isolated protostar showing non-thermal radio emission; and Monoceros R2, a star forming region coincident with a source of the 2nd Fermi-LAT catalogue. In the case of IRAS 16547- 4247, a deep analysis of the archival X-ray data resulted in the detection of a hard source. We find that this X-ray emission can be produced through thermal Bremsstrahlung by a fast shock at the jet end, and in addition significant γ-ray emission is expected. In the case of Monoceros R2, our analysis of the 3.5 years of Fermi-LAT data confirms with 12 sigma the former source detection. Our results are compatible with the source being the result the combined effect of multiple young stellar objects in Monoceros R2.

Gamma-ray emission from black hole accretion flows

Niedzwiecki, Andrzej (University of Lodz), Fu-Guo Xie, Agnieszka Stepnik

A substantial observational evidence indicates that low-luminosity black-hole systems, below a characteristic luminosity of 0.01 of the Eddington luminosity, are powered by optically thin accretion flows. The models of such flows predict the presence of hot protons, collisions of which may lead to substantial gamma-ray emission. We study such a hadronic gamma-ray component and discuss constraints on the model parameters from the X-ray to gamma-ray luminosity ratios observed in nearby objects. We point out that accretion flows may contribute significantly to the persistent gamma-ray emission observed in low emission states of Cen A and

M87.

Multiwavelength monitoring of the Crab Nebula

Nilsson, Kari (Finnish Centre for Astronomy with ESO (FINCA)), T. Schweizer, N. Bucciantini, J. Garcia, W. Idec, A. Tennant, M. C. Weisskopf, R. Zanin

The Crab Nebula exhibits strong gamma-ray flares in the *Fermi* energy band roughly once per year. So far the origin of these flares is unknown. We present the first results of an optical and X-ray monitoring campaign of the Crab Nebula with an aim to detect the exact location of the gamma-ray flares. Altogether 36 and 22 images have been obtained in the optical and X-rays, respectively, in 2010-2013. We discuss the results on the flow kinematics in the so called "wisps" and the flux changes in various active regions in the vicinity of the Crab pulsar.

On the connection between radio and gamma rays. Variability and polarization properties in relativistic jets

Orienti, Monica (INAF-IRA Bologna), D'Ammando, F., Giroletti, M., on behalf of the Fermi-LAT collaboration, and Dallacasa, D., Giovannini, G., Venturi, T.

Relativistic jets are one of the most powerful manifestations of the release of energy produced around supermassive black holes at the centre of active galactic nuclei (AGN). Their emission is observed across the entire electromagnetic spectrum, from the radio band to gamma rays. Despite decades of efforts, many aspects of the physics of relativistic jets remain elusive. In particular, the location and the mechanisms responsible for the high-energy emission and the connection of the variability at different wavelengths are among the greatest challenges in the study of AGN. In this presentation I will discuss results on radio sources which underwent strong gamma-ray flaring activities detected by Fermi-LAT. From the comparison of the radio and gamma ray light curves there is evidence that some flares, either in radio or in gamma rays, have not an obvious connection at the other extreme of the electromagnetic spectrum, like in the case of the Narrow Line Seyfert 1 SBS 0846+513. An intriguing aspect pointed out by high resolution radio observations is the change of the polarization properties close in time with some high energy flares. In particular, in PKS 1510-089 and 3C 454.3 a rotation of almost 90 degrees have been observed after strong gamma-ray flares. The swing of the polarization angle may be related either to the propagation of a shock along the jet that order the magnetic field, or a change of the opacity regime.

An unified polar cap/striped wind model for pulsed radio and gamma-ray emission in pulsars

Petri, Jerome (Observatoire Astronomique)

Since the discovery by the Fermi/LAT instrument of more than hundred new gamma-ray pulsars, it becomes possible to look for statistical properties of their pulsed high-energy emission, especially their light-curves and phase-resolved spectra. These pulsars emit mostly gamma-ray photons but some of them are also detected in the radio band. For the latter, the relation between time lag of radio/gamma-ray pulses and gamma-ray peak separation, in case both high-energy pulses are seen, helps to put constrains on the magnetospheric emission mechanisms and location. I will show how to related radio and gamma-ray pulses, assuming a polar cap model for the former and the striped wind geometry for the latter. I will show radio and gamma-ray light-curves, summarizing the results in several phase plots. The phase lag as well as the gamma-ray peak separation dependence on the pulsar inclination angle and on the viewing angle are studied. The relation between the radio lag and peak separation is derived and satisfactorily compared to the Fermi/LAT results. This supports the idea of distinct emission locations for the radio and gamma-ray radiation. Finally, from the expected synchrotron gamma-ray luminosity we derive some important parameters of the wind like its bulk Lorentz factor.

The Fermi LAT and WMAP view of particle acceleration in supernova remnant HB21

Pivato, Giovanna (INFN and University of Padova), J.W.Hewitt, L.Tiblado

HB21 is a mixed-morphology supernova remnant interacting with molecular clouds. We present the analysis of nearly 4 years of high-energy gamma-ray observations with the Fermi Large Area Telescope (LAT). We

detected extended gamma-ray emission associated with the radio shell of the remnant, and possibly extending toward an adjacent molecular cloud complex traced by CO. The peak of gamma-ray emission coincides with shocked CO clumps in the southern region of the remnant. The gamma-ray spectrum shows a significant curvature at GeV energies, typical of evolved supernova remnants detected with the LAT. No significant spectral variations across the emitting region are detected. The analysis of 9 years of WMAP data, along with archival radio data, also gives evidence of a spectral break in the spectrum of relativistic electrons emitting through radio synchrotron. Modeling of the multiwavelength data favors an origin for gamma-rays either from hadronic interactions of accelerated nuclei with interstellar material, or from Bremsstrahlung of accelerated electrons in the dense filaments. An inverse-Compton origin for the gamma-ray emission is disfavored because of the low densities required to prevent Bremsstrahlung emission from dominating. In either the hadronic- or leptonic-dominated scenario, the total energy associated with accelerated particles is $\sim 10^{49}$ ergs.

Extragalactic gamma-ray emitting source populations and EBL

Reimer, Anita (University of Innsbruck)

Active galactic nuclei (AGN) which contain prominent jets constitute the majority of the extragalactic gamma-ray sources detected to date. While those whose jets are oriented closely aligned with the line-of-sight (blazars) are regularly detected at high photon energies if within the gamma-ray horizon, only few of the radio galaxy population of AGN are confirmed gamma-ray emitters on the level of the detection capabilities of current gamma-ray instruments. The horizon in the gamma-ray band is limited by the extragalactic background light. I will review the current status and understanding of the population of non-blazar jetted AGN and Seyfert-like AGN in the gamma-ray band as well as the gamma-ray horizon as limited by the extragalactic background light. Focus will be given on possibilites for future very-high energy instruments to tackle yet unsolved questions on those topics.

Optically triggered Very High Energy gamma-ray observations by the MAGIC telescopes

Reinthal, Riho (Tuorla Observatory), Elina Lindfors, Kari Nilsson, Leo Takalo, Aimo Sillanpää, Andrei Berdyugin

There are currently over 100 known emitters of Very High Energy (VHE, E>100 GeV) gamma-rays, more than 50 of extra-galactic origin. The extra-galactic VHE emitters are mostly blazars – BL Lac type objects and Flat Spectrum Radio Quasars (FSRQs). These sources are most effectively observed by ground-based instruments using the so-called Imaging Atmospheric Cherenkov Technique. MAGIC, one of three major Imaging Atmospheric Cherenkov Telescope (IACT) facilities on Earth, is the only one which has been performing optically triggered Target of Opportunity (ToO) observations of flaring blazars since the beginning of its scientific operations. These triggers originate from the Tuorla Blazar monitoring Program, which started the optical monitoring of candidate TeV blazars in 2002 and has now collected up to eleven years of data on more than 50 blazars with the list of monitored sources ever growing. This strategy has proven to be very effective over the years resulting in the discovery of five new VHE gamma-ray emitting blazars (Mrk 180, 1ES 1011+496, S50716+714, B3 2247+381 and ON 325). Additional discoveries of BL Lac, 3C 279 and several VHE detections of known sources were made during optical outbursts. In this talk we present some of the more interesting and recent results of the ToO observations and discuss the future outlooks of optically triggered VHE observations with IACTs.

Supernova remnants in the CTA era

RENAUD, Matthieu (LUPM CNRS/Montpellier University), CTA consortium

Supernova remnants (SNRs) are thought to be the main Galactic cosmic ray (CR) sources and several tens of them have recently been detected in the high-energy (with Fermi/LAT and AGILE) and very-high-energy (with current imaging atmospheric Cherenkov telescopes, or IACTs, such as H.E.S.S., VERITAS, and MAGIC) gamma-ray domains. Although these observations allow one to probe shock-accelerated particles at energies close to the CR knee, there is, in most cases, no conclusive proof as to know whether the gamma-ray emission arises from leptons or hadrons, and hence, what is the CR efficiency. Detailed spectro-imaging analyses of the brightest TeV SNRs (RX J1713.7-3946 and Vela Jr) at the arcmin scale and population studies through the discovery of many more SNRs in the Galactic Plane are the next steps forward in order to address the paradigm of the SNRs at the origin of Galactic CRs. This is one of the prime objectives of the next generation of IACTs, the Cherenkov Telescope Array (CTA), thanks to a 10-fold improvement of the sensitivity above

100 GeV, substantially better angular and spectral resolutions and wider field-of-view in comparison with currently operational experiments. In this contribution, quantitative examples of the capability of CTA to achieve these objectives will be presented.

Coordinated VLBA and Multi-waveband Monitoring of the Gamma-ray Quasars 3C273 and 3C279

Savolainen, Tuomas (Max Planck Institute for Radio Astronomy), the Quasar Movie Project team

Multi-wavelength monitoring is a key tool to investigate the energy dissipation in the "blazar zone" of the beamed active galactic nuclei jets and the origin of the gamma-ray emission arising within it. The flux variability studies generally lack spatial information, which makes VLBI imaging of blazars at the highest achievable angular resolution a useful complement to the multi-wavelength campaigns. In 2010-2012 we carried out a densely-sampled broad-band spectral energy distribution (SED) monitoring on two archetypical gamma-ray bright blazars, 3C273 and 3C279, using dozens of ground-based radio, millimetre, infrared and optical telescopes together with X-ray and gamma-ray satellites. The campaign was complemented with an unprecedentedly densely-sampled polarimetric VLBA monitoring of their (sub-)parsec-scale jets at 15-86 GHz. We will discuss the first results from the monitoring, especially concentrating on the large GeV flare seen in 3C279 in the spring 2011. The extended gamma-ray activity period coincides with a ∼1.5-magnitude optical outburst that has several sub-flares. The optical event is accompanied by a smooth 360-degree rotation of the optical polarization angle, which starts and ends at about the same time as the gamma-ray activity and lasts for ∼100 days. This suggests that the whole gamma-ray activity period may be linked to a single disturbance which propagates down the jet along helical streamline. The EVPA rotation in our data is twice as large as the ∼180-degree rotation in 2009 reported by Abdo et al. (2010) and it cannot be explained by the bending jet model applied to the 2009 event.

Stacked Fermi/LAT spectra of blazars confirm stable GeV breaks and the location of the gamma-ray emission zone within the broad-line region

Stern, Boris (Institute for Nuclear Research, RAS), Juri Poutanen

Fermi Large Area Telescope has detected hundreds of AGNs, most of them are blazars. The GeV spectra of the flat spectra radio quasars (FSRQ) cannot be described by a simple power law model or any smoothly curved models. A much better description is obtained with a broken power law, with the break energies of a few GeV. The sharpness and the position of the breaks can be well reproduced by absorption of gamma-rays via photon-photon pair production on He II and H I Lyman recombination continuum (LyC) and lines suggesting that gamma-rays are produced close to the broad-line region (BLR). To check the stability of the break energy in different FSRQ and confirm their nature, we have produce stacked spectra of weaker blazars correcting for their redshift. We show that the stacked spectra show the same features that one can see in the brightest sources individually. The breaks at 5 GeV are extremely significant. The stacked spectra can be extremely well reproduced by a log-normal distribution with photon-photon absorption caused by the BLR. This constitutes a definite proof that the majority of FSRQ have breaks caused by the BLR photons and the gamma-rays therefore have to be produced within or near BLR.

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in different FSRQ and confirm their nature, we have produce stacked spectra of weaker blazars correcting for their redshift. We show that the stacked spectra show the same features that one can see in the brightest sources individually. The breaks at 5 GeV are extremely significant. The stacked spectra can be extremely well reproduced by a log-normal distribution with photon-photon absorption caused by the BLR.This constitutes a definite proof that the majority of FSRQ have breaks caused by the BLR photons and the gamma-rays therefore have to be produced within or near BLR.

A Day-by-day Characterization of the Temporal Evolution of the Broadband SED of the TeV Blazar Mrk 421 during Flaring Activity in March 2010

Sun, Shangyu (Max-Planck Institute for Physics), A. Boller, L. Fortson, N. Galante, N. Mankuzhiyil, D. Paneque, M. Perri

We are performing an unprecedentedly long and dense monitoring of the broadband (radio to TeV) emission from the classical TeV blazar Mrk 421. This object is among the brightest X-ray/TeV blazars in the sky and among the few sources whose Spectral Energy Distribution (SED) can be completely characterized by the current instruments. This is a multi-year, multi-instrument program involving the participation of MAGIC, VERITAS, F-GAMMA, Swift, RXTE, GASP-WEBT, VLBA, and other collaborations and instruments which are providing the most detailed temporal and energy coverage on this source to date. During the 6-month-long campaign in 2010, a flaring activity in March was characterized with unprecedented detail. We will show that the complete SED can be resolved on timescales of one-day, which allows for exquisite studies on the time-evolution of the broadband emission of this object. We found that, within the framework of the Synchrotron Self-Compton scenario, the observed evolution of the SED favors the presence of two blobs, rather than the one-zone single blob used typically to describe flares in TeV blazars.

The Fermi Large Area Telescope gamma-ray sky

Tosti, Gino (University & INFN Perugia (Italy), Fermi-LAT Collaboration

The Fermi mission was launched was launched on June 11th 2008. Now in its 5th year of data taking, the primary instrument, the Large Area Telescope (LAT) have seen numerous exciting scientific results. I will review the results so far reached on galactic and extra-galactic sources classes.

Systematic Studies of the TeV Blazar Sample

Wagner, Robert (Stockholm University), J. Becerra-Gonzalez, M. Raue

Due to the increased sensitivity of the present generation Cherenkov telescopes, the knowledge of the Very High Energy (VHE) gamma-ray sky has been improved substantially in the recent past. More than 45 blazars have been detected in this energy range (E > 100 GeV). A population study of them has been carried out investigating correlations among different physical parameters inherent to the VHE measurements as well parameters coming from other wavelengths, extending beyond quantities strictly related to the emission characteristics of the blazar (e.g., BH mass). This study is particularly interesting for the future perspective of present generation of Cherenkov telescopes as well as for the future Cherenkov Telescope Array in order to identify the characteristics the sources which are likely to be detected with these instruments. We will present results from the population study and implications for studies with future instruments.

High-energy gamma-ray emission from Cyg X-1

Zdziarski, Andrzej (N. Copernicus Astronomical Center), D. Malyshev, M. Chernyakova

We have obtained measurements and upper limits of the emission of Cyg X-1 in the photon energy range of 0.03–300 GeV based on observations by the Fermi LAT. We present the results separately for the hard and soft spectral states, as well for the all analyzed data. In the hard state, we obtain a 4-sigma detection. In the soft state, we find no emission and present the upper limits. The hard-state fluxes are compatible with emission due to Compton upscattering by relativistic electrons in the jet (observed in radio) of the stellar blackbody photons. In the soft state, our upper limits constrain the size of the non-thermal disc corona to about 20 gravitational radii.

2 Posters

Fermi interactive analysis tools and data interfaces provided by ASDC

Ciprini, Stefano (ASI Sciende Data Center & INAF Observatory of Rome, Italy)

The ASI Science Data Center is contributing to the Fermi mission by establishing and maintaining a mirror data archive of the photon event science data of the Large Area Telescope, interactive gamma-ray source catalogs and lists, and participating in development of high-level data analysis tools and interfaces dedicated to visualization, exploration and analysis of Fermi LAT and multifrequency data. In this poster some examples of these services and products for the scientific multifrequency community are reported.

Five Years of Fermi LAT Flare Advocate Activity

Ciprini, Stefano (ASI Sciende Data Center & INAF Observatory of Rome, Italy)

The Fermi Flare Advocate program (also known as Gamma-ray Sky Watcher, FA-GSW) is a science operation service providing a continuous day-by-day and quicklook analysis of the high-energy gamma-ray sky seen by the Fermi Large Area Telescope. The volunteer duty, carried out by members of the Fermi LAT team, offers a review of information about the observed gamma-ray sky above 100 MeV energies, providing alerts for potentially new gamma-ray sources, interesting transients and source flares. A weekly digest containing the highlights about the GeV gamma-ray sky is published in the web-based Fermi Sky Blog. During the first 5 years of all-sky survey, almost 250 Astronomical Telegrams, several alerts to the TeV Cherenkov telescopes and GCNs, and many targets of opportunity to Swift and other observatories, were realized. Those communications increased the rate of simultaneous multi-frequency observing campaigns and the level of international cooperation. Some highlights and science results triggered by the FA-GSW duty service are presented here.

Monitor high-energy gamma-ray variability with the Fermi Large Area Telescope

Ciprini, Stefano (ASI Science Data Center & INAF Rome), (on behalf of the Fermi LAT Collaboration)

The Fermi Large Area Telescope, as an all-sky survey mission, is continuosly monitoring bright high-energy and variable gamma-ray sources (blazars, other AGNs, and variable galactic sources like the Crab nebula). The Fermi Flare Advocate (Gamma-ray Sky Watcher) service complements the LAT all-sky survey monitor offering quick-look results and alerts for potential new gamma-ray sources, new transients, interesting variability trends and relevant flares. Highlights of the variability properties of gamma-ray blazars as well as selected results of different multi-frequency campaigns are illustrated.

The PWNe population in the H.E.S.S. Galactic Plane Survey

de Ona Wilhelmi, Emma (IEEC-CSIC), Carrigan, S., Deil, C., Foerster, A., Klepser, S., Marandon, V., Mayer, M., Stycz, K., Valerius, K. for the H.E.S.S. collaboration

The H.E.S.S. Cherenkov Array has performed a deep survey of the Galactic Plane from 2004 to 2013, providing us with a very sensitive and complete coverage of the very-high-energy pulsar wind nebulae (PWNe) population. In addition to a systematic analysis of spectral and morphological parameters, for the first time also flux upper limits for energetic young pulsars are derived from the data. We present a discussion of the correlation between energetic pulsars and TeV objects, and their properties. We will put the results in context with the current theoretical understanding of PWNe and evaluate the plausibility of previously non-established PWN candidates.

Special Session Sp1

Astronomy education and public outreach

1 Oral contributions

BRINGING THE FUTURE TO THE HANDS OF STUDENTS

Doran, Rosa (NUCLIO)

The future will be a successful journey to human beings if we start preparing it properly today. The new generation needs different skills in order to be properly prepared to embrace the challenges they will be facing in the very near future. Our generation is leaving a very strong legacy of responsabilities and possibilities. Training teachers to inspire students for scientific thinking, enabling them to use cutting edge resources for science education is mandatory to ensure this mission is properly achieved. In this presentation some innovative programs will be presented.

EU-HOU project - Connecting classrooms to the Milky Way

Ferlet, Roger (Institut d'Astrophysique de Paris)

The European Hands-On Universe (EU-HOU) project has implemented the first network of radio telescopes dedicated to education. Six small antennas in five different countries open the radio wavelength domain to classrooms and offer the possibility to map the neutral hydrogen in our Galaxy, the Milky Way. A complete educational scenario has been produced, enabling students to discover by themselves the existence of dark matter in the Universe.

Animations for Better Understanding of Tides

Franc, Tomas (Charles University in Prague)

A lot of research studies have shown that tides are difficult to understand not only for students, but also for some teachers. We have created several animations in Wolfram Mathematica for better understanding of tides, for example the animation explaining the period of tides, the animation demonstrating tidal forces of the Moon, the Sun and of the resulting tidal forces of these bodies, or the animation showing why we can see only one side of the Moon. During our presentation we will show these animations and we will discuss the difficulties with explaining tides. We are going to mention some other tidal effects like slowing down of the Earth's rotation.

The Role of Planetariums in Astronomy Education

George, Martin (International Planetarium Society),

It is now 90 years since the appearance of the first projection planetarium. Today, planetariums can be found in about half of the world's countries, with well over 3,000 planetariums worldwide known to the International Planetarium Society. I shall give a brief outline of the planetarium industry and its increasingly important role in astronomy education.

NOT Science School

Korhonen, Mikko (NOT Science School, Finland),

Nordic Optical Telescope - Science School is project which started 2007 by two high schools from Mikkeli, Finland. Science School expanded from Mikkeli to national project with support of National Board of Education and The Federation of Finnish Technology Industries. Talented students from high school are selected to take part to NOT -Science School. Students are prepared to work with their own project in Nordic Optical Telescope, La Palma, where they have been access to a small amount of observing time. During the week in La Palma students get a hands-on experience in practical astronomy and they familiarise themselves with photometry, spectroscopy and polarimetry.

Current and Future Gamma-ray experiments and Astronomy Education

Lindfors, Elina (Tuorla Observatory),

We are living a golden era of gamma-ray astronomy. The Fermi gamma-ray satellite has been scanning the gamma-ray sky in full sky mode since August 2008 and the improved sensitivity of Imaging Air Cherenkov Telescopes has enabled unexpected discoveries in the highest energy regime in past 10 years. I will describe the current instruments with the emphasis on the outreach and education material from these experiments.

Astronomy education and public outreach in Armenia

Mickaelian, Areg (Byurakan Astrophysical Observatory (BAO), Armenia),
Mickaelian A.M.

Armenia is a small country with rather high level of professional astronomy, as well as astronomy education and public outreach are being promoted by professionals and amateurs. Astronomy education includes school astronomy, local and international astronomical Olympiads, Galileo Teachers Training Program (GTTP), university level astronomy (B.Sc. and M.Sc.), Ph.D. studies, local and international summer schools organized in the Byurakan Observatory, participation of the Armenian students in the international summer schools, etc. The present young generation gradually finds more and more attraction in astronomy and space sciences. In addition, the knowledge of computers and Internet is their typical difference from the previous students and it is important to keep the astronomy education up-to-date and introduce interactive, online and virtual methods in teaching. DVDs “Astronomy for schools” and “Astronomy for students” prepared for the schools and university students, respectively, serve as a good basis for both classic and modern knowledge. The Armenian Astronomical Society (ArAS) gives a strong importance to the education and public outreach, such as by placing educational and public material on its webpage, organizing ArAS school lectures by professional astronomers, producing and publishing educational and promotional materials, developing scientific journalism (distributing press-releases, organizing seminars, etc.).

Amateur astronomy by Jyväskylän Sirius

Oksanen, Arto (Jyväskylän Sirius ry, Finland),

Activities of astronomical association Jyväskylän Sirius will be presented with focusing to the scientific observations made at their two countryside observatories.

Amateur astronomy by Taurus Hill Observatory

Salmi, Tuomo (Taurus Hill Observatory (Warkauden Kassiopeia ry), Finland),

Astronomical association Warkauden Kassiopeia and their scientific observations (e.g. exoplanet light curve measurements and supernova discoveries) at Taurus Hill Observatory will be presented.

Transdisciplinarity and Astronomy education

Stavinschi, Magda (Astronomical Institute of the Romanian Academy)

It is estimated that nowadays there are over 8000 scientific disciplines. It is clearly impossible for one person to study all of them. One huge problem is selecting which ones to include in the school curriculum. This is one of the reasons why the transdisciplinary methodology has gained great momentum in recent years. As the prefix ”trans” indicates, transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines, and beyond each individual discipline. Its goal is the understanding of the present world, of which one of the imperatives is the overarching unity of knowledge. By definition, astronomy may cover a

number of subjects, from mathematics to physics, from chemistry to biology, and so on. What is important, is how we prepare students to expand their knowledge of life and of our planet, through astronomy. This paper intends to provide an overview of this new methodology and to explain in what ways it can help to find the best solutions in astronomical education.

Fireballs and dance of the sprites at the border of space

Taavitsainen, Aki (Mikkelin Ursa ry, Finland),

Amateur astronomers in Mikkeli are specialized in photographing fireballs and high-altitude lightning called sprites. Active amateur astronomers Aki Taavitsainen and Jani Lauanne are members of the fireball workgroup of Ursa Astronomical Association. The mission of the workgroup is to photograph fireballs, investigate possible meteorite droppers and also locate and find the meteorites. The sprites are a relatively new discovery. Photographing them in Finland is extremely difficult and challenging. This rare phenomenon intrigues both pros and the amateurs. The Finnish Meteorological Institute collects information about sprites in cooperation with members of associations. Chairman of Mikkelin Ursa, Aki Taavitsainen, tells how they have succeeded in all this.

Practical astronomy for accountants, photographers and satellite engineers – experiences with a highly-multidisciplinary astronomy course in the Aalto University

Tammi, Joni (Aalto University Metsähovi Radio Observatory), Anne Lähteenmäki, Elizaveta Rastorgueva-Foi

Aalto University was formed in 2010 from the merger of Helsinki University of Technology, Helsinki School of Economics, and the University of Art and Design in Helsinki, leading to the body of 20 000 students in very different fields. In the spring 2013 we gave a new astronomy course in a series of so-called "Aalto courses", intended for "everyone in the Aalto University." The teaching and evaluation methods, as well as the content, were strongly limited by the target audience, which included students with diverse backgrounds ranging from space technology and radio astronomy to computer science and engineering, to marketing and photography. We set two-fold goals for the learning: firstly, we wanted the students to form a concept of the up-to-date scientific knowledge of the Universe, and, secondly, we wanted the students to obtain the information background as well as the "vocabulary" for being able to consider various astronomical aspects in their own work, regardless of their field of study.

In this talk we will address some of the challenges we met in providing meaningful content and learning assessment methods for such a diverse audience. We will describe our approaches for arranging the teaching and assessment, and discuss the outcomes. We will also discuss the planned improvements for the next execution of the course that can be applied to other similar university-level courses intended for highly heterogeneous audience.

Astronomy education and amateur astronomy in Ukraine

Vavilova, Irina (MAO NAS of Ukraine)

A current status and analysis of the astronomy school-. high-, and post-graduated education (1991-2013)in Ukraine will be presented in detail.

2 Posters

On the road with telescope

Gális, Rudolf (Faculty of Science, P. J. Šafárik University in Košice), Peter Kaňuk

The main goal of the project "On the road with telescope" is to increase young people's interest in science and exploration. To reach this goal we chose what we considered to be a highly attractive form. As our experience has shown, we are able to catch the interest of most young people involved through an interesting presentation containing the latest facts about space but especially through a direct experience with observing the night

sky objects through telescopes. There has been a continuous interest in our activities, which is supported by the fact that during three years we managed to organize 164 events popularising science attended by 8346 participants. We are organising these events directly at schools in cities and villages in East Slovakia to create equal opportunities for all young people, also for these from geographically and socially disadvantaged environment. Our activities have received positive reviews not only from teachers but also from parents, who consider our activities to be an excellent opportunity for their children to spend their free time in an interesting and educational way. We also organized three correspondence competitions for young people and three conferences for physics and science teachers, where the participants could attend a series of lectures on the recent discoveries in astronomy research. Apart from that, we organized 38 other activities for all people from the general public, who are interested in the latest news from astronomy.

Excursion to the Universe in frame of Slovak Astronomical Society

Hric, Ladislav (Astronomical Institute of Slovak Academy of Sciences, Tatranská Lomnica), Rudolf Gális, Emil Kundra

Slovak Astronomical Society of the Slovak Academy of Sciences is an association of friends of astronomy and related sciences, professionals, educators and students. It was established as a scientific society in 1959. Its aim is to organize workshops, scientific conferences (e.g. International Conference about successes of stellar astronomy with more than 50 years of tradition), summer camps for young people aimed at observing astronomical phenomena in the sky, the popularization of scientific knowledge and issuing publications and guidance materials. Members of the society are organized in seven regional offices and according their interests may take place in six specialized sections (e.g. section of protection against light pollution). Slovak Astronomical Society also regularly organizes the expedition for observing interesting astronomical phenomena(solar eclipses - Turkey 2006, China 2009, Australia 2012, Venus transit - Norway 2012). Slovak Astronomical Society is the organizer of the Astronomy Olympiads for students in Slovakia and their winners regularly achieve top rankings on the International Astronomy Olympiads.

Special Session Sp2

RADIONET: "The role of modern radio observatories in black hole and jet studies"

1 Oral contributions

AGN powerful jets and SMBH accretion

Ros, Eduardo (University of Valencia and MPIfR Bonn)

Active galaxies host extremely violent phenomena in the neighbourhood of their nuclei, where super-massive black holes power highly relativistic jets, capable to eject matter up to intergalactic distances. The understanding of the physics involved in these processes is possible thanks to the most advanced radio instruments such as high-frequency very-long-baseline interferometry, also complemented by space radio telescopes to enhance the observing resolution up to scales down to several gravitational radii. Radio observations are complemented by multi-band studies and by theoretical studies including numerical simulations. I will review the present understanding and the observational challenges for the accretion onto supermassive black holes and for the parsec-scale jets triggered by this process.

Jets in Radio-Quiet AGN

Panessa, F. (IASP-INAF), M. Giroletti, IRA-INAF

The class of radio-quiet AGN presents a variety of radio morphologies, temperature brighteness and spectral slopes, such that different physical mechanisms are invoked to explain their emission properties. I will present the results from the first census of VLBI sub-parsec cores of a complete sample of radio-quiet Seyfert galaxies and their connection to the X-ray emission and to the accretion rate.

The F-GAMMA program: Multi-frequency monitoring of *Fermi* blazars with the Effelsberg 100-m, IRAM 30-m and APEX 12-m telescopes

Fuhrmann, L. (MPIfR), E. Angelakis, J. A. Zensus, T. P. Krichbaum, I. Nestoras, N. Marchili, V. Karamanavis, I. Myserlis (MPIfR), H. Ungerechts, A. Sievers (IRAM), S. Larsson (Stockholm University)

The F-GAMMA program comprises the coordinated efforts of a broad consortium of scientific groups and observatories with the aim to collect (quasi-) simultaneous and high-precision broad-band monitoring data (total intensity and polarisation) for a large number of -ray loud sources in the 'low-energy' synchrotron part of AGN/blazar SEDs. It stands for Fermi Gamma-ray Space Telescope AGN Multi-frequency Monitoring Alliance and is monitoring monthly the variability and spectral evolution of about 60 γ-ray blazars using the Effelsberg 100-m, IRAM 30-m and APEX 12-m telescopes since 2007. The program covers quasi-simultaneously 11 frequency bands between 2.6 and 345 GHz in a highly synchronized manner with the specific goal of studying the origin of blazar variability and the radio/ γ-ray connection. Here, we present details of the program and involved radio telescopes, the scientific aims and selected, interesting results emerging from the first 6 years of monitoring.

The mm-γ-ray connection in the blazar 1156+295

Ramakrishnan, Venkatessh (Aalto University Metsähovi Radio Observatory, Finland), Elizaveta Rastorgueva-Foi, Jonathan León-Tavares, Kaj Wiik, Joni Tammi, Merja Tornikoski, Anne Lähteenmäki, Esko Valtaoja, Svetlana G. Jorstad, Alan P. Marscher

Result from the analysis of the connection of γ-ray flare to the passage of a superluminal component in the jet of the blazar 1156+295 is reported. The kinematics of the jet is studied using the 43 GHz VLBA data from the Boston University Blazar Monitoring Programme. The flaring behaviour in the γ-rays was analysed by constructing the γ-ray light curve from the Fermi/LAT data. From the comparison of the ejection epoch of the component and the time of the γ-ray flare, the location of the γ-ray emitting region was constrained to be on sub-parsec scales in the jet of the blazar 1156+295.

Early Science Program in RadioAstron Mission

Popov, M. V. (ASC FIAN)

Main characteristics of the mission: observing bands, synchronization and data transfer, orbit and its evolution will be described in short. General parameters of 10-m space radio telescope as measured in real flight astronomical tests, as well as the information on space-ground interferometer performance (sensitivity and coherent integration time) confirmed by numerous tests during Fringe Search Program will be presented. The main focus will be on the first results obtained in the course of Early Science Program (ESP). The ESP objectives are to achieve high-quality, high-profile scientific results and to provide a bridge between the starting "experimental" mode of RadioAstron operations and a routine one planned to start after the ESP, from July 2013. The ESP was driven by the international working teams on quasars/AGN, pulsars, and cosmic masers (OH/H2O). Interferometric fringes were detected for all types of objects and in every frequency bands (92, 18, 6 and 1.35 cm). To date, a few dozen AGNs were observed at different space-ground baseline projections up to about 20 Earth diameters. Fringes detected on the famous quasar 3C373 at 1.35 cm wavelength set an absolute record on achieved direct angular resolution in astronomy. Obtained results suggest that AGN cores of many observed sources have apparent brightness temperatures exceeding 10^{13} K. Observations of scattered pulsars have revealed new phenomena in addition to offering to unlock some long-standing puzzles of interstellar scattering and pulsar emission. Many cosmic masers also were detected by RadioAstron both at 18 cm and 1.35 cm.

AGN active-state alert system for geodetic and astrophysical VLBI observations

Rastorgueva-Foi, E. (Aalto University Metsähovi Radio Observatory), N. Zubko, S. Šćepanović, V. Ramakrishnan

Active galactic nuclei (AGN) are compact extragalactic radio sources that are characterized by strong radio flux variability. Their structure is resolved on milliarcsecond scale, that can be achieved only with Very Long Baseline Interferometry (VLBI) observational technique. VLBI allows direct observations of relativistic AGN jet, that appears as time-variable extended structure protruding from a compact bright VLBI core. AGN are also used in geodesy to define the celestial reference frame (CRF). This is done by estimation of their positions via geodetic and astrometric VLBI observations. GeoVLBI is the only technique at the moment that is able to define CRF. For geodetic applications, presence of extended time-variable jet impairs the accuracy of VLBI observables and, thus, affects all estimated geodetic parameters. New jet components, that tend to appear during recurrent periods of AGN activity, make AGN during the active state bad targets for geodetic VLBI. At the same time, active AGN become the most desired targets for astrophysical VLBI for the same reason. Brightest AGN are monitored in multiple wavebands in order to study their behavior and test physical models. Active state alerts are often used to trigger VLBI observational campaigns. We propose to use this information for scheduling of the geoVLBI observations as well. Such alerts should be used for geoVLBI in the opposite manner: flaring source should be suspended from use in geoVLBI until it "calms down". By today, a vast amount of astrophysical and geodetic VLBI data is available for AGN that define CRF, together with their continuum single-dish monitoring data. We propose to combine this knowledge in order to create a global alert system, that will use data on individual AGN to set personalized thresholds for the determination of the active state. Active state alerts can be used by geoVLBI schedulers to optimize source lists. We present a prototype alert software created at Aalto University for Metsähovi Radio Observatory 37 GHz AGN monitoring data.

Special Session Sp3

Fundamental stellar parameters

1 Oral contributions

Fundamental stellar parameters from photometry

Casagrande, Luca (Australian National University)

Homogeneous and accurate stellar parameters are vital for a number of purposes in stellar and Galactic astronomy. While different photometric and spectroscopic methods exist to translate stellar observables into physical parameters, each one of those comes with its pros and cons. Photometry provides a relatively cheap -yet powerful- way to gauge into those uncertainties. I briefly review different photometric methods, highlight the importance of correctly translate magnitudes into physical fluxes, and discuss some of the most recent results and their implications.

Asteroseismic estimation of fundamental stellar properties

Chaplin, William (School of Physics and Astronomy, University of Birmingham)

Recent advances in observational asteroseismology are making it possible to estimate accurate and precise fundamental properties of a growing number of solar-type and red giants stars. These advances have come in large part from new satellite observations, for example from the French-led CoRoT satellite. In this talk I will review briefly the asteroseismic techniques, and present and discuss recent results from their application.

The Stagger-Grid project: a grid of 3D model stellar atmospheres for high-precision spectroscopy

Collet, Remo (Australian National University), Zazralt Magic Martin Asplund

I will present the Stagger-Grid project, a comprehensive grid of realistic, time-dependent, three-dimensional, hydrodynamical model atmospheres of solar- and late-type stars. The recently completed Stagger-Grid covers a wide range of stellar parameters and compositions, from main-sequence stars to red giants, with metallicities from [Fe/H]=+0.5 to [Fe/H]=-4. The three-dimensional model atmospheres have been generated using a custom version of the radiation-magnetohydrodynamics Stagger-Code which implements state-of-the-art input micro-physics, equation of state and opacity data, and a realistic treatment of non-grey radiative transfer. In this contribution, I will present the main properties of the Stagger-Grid simulations and discuss the application of three-dimensional model atmospheres to spectral line-formation calculations, high-precision spectroscopy, and stellar parameter determinations. I will illustrate the main effects of three-dimensional model atmospheres and three-dimensional spectral synthesis on the predicted strengths, wavelength shifts, and shapes of spectral lines, and spectral energy distributions, highlighting the systematic differences with respect to calculations based on classical, one-dimensional, hydrostatic models. I will focus in particular on the application of Stagger-Grid models to the analysis and interpretation of data from stellar surveys for the determination of accurate stellar parameters, elemental abundances, and radial velocities.

Improving fundamental parameters of stars through stellar modelling with interferometry

Creevey, Orlagh (Institut d'Astrophysique Spatiale)

Determining precise fundamental parameters is a requisite if we wish to improve our understanding of stellar, planetary, or galactic physics. Since many stellar properties are model-dependent (e.g. ages and in many cases masses) it is crucial that we obtain as many model-independent measurables as possible. Interferometry offers this possibility by providing the angular diameter of a star. When we combine this with the observed bolometric flux of a star or its distance we obtain direct estimates of effective temperature or radius. In this talk I will review some recent work on fundamental properties obtained by interpreting interferometric data and discuss some limitations and perspectives.

Testing the temperature and metallicity scales

Datson, Juliet (Tuorla Observatory, University of Turku)

When using catalogues of stellar parameters, it is essential that you can trust their scales. We have developed methods to test the scales for stellar temperature and metallicity around solar values, by using a differential comparison of the spectra of solar analogues and solar twins with respect to a reference solar spectrum (Ceres). We derive from interpolation in the differential trends the point in the temperature-metallicity plane of the tested catalogue where the Sun would be situated, which allows us to find any possible offsets with respect to the known solar values. We have used high-resolution spectroscopic data taken with FEROS and HARPS to test the Geneva-Copenhagen-Survey catalogue and have found evidence, that its temperature and metallicity scales may be offset by about -75K and -0.1dex, respectively. In future we plan to extend our sample to test other catalogues and other points in the temperature scale.

Consistent modeling of stars

Degroote, Pieter (Instituut voor Sterrenkunde (KULeuven, Belgium) SAC (Aarhus, Denmark)), Prsa, A., Giammarco, J. Bloemen, S., Conroy, K., Matijevic, G., Hambleton, K.

Fundamental parameters of stars are often derived from a wide variety of data, which all have their separate methods and tools on the one hand, but also use different approximations to describe the stars. Depending on the required precision, it is often difficult to combine values from different sources or assess the influence of the approximations, let alone determine their accuracies.

We present the development of one consistent open-source framework in which data from stars can be analyzed in their full complexity. The framework aims at generating high-precision geometric models for stellar and substellar object, including pulsations, spots, simple magnetic fields, deformations due to multiplicity or (differential) rotation and accretion disks. Multicolour photometry, radial velocities, spectroscopic line and Stokes profiles, interferometric visibilities and images can be generated and fitted to observations. The influence of different limb darkening assumptions, stellar atmospheres, Doppler beaming, interstellar reddening etc on the derived parameters can readily be investigated. We illustrate the applicability to well-studied targets such as Vega, Beta Cephei and the HAT-P7 planetary system.

Stellar radii and masses from long-baseline interferometry

Kervella, Pierre (LESIA, Paris Observatory)

The current generation of long baseline interferometers can measure the angular diameter of nearby stars with sub-percent accuracy. They can also resolve the astrometric orbits of spectroscopic binaries down to separations of a few milliarcseconds, giving access to high precision stellar masses. Considering the sensitivity and angular resolution accessible with the current generation of interferometers (e.g. VLTI, CHARA), many types of stars are within reach of such precise measurements. I will discuss the current precision limits on the derived parameters (e.g. radii and binary orbit parameters), and show a few examples of recent works that employ interferometric measurements as constraints. Finally, I will present an overview of the domain in the HR diagram currently accessible to interferometric radius measurements, and briefly summarize the potential of the future interferometric instrumentation for stellar physics.

Stellar parameters in the Gaia-ESO and Gaia surveys

Korn, Andreas (Uppsala University)

I will review the efforts under way to extract stellar parameters from the data collected in the Gaia-ESO (2012-2016; medium-resolution spectroscopy of 200,000 stars) and Gaia (2013-2018, spectrophotometry of 1+ billion stars) public surveys. As dissimilar as these two surveys and their scientific goals are, there is a fair degree

of overlap in the methods employed, in particular when it comes to the calibration with the help of so-called benchmark stars. The ambition is to put both surveys on the same stellar-parameter scale to maximize the science return for chemo-dynamical studies of Milky-Way evolution.

Stellar models uncertainties and grid-based estimates of stellar parameters

Prada Moroni, Pier Giorgio (Università di Pisa), Valle G., Dell'Omodarme M., Degl'Innocenti S.

We study the impact of the uncertainty on the input physics adopted in stellar models, on the mixing-length value, on the helium abundance, and on the microscopic diffusion in mass and radius estimates from grid-based techniques. To do this, we computed several grids of stellar models with perturbed input physics and parameters. We found that the statistical error components are nearly constant at about 4.5% and 2% on mass and radius, respectively. The systematic bias on mass and radius determination due to extreme variation of the helium abundance or of the mixing-length value account for a 2% and 1% errors; those due to the uncertainty affecting radiative opacity are of the order of one half of the previous values. The most important bias source is neglecting the microscopic diffusion, which accounts for errors of about 4% and 1.5% on mass and radius.

High-Precision Spectroscopy and Fundamental Parameters of Cool Stars.

Ruchti, Gregory (Lund Observatory)

Spectroscopic observations of low-mass stars have shaped our understanding of Galactic structure and evolution. Major breakthroughs are expected from large-scale stellar surveys, such as RAVE and Gaia-ESO, which have delivered and will deliver spectra for many thousands of stars in the Milky Way. However, the most common method to extract information from stellar spectra has relied on the excitation-ionization balance of Fe under the assumption of hydrostatic equilibrium and local thermodynamic equilibrium (LTE).

In a recent paper, we presented a comprehensive analysis of different techniques available for the spectroscopic analysis of FGK stars. I will discuss our recommended methodology which utilizes the Balmer temperature scale and, for the first time, on-the-fly non-local thermodynamic equilibrium corrections of individual Fe I lines. I will show that we are able to recover accurate values of effective temperature, surface gravity, and metallicity, without resorting to semi-empirical calibrations of spectroscopic parameters that is common to other available (1D LTE) pipelines. Furthermore, I will show that the large differences between our method and standard methods have significant consequences for the determination of masses, ages, and spectroscopic distances to stars.

Probabilistic methods of stellar parameter determination

Schönrich, Ralph (Hubble Fellow, OSU)

The advent of large Galactic surveys raises the need to improve our tools to exploit the collected abundance of spectroscopic and photometric information. In the past years increasing efforts have been devoted to the development of Bayesian techniques to determine stellar ages and more recently distances. Albeit computationally costly, these methods are key to control systematic biases in larger samples. I will present novel approaches in probabilistic stellar parameter analysis and outline their benefits and limitations.

The PTI Giant Star Survey

van Belle, Gerard (Lowell Observatory), Kaspar von Braun, David Ciardi

The Palomar Testbed Interferometer (PTI) Giant Star Survey is a major research activity aimed at producing a comprehensive catalog of linear radii and effective temperatures for giant stars. Over the course of its 11-year run, PTI directly measured angular diameters of hundreds of giant stars, most of them repeatedly, which are now in the process of being published. Additionally, advances in the available distances and bolometric flux estimation (particularly with regards to reddening and spectral energy distribution templates) mean that linear radii should be good to 1%, and effective temperatures to 25-40K. Discrete bandpasses within the K- and H-bands will provide probes of limb darkening. This survey will be a significant advance over the previous large, homogenous surveys of van Belle et al. (1999) and Mozurkewich et al. (2003), in terms of scope and precision.

Fundamental Stellar Parameters of Main Sequence Stars with an Eye on Exoplanets

von Braun, Kaspar (MPIA), Gerard van Belle (Lowell Observatory), Tabetha Boyajian (Yale University)

Combining direct measurements of stellar angular diameter (interferometry), distance (trigonometric parallax), and bolometrix flux (SED fit of photometry measurements to empirical stellar spectral templates) provides largely model-independent values for stellar physical size, luminosity, and effective temperature. We present results of our interferometric survey of over 100 main-sequence stars using the CHARA Arrray, including our empirically determined HR diagram and relation of various relations between stellar astrophysical parameters and observables. In addition, we show how the study of exoplanet host stars in particular characterizes the planetary environment with respect to incident stellar flux, which in turn determines the location and extent of the circumstellar habitable zone. For transiting exoplanets, the combination of interferometric measurements with literature transit photometry and radial velocity data provides a full characterization of stellar and planetary astrophysical parameters.

Galactic Spectroscopic Surveys, stellar parameters and reddening

Zwitter, Tomaz (University of Ljubljana)

Last decade has introduced massive spectroscopic surveys as a new way of researching Galactic stellar populations. Following the successes of the Geneva Copenhagen Survey, Sloan and RAVE, new and even more ambitious efforts include the Gaia-ESO survey, Hermes-Galah, and of course Gaia. While spectroscopic determination of fundamental stellar parameters is reddening independent, interstellar extinction cannot be ignored even at high Galactic latitudes when using photometric supplementary information. I will review the experience gained with RAVE, and discuss the prospects for GES, Hermes and Gaia.

2 Posters

SPACE: a new code for stellar parameters and chemical abundances estimations

Boeche, Corrado (Astronimichen Rechen-Institut Heidelberg)

I present SPACE (Stellar PArameters and Chemical abundances Estimator), a new code capable to derive stellar parameters and elemental chemical abundances. The code can works on any wavelength range, if a list of absorbtion lines with corrected oscillator strengths is provided. To date, SPACE works on the wavelength ranges 5212-6260A and 8400-8900A, where I prepared a linelist of ∼3500 lines with oscillator strengths calibrated via inverse spectral analysis on 5 different star spectra. Other spectral ranges will be covered soon. Tested on the wavelength range 5339-5629A of the ELODIE spectral library spectra (degrade to R=20000, S/N∼70), SPACE provides stellar parameters with uncertainties of ∼170K in Teff, ∼0.3dex in log g, and ∼0.1dex in [M/H] and expected errors in chemical abundances of ∼0.1dex for 9 elements. At R=5000 the results are still satisfactory. I will also show and discuss the comparison of the calibrated oscillator strengths used by SPACE with the values available in literature, and show how the Generalized Curve of Growth (GCOG) library used by SPACE can be a useful tool to identify absorption lines sensible to Teff and log g.

The Initial Helium Content of Galactic Globular Clusters Stars

Di Criscienzo, Marcella (INAF-Osservatorio di Capodimonte, Napoli), Ventura, P., D'Antona F., et al.

In the context of the multiple stellar population scenario in globular clusters, a variable initial helium has been proposed as the key element to interpret the observed multiple main sequences, subgiant branches and red giant branches. As known, in the Color Magnitude Diagram the Horizontal Branch is the locus where differences in the initial helium abundance of stars are most evident recalling that it can be directly measured only in GC stars with temperature between about 8500 and 11500K. Here I discuss the most popular techniques used to infer the initial helium distribution from the photometry of HB stars and their consequences.

Chemically-peculiar low-metallicity stars BD+03°2688 and HD 55496: fundamental parameters, chemical abundances and evolution states

Drake, Natalia A. ((1)Observatorio Nacional/MCTI, Rio de Janeiro, Brazil, (2)Saint Petersburg State University, Saint Petersburg, Russia), Claudio B. Pereira(1)

We determined the atmospheric parameters and abundance pattern of two low-metallicity stars, BD+03°2688 and HD 55496, showing the s-element enrichment of their atmospheres. We showed that BD+03°2688 has high carbon and s-element abundances; its nitrogen abundance however, is low for an evolved K-giant star. In turn, the spectrum of HD 55496 reveals low carbon enhancement and high nitrogen and s-element abundances. We analyzed the influence of the uncertainties in the adopted atmospheric parameters on the derived chemical abundances. The evolutionary state and nature of the s-element enrichment of these stars are discussed.

$\Delta Y/\Delta Z$ from binary stars: metallicity dependence and helium saturation

Fernandes, João (University of Coimbra), A. Costa

During the last decades the studies about reliable helium-to-metal chemical enrichment parameter, $\Delta Y/\Delta Z$, have played an important role on stellar evolution with considerable impact on galactic and extra-galactic chemical evolution studies. The main goal of this poster is to determine the $\Delta Y/\Delta Z$ based on the comparison between updated stellar evolutionary models and recent observational data for 64 binaries, where luminosity, effective temperature, gravity and metallicity are available (Torres et al. 2010), assuming that both members of the binary are coeval. The mass of these stars are known, at most, with a 3% precision. Results. Our results show a clear dependence (but non-linear) between $\Delta Y/\Delta Z$ and metallicity. On the other hand we see a "kind" of helium saturation for more metallic stars.

Chemical Abundance Scale in Giant and Dwarf stars

Ferreira, Leticia (ESO-Garching), Luca Pasquini, Rodolfo Smiljanic

In stellar population studies, it is often assumed that dwarfs and giants share the same abundance scale. This assumption, if not applicable, may have implications on the interpretation of several astronomical questions, for example, on planet formation theories and on chemical evolution studies. It is therefore crucial to investigate whether the metallicity discrepancies found between these two different stages of the stellar evolution are real or are produced by systematic errors in the analysis. To achieve that we used open clusters, under the assumption that they share the same chemical composition. We have begun this investigation using the Hyades open cluster. This is a special cluster because the giants stars have available both (i) high resolution spectra and (ii) direct interferometric measurements of the angular diameter. Since this cluster has also been studied by planet search surveys, a representative set of dwarfs with 4500K $\leq$ Teff $\leq$ 6300K are available. We propose a novel approach based on 1D-LTE spectroscopic analysis, with a bechmark test to investigate how much non-LTE effects are relevant for the stars in this cluster. A set of well constrained stellar parameters were fixed and then compared with the results of a classical spectroscopic analysis. The microturbulence parameter has also been fixed according to 3D models. Here we present the abundances results for giants and dwarfs of the Hyades cluster.

High-Precision Stellar Diameters from Coherent Integration of NPOI Data

Jorgensen, Anders (New Mexico Tech), J. T. Armstrong, H. R. Schmitt, E. K. Baines, D. Mozurkewich, T. Hall, D. Hutter, G. T. van Belle

We will discuss a technique which we have used to improve stellar diameter measurement precision from the NPOI by an order of magnitude, as well as some results. Extremely high-precision stellar diameters, above 1:2000, as a function of wavelength, can be used to probe stellar atmospheres, oblateness, and small-amplitude pulsations, in detail. Achieving this precision or accuracy requires a sensitive measure which can be compared between model and observations. Fitting a model to the large-amplitude visibilities is not effective because while those visibilities have good SNR their accuracy is limited by calibration. Good proxies for diameter and other parameters are visibility nulls, requiring only good wavelength calibration of the instrument, not

amplitude calibration. Because the SNR of squared visibilities near the null is small we must use coherently integrated visibility amplitudes which provide the necessary SNR. We will discuss coherent integration, how the null measurements are made and show some results using NPOI data, including diameters to a precision of approximately 1:1000 from a few minutes of observations.

A precision photometry study of Galactic star-forming sites

Kaltcheva, Nadia (University of Wisconsin Oshkosh), Valeri Golev (St Kliment Ohridski University of Sofia)

We compare various color excess and luminosity calibrations in order to determine a reliable way to calculate accurate stellar parameters for large samples of early-type stars. We utilize both wide-band and intermediate-band photometries to select spectro-photometric calibrations that yield distances in agreement with the precise $uvby\beta$ results. This approach provides new, more detailed insights on the structure of complex Galactic star-forming fields. It allows us to reliably identify the young stellar content of large-scale Galactic HI shells and to relate its spatial distribution to other tracers of interstellar gas (CO, HII) as well as to obscured stellar populations. Another application of this approach is obtaining homogeneous photometric distances for a large sample of Galactic HII regions.

Giant stars in the young open cluster NGC 3114: fundamental parameters and chemical abundances

Katime Santrich, O. J. ((1)Observatorio Nacional/MCTI, Rio de Janeiro, Brazil, (2) Saint Petersburg State University, Saint Petersburg, Russia), C. B. Pereira(1), N. A. Drake(1,2)

We present the results of detailed spectroscopic analysis of seven red giants in the young open cluster NGC 3114. Using the local-thermodynamic-equilibrium model atmospheres of Kurucz and the spectral analysis code MOOG we determined atmospheric parameters and abundances of 17 chemical elements, including the light elements (CNO, Li) and the $^{12}C/^{13}C$ ratio. A turn-off mass of the cluster of $4.2\,M_{\odot}$ was derived by means of an isochrone fit. We showed that the analyzed giant stars of NGC 3114 have low oxygen abundances, $\langle[O/Fe]\rangle = -0.16 \pm 0.10$, whereas their sodium abundance is enhanced. The influence of the errors in the adopted atmospheric parameters on the derived chemical abundances is discussed.

Mass inference of solar type stars: comparison between methods

Pinheiro, Fernando (Centro de Geofísica da Universidade de Coimbra & Observatório Astronómico da U.C.), J.M. Fernandes, M. Cunha, M.J. Monteiro, N. Santos , J.P. Marques, J. Sousa, S. Sousa and J. Fang

Different approaches can be used to infer stellar masses, from methods which rely on empirical relationships between known global stellar parameters, to the use of stellar evolutionary models. In this presentation we evaluate four of such methods for a homogeneous sample of 300 main sequence FGK type stars. By combining the results obtained with these methods, we have determined the best mass-value for each individual star, as well as the associated error bar. Our results point out towards the expected consistency between the different mass estimation methods. Nonetheless, for masses above $1.2M_{\odot}$ the spectroscopic surface gravities seem present an overestimation of the targets' masses.

The importance of appearing right

Portinari, Laura (Tuorla Observatory, Dept. of Physics and Astronomy, University of Turku), L. Casagrande, J. Andersen, I. Glass, D. Laney, B. Nordström, et al.

The apparent size of stars provides a crucial benchmark in determining fundamental stellar properties such as effective temperatures, radii and surface gravities. While interferometric measurements of stellar angular diameters are the most direct method to gauge into those, they are still limited to relatively nearby and bright stars, which in most of the modern photometric surveys are usually saturated. This dichotomy prevents from safely extending well calibrated relations to the faint stars targeted in large spectroscopic and photometric surveys. Here, we break this bottleneck by presenting SAAO near-infrared JHK observations of about 60 stars: 16 of them have interferometric angular diameters, and 38 are in common with the 2MASS (unsaturated) dataset, thus allowing to tie to the interferometric scale the stellar parameters derived via the Infrared Flux

Method. A critical evaluation is carried out, to infer the accuracy at which stellar parameters can be determined from fundamental methods, highlighting the systematics involved and concluding that the 1 percent level is within reach. Realistic zero-point uncertainties on stellar parameters have far reaching implications, from understanding the metallicity distribution function in the local Galactic disc, to deriving accurate ages and asteroseismic distances of stars, to buildind 3D maps of reddening over the Galaxy.

Fundamental parameters and abundance patterns of a sample of debris-disks and planet-hosting stars

Rojas Garcia (1), M. M. ((1)Saint Petersburg State University, Saint Petersburg, Russia, (2) Observatorio Nacional/MCTI, Rio de Janeiro, Brazil, (3)Observatorio Astronomico de Cordoba, Cordoba, Argentina), N.A. Drake(1,2), C. Chavero(3), C.B. Pereira(2), A.F. Kholtygin(1), J.A. Cahuasqui Llerena(1)

We present a detailed analysis of the chemical composition of stars with debris-disks and planet-hosting stars based on high resolution spectra obtained with the FEROS echelle spectrograph and the 2.2 m ESO telescope at La Silla, Chile. Atmospheric parameters were derived employing the local-thermodynamic-equilibrium model atmospheres of Kurucz and the spectral analysis code MOOG. We derived chemical abundances of different groups of elements, including light (C, N, O), iron-peak, and neutron-capture elements (Y, Zr, Ba, Nd, Eu), by means of a synthetic spectrum method and equivalent width measurements. The hyperfine splitting of the Ba II and Eu II lines has been taken into account. The comparison of the abundance patterns of debris-disk, planet-hosting and field stars of the same metallicity is presented. The comparison of abundance patterns of different samples is very important for a better understanding of the connection between discs and planets.

The effective temperature and entropy production as a function of star age

Zubarev, Sergey (Ural Federal University), Leonid Martyushev (Ural Federal University)

The effective temperature, luminosity, density of entropy production and entropy production for a number of open cluster stars as a function of age are studied. We used BV photometric data provided on the WEBDA project site [http://www.univie.ac.at/webda/]. The nearest clusters (E (BV) $\leq$ 0.55) with the number of single stars is no less than 50 and membership probability more than 50% are only investigated. In addition, we compare the HR-diagrams of these clusters with theoretical isochrones for the same ages and metallicity [Fe / H]. Thus, 13 open clusters for the age from 12.6 Myr to 7.5 Gyr are selected (IC 4725, Melotte 25, NGC 188, NGC 869, NGC 884, NGC 1039, NGC 2099, NGC 2281, NGC 2506, NGC 2516, NGC 2632, NGC 2682, NGC 3532). We use the effective temperature calibration [Casagrande 2010] for the dwarfs and subgiant stars and the calibration [Ramirez & Melendez 2005] for the giant stars. Depending on the star type either [Flower 1996] or [Cameron Reed 1998] methods are used for the bolometric correction calculation. The thermo-physical star data and a statistical analysis are made using our special software [http://fisica.hol.es/sc/]. The obtained results are compared with the model results based on the Padova database of stellar evolutionary tracks and isochrones [http://pleiadi.oapd.inaf.it/] and different initial mass functions [Chabrier 2001, Kroupa 1998, Salpeter 1955].

Homogenized HR diagram for the open cluster NGC 188

Zubarev, Sergey (Ural Federal University), Valeri Malyuto (Tartu Observatory)

We consider some selected published stellar catalogues of $B-V$ and V values for the open cluster NGC 188, the errors of these data are estimated from data intercomparisons with the use of an approach outlined by Malyuto and Shvelidze (2011, Baltic Astronomy, 20, 91). The results are used to homogenize the data by their averaging (with the weights inversely proportional to the squared errors). A recent calibration by Casagrande et al. (2010, A&A, 512, 54): $B-V$ versus effective temperatures for F-G-K dwarfs and subgiants is then used to produce the homogenized effective temperatures for these stars. The homogenized HR diagram (the relationship between the effective temperatures and their absolute magnitudes) is presented and analysed.

Special Session Sp4

The origin of interstellar dust

1 Oral contributions

Molecule and dust reprocessing by shocks in the supernova remnant Cas A

Biscaro, Chiara (Basel University), Isabelle Cherchneff

Dust and molecules are observed in various supernovae (SNe) and their remnants, but their formation and evolution in these hostile, shocked environments are still unclear. Recently, transitions of warm CO have been detected with the Spitzer, Akari and Herschel telescopes in the 330 years-old SN remnant Cas A. In particular, CO lines were detected with Herschel in a small O-rich clump, and a high CO column density and temperature, compatible with shocked gas, were derived from line modelling. These observations thus show that fair quantities of CO reform after the passage of the reverse shock. The Cas A remnant results from the explosion of a 19 Msun star as a supernova. We first model the SN ejecta chemistry to identify the molecules and dust clusters that form after the explosion. We then model the impact of the reverse shock on a O-rich ejecta clump, using a chemical kinetic approach. The reverse shock slows down while crossing the high-density gas of the clump to reach a speed of 200 km/s. We investigate the post-shock chemistry, considering the destruction of molecules and dust clusters by the shock and their reformation. We consider the impact of X-rays coming from the hot post-shock region on the ionization fraction of the post-shock gas. We found that the reverse shock destroys the molecules and dust clusters present in the O-rich clump. CO reforms in the post shock gas with abundances that concur with the latest Herschel observations, confirming a post-shock origin for the submm CO lines. Small dust clusters do not efficiently reform in the shocked gas, indicating that once destroyed by the reverse shock, the SN ejecta dust won't be able to reform in the remnant.

Herschel and ALMA observations of dust in supernovae and their implications of origin of dust in the interstellar media

Matsuura, Mikako (University College London), Mikako Matsuura

The origin and evolution of dust grains in the interstellar medium of galaxies is largely unknown. Theoreticians have proposed that supernovae could be an important source of dust, if they can form between about 0.1-1.0 solar mass of dust per supernova. This requires observational measurements. I am going to review recent Herschel and ALMA observations of dust in supernovae. The measured dust masses in SNe range between 0.07-0.7 solar masses, matching the theoretical required values. These observations started revealing that supernovae could be a crucial site for the dust formation, and potentially destruction. I also present ALMA observations of molecules in supernova 1987A. As elements formed in supernovae limit the total mass of molecules and dust, molecular mass must be small in SNe. SNe could have a significant impact on dust in the interstellar media of galaxies

Chemically-controlled synthesis of dust in the ejecta of Type II-P supernovae

Sarangi, Arkaprabha (University of Basel), Arkaprabha Sarangi & Isabelle Cherchneff

Observations in the infrared (IR) and sub-millimeter (submm) both indicate the presence of molecules and dust in the ejecta of Type II-P supernova (SNe) and their remnants. The mass of dust formed in the ejecta

of SNe is still uncertain and highly debated: IR observations indicate small dust mass (10-5 to 10-3 Msun) before 500 days post-explosion, when submm observations with Herschel reveal large reservoirs of cool dust (10-2 to 0.7 Msun) in supernova remnants. We study the ejecta of various Type II-P SNe using a chemical kinetic approach, and consider the synthesis of molecules and small clusters (e.g., silicates, carbon, metal oxides, metallic clusters etc) in the ejected material until 4 years after explosion. We find that the dust clusters form gradually over time in different ejecta zones, resulting in small dust masses produced before $\sim$ 600 days ($\sim$ 10-4 solar mass), that gradually increase up to $\sim$ 0.1 Msun at 1500 days post-explosion. These small clusters undergo coagulation processes to form dust grains. We model the contribution of these grains to the IR flux at $\sim$ 500 days post-explosion in SNe, and to the submm flux of SN remnants (e.g., SN87A, the Crab Nebula) measured with Herschel. Both clumped and unclumped ejecta are considered. Our small dust mass can reproduce the IR fluxes of SNe at early post-explosion time, when our larger dust mass at late time (10-2 to 0.1Msun) can reproduce the submm fluxes of SNe remnants. The gradual dust growth in SN ejecta with time therefore reconciles IR and submm data. We conclude that Type II-P supernovae are moderate dust producers to galaxies.

2 Posters

STALLED WAVE THEORY A POSSIBLE SOLUTION TO DARK ENERGY RIDDLE.

ANGEL, PEREZ (COMILLAS MADRID)

you can find poster (pdf) in the next link;
http://www.magnetismo.es/dark-energy/

Special Session Sp5

Thick discs: clues for galaxy formation and evolution

1 Oral contributions

Our current understanding of the Milky Way thick disc

Bensby, Thomas (Lund Observatory)

I will review the properties of the Galactic disk, and the thick disk in particular, using observational evidence from local samples of dwarf stars as well as larger samples coming from new large surveys. I will put special focus on the existence (or non-existence?) of the thin disk/thick disk dichotomy.

Cosmological Simulations of Thick Discs

Brook, Chris (Universidad Autonoma de Madrid de Madrid)

Thick disc formation within hydrodynamical cosmological galaxy formation simulations is reviewed, highlighting where agreement with observation provides encouragement, and where weaknesses in the models remain. Although models identify thick and thin disc components, the nature of the separation is worthy of inspection: we look closely at the origin of stars within each component and the processes involved in their formation. We argue that it may require a combination of local, "archaeological" observations and direct high redshift observations of galaxy formation in order to get to the bottom of thick disc formation.

The origin of thick discs

Comeron, Sebastien (University of Oulu)

Thick discs are defined to be disc-like components with a scale height larger than that of the classical discs. They are known to be made of mostly old and metal-poor stars and are most easily detected in close to edge-on galaxies in which they appear as a roughly exponential excess of light which appears a few thin disc scale heights above the midplane. Their origin has been considered mysterious until recently and several formation theories have been proposed.

One main family of thick disc formation theories advocates for having them formed by the heating of the thin disc, either by its own overdensities or by satellite galaxies/haloes interacting with the disc. Another family of models proposes that thick disc have been formed through accretion of stars in satellites, and finally it has been suggested they have formed in situ at high-redshift. Thus, unveiling the origin of thick discs is of key importance for understanding galaxy evolutionary processes.

I will present a review on thick discs and their origin and I will show recent results which suggest that thick discs are much more massive than previously thought, which would indicate an in situ origin and would make them a reservoir of some of the missing baryons.

The age structure of stellar populations in the solar vicinity.

Haywood, Misha (Paris Observatory), Paola Di Matteo, Matthew Lehnert, David Katz, Ana Gomez

I will present new results based on the analysis of a sample of high quality abundances data set of solar

neighborhood stars and show that there are two distinct regimes of [alpha/Fe] versus age which we identify as the epochs of the thick and thin disk formation. A tight correlation between metallicity and [alpha/Fe] versus age is clearly identifiable on thick disk stars, implying that this population formed from a well mixed interstellar medium, probably first in starburst, then in a more quiescent mode, over a time scale of 4-5 Gyr. We suggest that the youngest thick disk set the initial conditions from which the inner thin disk started to form 8 Gyr ago, while the outer thin disk developed outside the influence of the thick disk, giving rise to a separate structure, but also that the high alpha-enrichment of the outer regions may originate from a primordial pollution of the outer regions by the gas expelled from the forming thick disk. Metal-poor thin disk stars in the solar vicinity, whose properties are best explained by an origin in the outer disk, are shown to be as old as the youngest thick disk (9-10 Gyr), implying that the outer thin disk started to form while the thick disk was still forming stars in the inner parts of the Galaxy.

Thick disk kinematics from RAVE and the solar motion

Pasetto, Stefano (University College London), Pasetto, S.; Grebel, E. K.; Zwitter, T.; Chiosi, C.; Bertelli, G.; Bienayme, O.; Seabroke, G.; Bland-Hawthorn, J.; Boeche, C.; Gibson, B. K.; Gilmore, G.; Munari, U.; Navarro, J. F.; Parker, Q.; Reid, W.; Silviero, A.; Steinmetz, M.

The RAdial Velocity Experiment (RAVE) is a survey that provide us with measurements of about half a milion of nearby stars most of which belong to the Galactic thin, thick disk or halo. In this work, with the aid of the RAVE survey, we studied the thick and thin disks of the Milky Way, focusing on the thick disk velocity space properties. We introduced selection criteria in order to clean the observed radial velocities from the Galactic differential rotation and to take into account the partial sky coverage of RAVE and we developed a numerical technique to statistically disentangle thin and thick disks from their mixture. We deduced the components of the solar motion relative to the local standard of rest (LSR) in the radial and vertical direction, the rotational lag of the thick disk component relative to the LSR, and the square root of the absolute value of the velocity dispersion tensor for the thick disk alone. We find good agreement with previous independent parameter determinations. Finally we present the same exercised on the RAVE thin disk stars. The results are presented in Pasetto et at. 2012a,b.

Radial exchange and the thick disc

Schönrich, Ralph (Hubble Fellow, OSU)

In the past years, radial migration and gas flows have been recognized to influence the structure of the Galactic Disc we observe. I will discuss these processes and their consequences. I will give an assessment on how much radial migration contributes to the thick disc with new models and discuss recent observational evidence. If time permits I will further discuss the possible imprints of inside-out formation.

2 Posters

Exploring the origin and evolution of Iron peak elements in the Galactic Disk

Battistini, Chiara (Lund Observatory), Thomas Bensby

We present abundance analysis results odd Iron peak elements (Sc, V, Mn and Co) in 700 F and G dwarf stars in the solar neighborhood. The stars have been kinematically selected to trace the Galactic thin and thick disks as well as well other velocity sub-structures in the solar neighbourhood. The abundances were determined through comparisons between observed high-resolution spectra and synthetic spectra based on the Uppsala MARCS stellar atmosphere models. The results will increase our understanding of the origin of these elements, if are mainly produced during core collapse supernovae (SN II) or from core degeneracy supernovae (SN Ia) and if there is any correlation with the metallicity of the progenitor stars. In addition to this it could also help us to comprehend better the formation history and the structure of thin and thick disks in our Galaxy.

Open-cluster populations in Scutum

Kaltcheva, Nadia (University of Wisconsin Oshkosh), Beaver, John (University of Wisconsin - Fox Valley), Briley, Michael (Appalachian State University)

We combine all available data on fundamental astrophysical parameters, along with new estimates based on uvbyBeta photometry, to refine the characteristics of a sample of open clusters between 20 and 40 degree Galactic longitude toward Scutum. We present new uvbyBeta photometry of NGC 6705, the most outstanding open cluster in the field. These new data yield independent estimates of color excess, distance and metallicity, allowing us to obtain the age of this cluster with less uncertainty. The separation of the open-cluster sample into thin and thick disc components is analyzed.

Special Session Sp6

AGN, galaxy mergers, supermassive binary black holes and gravitational waves

1 Oral contributions

Using infrared bright galaxies to explore the relation between star formation activity and black hole growth in galaxies

Alonso-Herrero, Almudena (IFCA, CSIC-Universidad de Cantabria)

Local luminous and ultraluminous infrared galaxies (LIRGs and ULIRGs, respectively) have both high star formation rates and a high AGN (Seyfert and AGN/starburst composite) incidence. It is reasonable to assume that the same gas that is used to form stars in the host galaxy can also be used to feed the AGN provided that there is a mechanism able to transport the gas to the inner region (on scales of less than 0.1 pc) near the black hole (BH). Therefore, local LIRGs and ULIRGs are ideal candidates to explore the co-evolution of BH growth and star formation activity associated with both major mergers and secular processes. In this talk I will review recent results using infrared observations on the interplay between star formation and AGN activity in local LIRGs and ULIRGs.

"Dark Star Clusters" and their implications on gravitational wave detection

Banerjee, Sambaran (Argelander-Institut fuer Astronomie, University of Bonn, Germany), Pavel Kroupa

Among the most explored directions in the study of dense stellar systems is the investigation of the effects of the retention of supernova remnants, especially that of the massive stellar remnant black holes (BHs), in star clusters. By virtue of their eventual high central concentration, these stellar mass BHs potentially invoke a wide variety of physical phenomena, the most important ones being emission of gravitational waves (GWs), formation of X-ray binaries, and modification of the dynamical evolution of the cluster. Here we propose, for the first time, that rapid removal of stars from the outer parts of a cluster by the strong tidal field in the inner region of our Galaxy can unveil its BH sub-cluster, thereby appearing as a star cluster that is gravitationally bound by an invisible mass. We study the formation and properties of such systems through direct N-body computations and estimate that they can be present in significant numbers in the inner region of the Milky Way. We call such objects "dark star clusters" (DSCs) as they appear dimmer than normal star clusters of similar mass and they comprise a predicted, new class of entities. The finding of DSCs will robustly cross-check BH retention; they will not only constrain the uncertain natal kicks of BHs but will also pinpoint star clusters as potential sites for GW emission for forthcoming ground-based detectors such as the Advanced LIGO.

Black Holes in Galactic Nuclei simulated with up to 700k GPU cores.

Berczik, Peter (ARI, ZAH, Heidelberg, Germany; NAOC, CAS, Beijing, China), Spurzem Rainer and Silk Road Project Team of NAOC.

Many, if not all galaxies harbor super-massive black holes. If galaxies merge, which is quite common in the process of hierarchical structure formation in the universe, their black holes sink to the center of the merger remnant and form a tight binary. Depending on initial conditions and time super-massive black hole binaries are prominent gravitational wave sources, if they ultimately come close together and coalesce. We model such systems as gravitating N-body systems (stars) with two or more massive bodies (black holes), including if necessary relativistic corrections to the classical Newtonian gravitational forces, and model their gravitational radiation emission directly from the simulation.

Obscured accretion in AGNs

Bottacini, Eugenio (Stanford University)

Accretion in active galactic nuclei (AGNs) is obscured by gas and dust that surround the central super-massive black hole. This intervening matter efficiently absorbes the primary photons up to X-ray energies hiding the AGN activity. Therefore even the most sensitive X-ray (<10 keV) surveys are missing the most obscured AGNs. Obscured AGNs are best sampled by surveys at hard X-rays (> 15 keV) that are energetic enough to pierce through the absorbing matter. At these energies most sensitive surveys are perfomed by the INTEGRAL Soft Gamma-Ray Imager (IBIS/ISGRI) and the Swift Burst Alert Telescope (BAT). However these two coded-mask detectors are limited in sentitivity due to the design of this imaging technique. In this talk I will show that the BAT and the IBIS/ISGRI observations can be combined obtaining the Swift-INTEGRAL X-ray (SIX) survey. The SIX flux sensitivity is more than a factor of $\sim$2 better than current parent surveys. This survey allows detecting efficiently the obscured AGNs. It extends over a wide sky area of 6200 deg^2 sampling 113 sources. I will discuss the evolution of AGNs in the local Universe through the luminosity function and the properties of the circum-nuclear environment of the SIX sample. These results are then compared to the expected results from the survey of the NuSTAR mission that carries for the first time focussing optics for hard X-ray photons. I will also show prelimiary results from the SIX survey applied to the entire sky.

Radio-optical, Swift and XMM-Newton observations of OJ 287

Ciprini, Stefano (ASI Science Data Center & INAF Observatory of Rome, Italy), Francesco Verrecchia, Mauri J. Valtonen

OJ 287 is one of the brightest and optically highly variable BL Lac object ever observed. This blazar has peculiarly also evidence for a central engine driven by a binary black hole system. OJ 287 has been observed from many observatories either on ground or from the space so that a huge public dataset is available, allowing detailed and long-term variability analysis. A complete reduction and processing of optical and UV space observations performed by the Swift UVOT from May 2005 to March 2011 are presented here in addiction to data and some results obtained through two intensive multifrequency campaigns driven by XMM-Newton space observations carried out in 2005 and including near-IR and optical data obtained by ground-based telescopes from fall 2004 to summer 2006.

Accretion into the Central Cavity of a Circumbinary Disk

D'Orazio, Daniel (Columbia University), Zoltan Haiman, Andrew MacFadyen

A near-equal-mass binary black hole can clear a central cavity in a circumbinary accretion disc; however, previous works have revealed accretion streams entering this cavity. We use 2D hydrodynamical simulations to study the accretion streams and their periodic behavior. In particular, we perform a suite of simulations, covering different binary mass ratios $q = M_2/M_1$ in the range $0.003 \leq q \leq 1$. In each case, we follow the system for several thousand binary orbits, until it relaxes to a stable accretion pattern. I will present our results on the mass ratio dependent evolution of the circumbinary disc and the consequences for observable electromagnetic emission from supermassive binary black holes.

Blazar variability: results from the F-GAMMA radio monitoring program

Fuhrmann, Lars (Max-Planck-Institut fuer Radioastronomie, Bonn), E. Angelakis, J. A. Zensus, T. P. Krichbaum, I. Nestoras, N. Marchili, V. Karamanavis, I. Myserlis, C. Fromm (MPIfR), H. Ungerechts, A. Sievers (IRAM), S. Larsson (Stockholm University)

Variability studies furnish important clues about the size, structure, physics and dynamics of the emitting

regions making AGN/blazar monitoring programs of uttermost importance in providing the necessary constraints for understanding the variability and energy production in these sources. The launch of the *Fermi Gamma-ray Space Telescope (Fermi-GST)* in June 2008 and its 'all-sky monitor' capabilities has introduced a new era in the field of AGN physics providing for the first time γ-ray light curves resolved at a variety of time scales for a large number of AGN. In order to fully exploit the opportunities opened up by *Fermi*-LAT, the complementary "F-GAMMA" program was initiated in 2007. This long-term program is monitoring contemporaneously the variability and spectral evolution of $\sim$60 *Fermi* bright sources at frequencies between 2.6 and 345 GHz using the Effelsberg 100-m, IRAM 30-m and APEX 12-m telescopes including polarization at several bands. After a short overview of the program, I will review interesting results emerging from the first 6 years of F-GAMMA monitoring including variability and spectral characteristics of the sample, shock-in-jet modeling and the detection of significant radio/γ-ray correlations.

Inter-stellar Scintillation in the strong, flat-spectrum radio source B0059+581

Jauncey, David (CSIRO Astronomy & Space Science and Research School of Astronomy and Astrophysics, Australian National University), J.E.J. Lovell[2], Y. Koyama[3], T. Kondo[3], S. Shabala[2], H. Aller[4] and M. Aller[4]

2: School of Maths and Physics, University of Tasmania 3: National Institute of Information & Communications Technology 4: University of Michigan Radio Astronomy Observatory

We have found a long-lived annual cycle in the intra-day 2.3 GHz flux density variability of the highly variable, flat-spectrum, z = 0.644, low Galactic latitude quasar B0059+581. The presence of this annual cycle establishes Inter-stellar scintillation, ISS, as the principal mechanism responsible for this rapid variability. More recent observations show a similar pattern of variability and also demonstrate its longevity. We are presently investigating potential relationships between the variability and ISS in this source and its VLBI properties.

Kinetic power of quasars from MOJAVE superluminal motions

López-Corredoira, Martín (Instituto de Astrofísica de Canarias), M. Perucho

The MOJAVE survey contains 101 quasars with a total of 354 observed radio components that are different from the radio cores, among which 95% move with apparent projected superluminal velocities with respect to the core, and 45% have projected velocities larger than 10c (with a maximum velocity 60c). We make an independent measure of the kinetic power required in the quasars to produce such powerful ejections. Doppler boosting effects are analyzed to determine the statistics of the superluminal motions. We integrate over all possible values of the Lorentz factor, the values of the kinetic energy corresponding to each component. The calculation of the mass in the ejection is carried out by assuming the minimum energy state, i.e., that the magnetic field and particle energy distributions are arranged in the most efficient way to produce the observed synchrotron emission. This kinetic energy is multiplied by the frequency at which the portions of the jet fluid identified as "blobs" are produced. Hence, we estimate the average total power released by the quasars in the form of kinetic energy in the long term on pc-scales.

The result is that the average total kinetic power of each MOJAVE quasar should be very high to obtain this distribution: $\sim 7 \times 10^{47}$ erg/s. This amount is much higher than previous estimates of kinetic power on kpc-scales based on the analysis of cavities in X-ray gas or radio lobes in samples of objects of much lower radio luminosity but similar black hole masses. The kinetic power is a significant portion of the Eddington luminosity, on the order of the bolometric luminosity.

The kinematic signature of the inspiral phase of massive binary black holes

Meiron, Yohai (KIAA), Ari Laor

Supermassive black holes are expected to pair as a result of galaxy mergers, and form a bound binary at parsec or sub-parsec scales. These scales are unresolved even in nearby galaxies, and thus detection of non-active black hole binaries must rely on stellar dynamics. Here we show that these systems could be indirectly detected through the trail that the black holes leave as they spiral inwards. We analyze two numerical simulations of inspiralling black holes (equal masses and 10:1 mass ratio) in the stellar environment of a galactic centre. We studied the effect of the binary on the structure of the stellar population, with particular emphasis on projected kinematics and directly measurable moments of the velocity distribution. We present those moments

as high-resolution 2D maps. As shown in past scattering experiments, a torus of stars counter-rotating with respect to the black holes exists in scales ~ 5 to 10 times larger than the binary separation. While this is seen in the average velocity map in the unequal mass case, it is obscured by a more strongly co-rotating outer region in the equal mass case; however, the inner counter-rotation could still be detected by studying the higher moments of the velocity distribution. Additionally, the maps reveal a dip in velocity dispersion in the inner region, as well as more pronounced signatures in the higher distribution moments. These maps could serve as templates for integral field spectroscopy observations of nearby galactic centres. The discovery of such signatures may help census the population of supermassive black hole binaries and refine signal rate predictions for future space-based low frequency gravitational wave detectors.

Interacting/merging pairs and multiples and the interrelationship between starburst, nuclear activity and interactions/merging phenomena

Mickaelian, Areg (Byurakan Astrophysical Observatory (BAO), Armenia), Mickaelian A.M., Harutyunyan G.S.

The interrelationship between starburst, nuclear activity and interactions/merging phenomena has been studied for interacting/merging pairs and multiples from the Byurakan-IRAS Galaxy (BIG) sample. This sample contains optical identifications for 1278 IRAS sources, mostly spiral galaxies, including 150 components in pairs and multiples. They have been proved to be AGN and Starburst by spectroscopic observations, as well as there is a number of ULIRGs among these objects. We have examined these systems to decide with the real IR-emitter and found a number of radio sources among them. Given that these objects are powerful IR sources, they are considered as young systems indicating high rate of evolution and starburst activity exceeding 100 $M_\odot$/yr. Spectroscopic observations showed that all these systems are physical ones and we were able to measure the mutual distances and sizes for all components. We have cross-correlated the sample with the recent more accurate IR catalogues, such as 2MASS, WISE and AKARI, as well as radio ones (NVSS, FIRST). In almost half of the cases, IR position indicates the intermediate regions between the components, which means that it comes from the system as a whole, thus indicating high IR from the interaction/merging region. Some more MW data (X-ray, UV, optical) have been matched to IR and radio to have MW flux ratios and an overall understanding on these systems of galaxies.

The role of radio jets in gas outflows and negative feedback

Morganti, Raffaella (ASTRON & Kapteyn Institute)

The characteristics (ionisation, kinematics etc.) of the different phases of gas in the circumnuclear regions of active nuclei hold clear signatures of the influences that the black hole activity has on its surroundings. I will report on recent results we have obtained on the study of fast AGN driven outflows of cold and warm gas and of their implications for the evolution of the host galaxy. In particular, I will concentrate on the effects of radio jets in generating the strong negative feedback of the kind invoked in current scenarios for galaxy evolution. Part of the talk will concentrate on the recent finding of objects were fast outflows of both atomic neutral and molecular gas are present and will compare the derived parameters (kinetic energy, mass outflow rate etc.) from these two different diagnostics.

The Nuclei of Galaxies

Mundell, Carole (ARI)

The distribution of gas and stars in nearby galaxies traced by '3-D' studies of molecular, neutral and ionised gas provide a unique view of the role of the multi-phase medium in triggering and fuelling nuclear activity in galactic nuclei on size scales ever closer to the central black hole.

Although technically challenging such studies are now evolving to include comparative study of gaseous and stellar dynamics in active and quiescent galaxies.

I will review 3D studies at optical, radio and mm wavelengths and highlight the importance of studying the inner kiloparsec, where activity and dynamical timescales become comparable. I will end with a new IFU-imaging spectroscopic comparative study of the distribution and kinematics of ionised gas in a carefully matched sample of Seyfert and quiescent galaxies, selected from the SDSS, that takes 3D studies to higher redshift.

AGN pairs and Supermassive binary black holes: constraints from emission lines

Popovic, Luka (Astronomical Observatory, Belgrade)

It is widely accepted that mergers play an essential role in the evolution of galaxies and consequently one can expect that mergers of super-massive black holes (SMBHs) are common. Theoretically, it is expected that SMBs should spend a substantial amount of time orbiting at velocities of a few thousand kilometers per second, and if a SMB is surrounded by gas observational effects might be expected from accretion onto one or both of the SMBHs. Thus, during evolution of a SMB, a binary Active Galactic Nucleus (AGN) system could exist for a period of time. Then, similarly to a single AGN, such a system would emit a broad band electromagnetic spectrum, as well as the broad and narrow emission lines. There is a number of AGNs that emit very broad and complex line profiles, showing two displaced peaks, one blueshifted and one redshifted from the systemic velocity defined by the narrow lines, or a single such peak. It has been proposed that such line shapes could indicate a SMB system. We discuss here how the presence of a SMB will affect the BLRs of AGNs and what the observational consequences might be. Additionally, we discuss the double-peaked narrow line AGNs and the expected line profile of broad Fe Kα that probably originated in the accretion disk(s) around SMBs.

eLISA : Revealing the Gravitational Universe

Porter, Edward (APC - Paris)

The next two decades will provide us with a richness of information regarding our Universe. LSST will answer questions regarding the stellar structure and evolution of the Milky Way, while SKA will survey supermassive black holes via pulsar timing, as well as the formation of galaxies and massive black holes during the dark ages.

In this talk we present the complementary future European space-based gravitational wave observatory eLISA, which will, for the first time, open up the gravitational Universe in the 0.01 mHz - 1 Hz band. While it is expected that we will individually resolve many thousands of compact galactic binaries in the Milky Way, the main goals of the mission are the formation and evolution of massive black holes out to redshifts of z=10. Furthermore, at redshifts out to z=1, by observing the hundreds of thousands of orbits traced out by stellar black holes in the strong gravitational field of galactic centers, we will be able to carry out unique tests of fundamental physics and of General Relativity itself.

Long-term variability of extragalactic radio sources

Rachen, Joerg (IMAPP, Radboud University Nijmegen), Xi Chen, IPAC, Caltech

Combining measurements taken by the WMAP and Planck satellites, we investigated the long-term flux density variability of extragalactic radio sources selected from the Planck Early Release Compact Source Catalogue. The single-year, single-frequency WMAP maps are used to estimate yearly-averaged flux densities of the sources in the four WMAP bands, Ka, Q, V, and W. We identify 82, 67, 32, and 15 sources respectively as variable at greater than 99% confidence level in these four bands. Almost all the sources that show variability are blazars. We have attempted to fit two simple, four-parameter models to the time-series of 32 sources showing correlated variability at multiple frequencies – a long-term flaring model and a rotating-jet model. We find that about 60% of the sources can be fit with the simple rotating-jet model, roughly half of them are also consistent with the long-term flaring model. The remaining 40% show more complex variability behaviour that is not consistent with either model. We discuss potential caveats of our method and possibilities for improvement by applying Bayesian classification methods.

XMM-Newton highlights of AGNs

Schartel, Norbert (ESA)

With about 300 refereed papers published each year, XMM-Newton is one of the most successful scientific missions of ESA ever. Observation of AGNs is one of the main research fields covered by the observing program of the mission. The talk highlights XMM-Newton contributions to our current view of AGNs. X-ray observations provide a unique opportunity to study the vicinity of supermassive black hole, i.e. the region where the strong gravitational field acts and allow the determination of black holes spin. XMM-Newton observations constrain the understanding of the underlying accretion physics. The main focus of the talk will be the discussion of scientific highlight results based on XMM-Newton observations of AGNs.

Recurring flares from supermassive black hole binaries: implications for tidal disruption candidates and OJ 287

Tanaka, Takamitsu (Max Planck Institute for Astrophysics)

I present a simple, semianalytic model of periodically recurring, luminous outbursts from accreting supermassive black hole binaries. The flares occur due to the periodic modulation of the central accretion rate in binaries embedded in prograde gas discs. The observational appearance is an Eddington-scale, optical/UV/X-ray outburst that interrupt (possibly prolonged) periods of relative quiescence. Some systems may appear quiescent between outbursts. The flares may resemble tidal disruptions of stars, but should (i) recur every binary orbit, and (ii) be produced by very massive black holes that do not tidally disrupt solar-type stars. This hypothesis should be confirmed or falsified by future surveys such as LSST or eROSITA. I use the flaring model to interpret the optical outbursts of OJ 287.

A merger-driven unified model for triggering active galactic nuclei and a new insight on the co-evolution between supermassive black holes and galaxies

Taniguchi, Yoshiaki (Ehime University), none

We discuss a possible merger-driven unified model for the triggering active galactic nuclei; all Seyfert galaxies were driven by minor mergers and all quasars were driven by major mergers. This unified model provides us a new insight on the so-called co-evolution between supermassive black holes and galaxies.

High-energy phenomena in blazars

Tavecchio, Fabrizio (INAF, Osservatorio Astronomico di Brera)

I review the current understanding of the emission of high-energy radiation from blazars, focusing in particular on: 1) the puzzling detection of very high energy ($E > 50$ GeV) photons from flat spectrum radio quasars (FSRQ) which, together with other observational results, hints for an emission region located at relatively large distances (> 1 pc) from the central engine; 2) the ultra-fast ($\sim$ min) variability detected in some sources (also FSRQ), which suggests the possible role of magnetic reconnection in the acceleration of ultra relativistic particles. These recent discoveries are starting to shade new light on the functioning of relativistic jets and particle acceleration in relativistic flows.

A helical jet in the binary black hole system OJ287

Valtonen, Mauri (FINCA, University of Turku)

OJ287 is a quasar with a quasi-periodic optical light curve where the 12 yr periodicity has been observed over ten cycles. This is generally accepted as resulting from a binary black hole system, with alternative explanations currently excluded at 5 sigma significance level (Valtonen et al. 2011). The resolved radio jet of OJ287 has been observed for a shorter time of only about 30 years. It has a complicated structure which varies dramatically in a few years time scale (Agudo et al. 2012, Tateyama 2013). We propose that this structure arises from a helical jet (Hardee 2000) being observed from a small and varying viewing angle. The orientation changes in the inner accretion disk are calculated to be in tune with the binary orbital motion. We assume that the jet is launched perpendicular to this disk. We find that this model reproduces the observations well if the changes in the axis of the conical helix propagate outwards with a relativistic speed of about 0.85 c. In particular, this model explains at the same time the long-term optical brightness variations as varying Doppler beaming in a component close to the core, i.e. at parsecs scale in real linear distance, while the mm and cm radio jet observations are explained as due to jet wobble at 100 parsecs scale distances from the core. The long term variations of optical polarization also follow this model if the jet magnetic field is parallel to the jet line. References: Agudo, I. , Marcher, A.P., Jorstad, S.G., Gomez, J.L., Perucho, M., Piner, B.G., Rioja, M. & Dodson, R. 2012, ApJ, 747, 63 Hardee, P.E. 2000, ApJ, 533, 176 Tateyama, C.E. 2013, ApJS, 205, 15 Valtonen, M.J., Lehto, H.J., Takalo, L.O. & Sillanpää, A. 2011, ApJ, 729, 33

AGN in duet with their neighbours: who plays the viola?

Villarroel, Beatriz (Uppsala Universitet)

We have used the Sloan Digital Sky Survey and Galaxy Zoo to study a large number galaxy neighbours to Type-1 and Type-2 AGN. Our aim was to test the AGN unification (Antonucci 1993), and we have found results more supportive of a evolutionary sequence between the two classes of objects (type-1 vs type-2 AGN). With our data, we can so far only reject the geometric model of AGN unification. From morphology constraints, we see that the AGN appear to interact very differently with their neighbours. Also, both they influence their neighbours star-formation in very disparate ways, but also it seems from our data that Type-2 AGN are very "fragile" states that do not survive subsequent merger and transform into something else. But into what? We will also discuss a zone-of-avoidance around AGN found in our data.

Optical variability of OJ287 at different time scales

Zola, Staszek (Jagiellonian University), + team of observers

This talk will give a review of optical variability observed in OJ287 and other blazars. New observations will be reported which are based on about seven years (2006-2013) of optical monitoring of OJ287. The observed amplitudes and time scales, including very short, intranight ones will be discussed. Preliminary results of a multisite campaign conducted in February 2013, aimed at detection of the secondary black hole in OJ287 will be presented.

Possible correlations between optical variability and that in other wavelenghts will be examined. Finally, comparison between optical variability of OJ287 and that seen in a sample of FRII radioquasars observed with the same equipment over more than last three years will be done.

2 Posters

Numerical modelling of AGN jets using novel C++11 implementation of smoothed-particle magnetohydrodynamics

Oksman, Miika (Aalto University Metsähovi Radio Observatory), Joni Tammi

We present a work-in-progress numerical model for radiative behaviour of variable AGN jets throughout the electromagnetic spectrum. The model is implemented using C++11 programming language and utilises smoothed-particle magnetohydrodynamics (SPMHD) to simulate jet's radiation phenomena upwards from particle level to parsec scale. By virtue of the SPMHD implementation, there is no need for assumptions of homogeneity or isotropy and the physical 3D system geometry becomes dynamic instead of being tied to rigid computational mesh. Calculational costs can be controlled by varying simulation resolution based on e.g. local particle density and its changes in time. The program code is meant to be adaptable to other astrophysical scenarios beyond the AGN jet context.

The X-ray population in eight pairs of interacting galaxies

Tomás, Laura (XMM-Newton SOC, ESAC/ESA), Nora Loiseau, Enrico Piconcelli, Elena Jiménez-Bailón, María Santos-Lleó

Infrared observations have revealed that most of the highly luminous infrared galaxies are interacting. The tidal forces produced by the close passage of a companion galaxy are generally assumed to cause perturbation and compression of the gas enhancing star formation. These processes would also be responsible for triggering black hole activity in the centre of the interacting galaxies. However, binary and dual AGNs are not as common as expected in interacting galaxies. This can be due to the fact that the effects might only be noticeable at given stages of the companion passage, and their intensity might also depend on the mass and type of the interacting galaxies.

In this context we analyse the X-ray population, and particularly the nuclear emission, in eight nearby IR luminous interacting pairs of galaxies of similar size (major mergers). We observed all eight galaxies with Chandra and we also analysed XMM-Newton archival data for one of these.

Special Session Sp7

Science with present and future interferometric instruments

1 Oral contributions

The VLTI today, tomorrow and in the future: a pragmatic road towards optical interferometry's enhanced scientific output

Berger, Jean-Philippe (ESO)

While VLTI medium and long term plans are strongly constrained by budgetary constraints associated to the development of the ELT there is still room for scientific ambition. In this talk I will explain how VLTI is preparing for the arrival of the GRAVITY and MATISSE instruments by conducting an important overhaul of the VLTI (fringe tracker, adaptive optics, polarization analysis,...). While this work will dominate the tasks at VLTI for the next 5 years a medium and longer term prospective is necessary and should start soon. VLTI third generation instrumentation will be competing will VLT single-dish instrumental proposals and care should be taken to establish compelling science cases. In the longer term (the so-called "ELT-era", 2020 and later) VLTI will be reaching its natural limits (angular resolution, sensitivity, sky coverage...) and all the astronomers in need for high angular resolution observations will be challenged to open new scientific avenues possibly by enhancing the VLTI infrastructure. While this plan will be developed in close collaboration with the community I will discuss possible directions and the challenges the interferometry community will meet.

Science with interferometry during the last decade

Chesneau, Olivier (Observatoire de la Côte d'Azur)

Optical interferometry has become a mature technique about 120yr after the first publication from Michelson. During the last decade about 400 papers were published, one half originating each year from the two main instruments of the ESO Very Large Interferometer at Paranal, Chile. Most of these studies concern stellar physics, the historical domain of application: diameter and shape of stars measurements joined with astero-seismological studies, pulsating stars such as Cepheids and distance indicators, binary detection and orbital follow-up for inferring accurate masses, mass-loss and winds, characterization of disks around Young Stellar Objects , evolved stars or around interacting binaries. The technique has also successfully been applied for spatially resolving the ejecta from bright novae a few days after eruption or to characterize of appearance of some asteroids in the thermal infrared. A new era opened with the detection of compact dusty tori around AGNs.

Pre-main-sequence binaries with tidally disrupted discs

Garcia, Paulo (Universidade do Porto, Faculdade de Engenharia, SIM Unidade FCT n. 4006, Rua Dr. Roberto Frias, s/n, P-4200-465 Porto, Portugal), M. Benisty, C. Dougados, F. Bacciotti, J.-M. Clausse, F. Massi, A. Mérand, R. Petrov and G. Weigelt

Active pre-main-sequence binaries with separations of around ten stellar radii present a wealth of phenom-

ena unobserved in common systems. Most importantly is the opening of a gap in the inner circum-binary disk due to orbital tidal effects. On one hand the gap changes the illumination and thermodynamics of the remaining disk, on the other it allows spiral material to flow into the inner system. Depending on the exact orbital characteristics of the system, the individual stars can even be stripped of their own circum-stellar disks. Furthermore, as these objects are very young they present intense magnetic activity in the form of extended magnetospheres. In the most eccentric objects magnetosphere collisions at periastron passage has been detected. In these young objects angular momentum is thought to be removed from the disk by powerful jets. Some of these close binaries present jets and others do not. As jet models require stringent disk properties these systems are able to constrain them. Finally, angular momentum transfer between the circum-binary disks and the stars is expected from models of secular evolution.

In this communication the above issues are presented, building on our recent observations of HD 104237 (Garcia et al. 2013, MNRAS, 430, 1839). These systems rotate with periods of a few weeks. This presents an observational advantage for optical long baseline interferometry as a few images during the orbital period can be obtained. They will be placed in context of coming instrumentation and new facilities. Finally, we highlight the interplay of combined optical long baseline interferometry and other observational techniques.

Dissecting the supermassive star Eta Carinae with interferometry

Groh, Jose (Geneva Observatory, Switzerland)

Massive stars are rare but essential constituents of stellar populations. Among these, Eta Carinae is one of the most luminous objects in the Galaxy, allowing for the study of massive stellar evolution under extreme conditions. Eta Car is generally accepted to be a massive binary system with a total luminosity of 5 million solar luminosities and total mass of at least 110 $M_{\odot}$. A violent wind-wind collision occurs between the stars, and the primary star may also be a rapid rotator. In this talk, I will discuss recent efforts to probe the effects of extreme mass loss, rotation, and binarity in Eta Carinae using long-baseline interferometry. Ignoring the effects of the companion, we find that the primary star is rotating close to break-up (80-90 %), and that the rotation axis is not aligned with the Homunculus polar axis. However, we obtain that the companion significantly affects the K-band photosphere of the primary, hampering a precise determination of the rotation.

The dusty heart of AGN revealed by IR interferometry

Hoenig, Sebastian (Astrophysik @ Kiel, Germany)

The last years have seen significant progress of our understanding of the dust distribution around the supermassive black holes in the nuclei of galaxies. This has only been made possible by increased sensitivity of interferometers that combine the largest single telescopes in the world. Our current sample of successfully observed AGN contains 35 objects and we expect to steadily expand it. I will summarize the state-of-the art of AGN observations in the near- and mid-IR and present some recent surprises from MIDI and the Keck interferometer. Finally I want to give an outlook on what we can expect in AGN science from the next generation instruments.

Cepheid science with long-baseline interferometry: distances and stellar physics

Kervella, Pierre (LESIA, Paris Observatory), Antoine Mérand, Alexandre Gallenne, Joanne Breitfelder

Cepheids are important stars both because of their role as standard candles to determine extragalactic distances, but also because of their remarkable properties as pulsating stars. From repeated angular diameter measurements with CHARA and the VLTI, we are engaged in a long-term program to obtain the distances of a sample of ∼20 Cepheids with an accuracy of 2-4% or better. We have assembled over the last few years a unique sample of angular diameter measurements of nearby Cepheids, and I will present a few examples of the resulting distance estimates. From interferometric observations, we also discovered a few years ago the presence of circumstellar envelopes around many Galactic Cepheids. We are now in the process of characterizing these envelopes, and their potential impact on the distance scale. The mass of Cepheids has been the subject of a controversy, due to the difference between the estimates based on the pulsation models, and the results from stellar evolution models. We are now studying a sample of binary Cepheids with the objective to determine accurate masses at the 1% level, and geometric distances to tightly constrain the two types of models.

Exploring the signatures of planet formation with multi-wavelength interferometry

Kraus, Stefan (University of Exeter)

Planets are believed to form in the circumstellar disks around young stars, likely through processes of dust sedimentation, coagulation, and core accretion. Once the planets have gained sufficient mass they will start interacting with the disk material, causing complex density structures and dust-cleared gaps.

In this talk, I will present first results from our ongoing observing campaign on transitional disks, which aims to study these signatures of planet formation with VLTI and Keck near- and mid-infrared interferometry. For instance, our observations on V1247 Orionis revealed an extended gap that separates the narrow, optically thick inner disk at 0.20 AU from the optically thick outer disk at radii $\geq$ 49 AU. Surprisingly, we find that the gap region is filled with significant amounts of optically thin material, suggesting that this object is in a particularly early stage of disk clearing. Furthermore, using Keck/NIRC2 aperture masking we detect asymmetries in the gap region that indicate the presence of complex density structures, possibly reflecting the dynamical interaction of the disk material with the planetary or sub-stellar mass bodies that are responsible for the gap clearing.

Finally, I will give an outlook on the groundbreaking results that can be expected from the 2nd-generation instrument MATISSE, which is scheduled for commissioning at VLTI in 2016. With its unique mid-infrared interferometric imaging capabilities, MATISSE will allow us to image the detailed structure and temporal evolution of these planet-induced disk asymmetries, enabling new insights into the planet formation and disk clearing process.

A roadmap for interferometry in Europe

Mourard, Denis (INSU)

A roadmap for interferometry in Europe (25 + 5 min.) by D. Mourard The long term planning of large or very large astronomical infrastructures has always been a difficult but necessary exercise. The rapid progresses of our knowledge of the Universe permanently force us to prepare, well in advance, the birth of future major facilities. The worldwide collaboration requires also a strong coordination for the decision processes in the different countries. Taking into account the already existing infrastructure roadmap at the European level, we will present some of the important steps and actions that look necessary for developing the case of a future major optical interferometric facility.

Unravelling the circumstellar material of massive evolved stars: OIR interferometry of Yellow Hypergiants and B[e] Supergiants

Oudmaijer, Rene (University of Leeds), Willem-Jan de Wit, Hugh Wheelwright

High spatial resolution observations of circumstellar material provide crucial information for reconstructing the post-main sequence evolution and final fate of high-mass stars. We will present our most recent discoveries made using infrared high spectral and spatial resolution observations using VLTI/AMBER. The observations aim to shed new light on the ongoing mass-loss of high-mass stars evolving in the HR-diagram. In particular, we will discuss new results on the milli-arcsecond (mas) scale mass-loss geometry of the yellow hypergiant IRC+10420. This object is one of the few known post-Red Supergiants. The data point towards an hour-glass wind geometry and mass-loss rates resulting in a pseudo-photosphere. In addition, we present our VLTI/AMBER results on supergiant B[e] stars, objects that may well be in a later evolutionary stage than the yellow hypergiants. The data are consistent with circumbinary Keplerian rotating disks rather than with the previously accepted outflowing disk paradigm for B[e] supergiants. As we also find that these objects have a large binary fraction, we discuss whether binarity is a mandatory condition or whether the blue supergiant component's mass loss is intrinsically peculiar in sgB[e]s.

Scientific prospects and technical challenges with GRAVITY

Pfuhl , Oliver (MPI for Extraterrestrial Physics)

I will present the design, the current status and the science prospects of the second-generation VLTI instrument GRAVITY. GRAVITY is designed to deliver micro-arcsecond astrometry on faint objects. The instrument includes an integrated optics, 4-telescope, dual feed beam combiner operated in a cryogenic vessel; near-infrared

wavefrontsensing adaptive optics; fringe-tracking on secondary sources within the field of view of the VLTI and a laser metrology. The prime science goal is to observe highly relativistic motions of matter close to the event horizon of the massive black hole at the center of the Milky Way. Furthermore, the imaging capabilities using six-baseline on faint objects will open exciting prospects in various fields, such as AGN, YSO or stellar research. GRAVITY has reached the assembly phase, which allows to present first lab results of critical subsystems. This includes the single-mode light injection, the fiber optics components, the fringe-tracking spectrometer and the novel 'photon-counting' Saphira detector. I will close with a short outlook on the next steps and the road to the telescope.

The Navy Precision Optical Interferometer: Status and Future Prospects

van Belle, Gerard (Lowell Observatory), Don Hutter, J. Tom Armstrong

The Navy Precision Optical Interferometer (NPOI) is a multi-aperture visible-light interferometer located on Anderson Mesa near Flagstaff, Arizona. NPOI is operated jointly by the Lowell Observatory, US Naval Observatory, and Naval Research Laboratory. The existing unique sub-milliarcsecond resolution capabilities of NPOI are being employed for wide-angle astrometry, to image stellar surfaces and Earth-orbiting satellites, resolve stellar diameters and orbits, and probe circumstellar disk structures. Funded upgrades for NPOI will add longer baselines and upgraded beam combination instrumentation, all of which are slated to become operational over the next 12 months; additionally, larger apertures are also under consideration for the facility.

2 Posters

Phase Retrieval Problem. Application to VLBI Mapping of Active Galactic Nuclei

Bajkova, Anisa (Central (Pulkovo) Astronomical Observatory)

The phase problem, which means image (equivalently spectral phase) reconstruction from only spectral modulus (amplitude), is considered in framework of VLBI mapping of compact active galactic nuclei (AGNs). We have shown that the images of AGNs with typical structure "bright core+one-sided week jet" can be well approximated by minimal-phase images, which can be uniquely reconstructed from the spectrum modulus, preliminary reconstructed from visibility amplitudes measured on a limited set of UV points. For reconstruction of intermediate images with zero-valued spectral phases we have used the Generalized Maximum Entropy Method (GMEM) searching for real sign-variable solutions (Bajkova, 1992). We have proved the possibility of the GMEM-based procedures to suppress effectively both additive and calibration errors. Final images were accurately reconstructed from the spectrum modulus using both Hilbert transform technique based on homeomorphic signal processing and the complex cepstrum and Fienup's error reduction algorithm. Another approach used to solving the phase problem was a modified GMEM (MGMEM), which includes spectral phases as unknown variables (Bajkova, 2005). The methods considered here can be used for VLBI imaging in case of degeneracy ("RadioAstron" at a very high orbit) or absence (two-element interferometer) of closure-phase equations preventing the use of standard self-calibration methods. The capabilities of our methods have been investigated on a lot of numerical experiments and applied to real imaging using VLBA data from NRAO archive. (The methods proposed are realized in the framework of Pulkovo "VLBImager" software program package based on MEM and GMEM deconvolution procedures.)

Science Drivers and Technical Feasibility in the Conceptual Design of the Magdalena Ridge Observatory Interferometer

Buscher, David (University of Cambridge), M. Creech-Eakman, C. A. Haniff, J. S. Young

Current interferometers have had numerous scientific successes but also have scientific limitations. This talk looks at the scientific limitations of current interferometers and how overcoming these limitations formed the basis of the conceptual design of the Magdalena Ridge Observatory Interferometer, a state-of-the-art interferometric array being built at 10,000 ft altitude in New Mexico. The scientific rationale for the design decisions taken will be explored and the lessons learned in the design process and the initial construction will be discussed. The talk will emphasise how the interaction between scientific drivers and technical feasibility

is a two-way process and the implications of this interdependency for the design of the next generation of interferometers.

Prospects for Submilliarcsecond Optical Imaging:Intensity interferometry with Cherenkov telescope arrays

Dravins, Dainis (Lund Observatory, Sweden)

Intensity interferometry measures the second-order coherence of light. Very rapid (nanosecond) fluctuations are compared between separate telescopes, without any optical connection. This makes the method insensitive to atmospheric turbulence and optical imperfections, permitting observations over long baselines, and at short wavelengths.

The required large telescopes are becoming available as those primarily erected to study gamma rays: the Cherenkov Telescope Array envisions telescopes distributed over a few square km. Digital signal handling enables very many baselines to be simultaneously synthesized between many pairs of telescopes, while stars may be tracked across the sky with electronic time delays, synthesizing an optical interferometer in software. Simulations indicate limiting magnitudes around m(v)=8, reaching a resolution of 30 microarcseconds in the violet.

Since intensity interferometry provides only the modulus (not phase) of any spatial frequency component of the source image, image reconstruction requires phase retrieval techniques. As shown in simulations, full two-dimensional images can be retrieved, provided there is an extensive coverage of the (u,v)-plane.

New Astron.Rev. 56, 143 (2012); Astropart.Phys., in press (2013)

OP/NIR astronomical observations at 36.6°E 28.5°N, 36.4°E 26.3°N and 41.7°E 27.5°N.

Hafez, Yaser (KACST)

We aim to establish a new project to build an array operated at 400-600 THz frequency range to observe new moon when it is close to the sun, Binary stars and extragalactic objects from different locations. Three suitable locations are suggested to build the array: Halat Ammar at 36.6°E 28.5°N, Alwajh at 36.4°E 26.3°N and Hail at 41.7°E 27.5°N. We present a study of the atmospheric effects on observations at these locations and solutions to achieve a good angular isoplanicity at different elevations for imaging through the turbulent atmosphere. Also, high resolution observations are essential to contribute to the related international projects such as Mitaka Optical Infrared Arrays (MOIRA), Keck Interferometer (KI) and Navy Prototype Optical Interferometer (NPOI), and so we discuss the required technical parameters for our project as part of the possible collaboration with other international institutions to achieve this goal.

Prospects for Unprecedented Imaging of Stellar Surfaces with the NPOI

Jorgensen, Anders (New Mexico Tech), H. R. Schmitt, D. Mozurkewich, G. T. van Belle, E. K. Baines, J. T. Armstrong, D. J. Hutter

We present the design of a low-cost approach to making high-resolution images with the Navy Precision Optical Interferometer (NPOI) with resolution and fidelity better than any stellar images published to date. The capability combines several existing advances and infrastructure at NPOI with modest enhancements. For optimal imaging there are several requirements that should be fulfilled. The observatory should be capable of measuring visibilities on a wide range of baseline lengths and orientations, providing complete UV coverage in a short period of time. It should measure visibility amplitudes with good SNR on all baselines as critical imaging information is often contained in low-amplitude visibilities. It should measure the visibility phase on all baselines. The technologies which can achieve this are the NPOI Y-shaped array with (nearly) equal spacing between telescopes and an ability for rapid configuration. Placing 6-telescopes in a row makes it possible to measure visibilities into the 4th lobe of the visibility function, and coherent integration techniques can be used to obtain good SNR on very small visibilities. Coherently integrated visibilities can be used for imaging with standard radio imaging packages such as AIPS. The commissioning of one additional station, the use of new hardware installed, and software enhancements can make this a reality. In this presentation we will give an overview of this potential new capability at NPOI and what it takes to get there.

Special Session Sp8

Galactic molecular clouds and their chemistry

1 Oral contributions

Sulphur chemistry in Orion KL

Esplugues, Gisela (Centro de Astrobiología (CAB)), José Cernicharo (CAB), Javier R. Goicoechea (CAB), Serena Viti (UCL), Belén Tercero (CAB), Herschel Hexos Team

The hot core phase of massive star formation shows a particularly rich chemistry resulting from gas phase chemical reactions and dust grain mantle evaporation. During cloud collapse, depletion of molecules onto dust surfaces takes place. When a new protostar forms, the surrounding gas and dust are heated and molecules sublimate from the grain mantles, giving rise to new species in the warm gas and to enhanced abundances of pre-existing species. The existence of molecular outflows and associated shocked regions also plays an important role in the chemical evolution, because they heat up the gas significantly and modify its chemistry.

Sulphur-bearing species are especially sensitive to physical and chemical variations during the lifetime of a hot core (Viti et al. 2001), and therefore are considered good probes of their time evolution (Hatchell et al. 1998). As such, they can be used as tools to investigate the chemistry and physical properties of complex star-forming regions (SFRs) located in dense molecular clouds. On the other hand, it is known that some molecules (SiO, H_2CS, SO, SO_2) show increased abudances in regions affected by shocks (Bachiller et al. 1996) as a result of the action of outflows on the surrounding gas. The study of molecular lines from shocked areas provides valuable information about chemical processes and the physical conditions of the shocked components.

Here, we present a deep study about the sulphur chemistry in Orion KL, the closest high-mass star-forming region. Through a radiative transfer code (Madex), we have analyzed more than 100 lines of SO and more than 700 lines of SO_2 (ground and vibrational states) and its isotopologues, which were observed with the 30-m IRAM and Heschel telescopes, covering a total frequency range of 1376 GHz. In order to study the sulphur chemistry, we have also modeled two components (hot core and plateau) of this molecular cloud, using a chemical time depending model. In addition, we presen

FORMATION OF COMPLEX ORGNIC MOLECULES IN SPACE

Geppert, Wolf (Stockholm University), M. Hamberg, E. Vigren, V. Zhaunerchyk, C. Walsh, T. J. Millar, C. Persson, E. Wirström, R.D Thomas, M. Kaminska, and M. Larsson

The formation of organic molecules in the interstellar medium has been a subject of intense discussions for many years. State-of the art telescopes have been used to detect more and more complex species, like ethers, alcohols esters and even primitives “sugars” like glyoxaldehyde. The detection of amino acids in meteorites opens the possibility of a delivery of biomolecules synthesized in the interstellar medium or star-forming regions to the primeval Earth. Whereas it can be doubted if more complex species like amino acids and carbohydrates can survive the strong UV radiation in the early Solar System, this does not necessary hold for more primitive precursor molecules like alcohols and nitriles [1]

If these compounds can be synthesised in the interstellar medium, the question of their formation sites and pathway arises. We have carried out experimental, computational and observational studies in order to elu-

cidate the origin of organic molecules like methanol, ethanol, dimethyl ether and formic acid and the results of these investigations are presented here. Generally, it can be said that there is no universal pathway of synthesising prebiotic molecules in space, but each species has its own chemical history and must be investigated separately, since even related compounds can have very different generation pathways.

Nitriles can serve as amino acid and nucleobase precursors can also be synthesized very efficiently in methane-nitrogen dominated atmospheres like the one present on Titan and, possibly, the early ages of Earth. Therefore I will also discuss recent results on the formation and degradation processes of nitriles in Titan's atmosphere and their possible role in the generation of biomolecules.

Reference [1] M. P Bernstein, S. F. M. Ashbourn, S. A.; Sandford, L. J., Allamandola, Astrophys. J., 601, 365 (2004

Circulation of matter in star formation regions.

Gösta, Gahm (Stockholm University)

Open stellar clusters form in massive concentrations of gas and dust in giant molecular clouds. Stellar activity forces the remnant cloud to expand, and the shell breaks up into filaments, elephant trunks and smaller cloudlets, which erode with time. Stars formed in these expanding systems are ejected from the complexes. In addition, perturbations inside the stellar clusters produce run-away stars. In the present review we focus on observations and model simulations of such H II regions that provide a view of the kinematics of stars and clouds and how these assemblies evolve with time at this early chaotic phase.

Observations and models of the evolution of prestellar cores

Harju, Jorma (FINCA)

We present the results of observational and modelling work on the structure and evolution of prestellar cores. We discuss the properties of three starless cores belonging to the Corona Australis complex. The cores have different central densities and therefore they represent different stages of dynamical evolution, which is also reflected in their chemical compositions. By combining chemistry models with observations that include molecular line maps and Herschel thermal dust emission maps at 160, 250, 350 and 500 micron, we aim to estimate the core ages. The results will be compared with theoretical predictions concerning the time-scale of core contraction and prestellar core lifetimes estimated from statistical studies.

Modeling the chemistry of interstellar clouds

Hogerheijde, Michiel (Leiden Observatory)

I will review the current status of models of the chemsitry of interstellar clouds. I will address the important chemical processes, and discuss the different ways in which solutions to the chemical networks can be found. The characteristic chemical signatures of different environments will be presented. No model can be complete if it cannot be tested against observations, and I will explore different ways in which radiative transfer methods can be used to infer the chemical composition of interstellar clouds.

On the temperature of pre-stellar cores

Juvela, Mika (University of Helsinki), Jorma Harju, Nathalie Ysard, Tuomas Lunttila

We have investigated the uncertainties of theoretically predicted temperature profiles of pre-stellar cores and of the empirical determination of gas temperature.

When shielded from ultraviolet radiation, gas temperature is determined by a simple balance between cosmic ray heating, line cooling, and coupling between gas and dust. However, we find that variations of gas phase abundances, grain size distributions, and velocity field can each affect the predicted temperatures at 1 K level. Even small differences can be important for the evolution of pre-stellar cores because, e.g., the depletion processes can be very temperature sensitive.

Using models of the radial temperature profile of cores, we have examined the accuracy of the gas temperature estimates derived from ammonia observations. Standard analysis assumes that all hyperfine components are tracing the same gas volume but this might no longer be true in the case of strong temperature gradients. In practice, we find ammonia to be a very reliable tracer of the mass averaged kinetic temperature. When the S/N ratio of the (2, 2) spectrum decreases below ten, the temperature errors increase to $\sim$1 K but without a significant bias. However, if the optical depths were just a few times higher than what is expected for gravitationally stable cores, the main group of the (1, 1) line saturates and there are no longer any guarantees

of the accuracy of the results of standard line analysis.

Formation and Evolution of Interstellar Dust-Grain Ices: A Statistical Learning Approach

Makrymallis, Antonios (UCL)

The formation of interstellar dust grain ices seems to trigger the formation of complex molecules, such as pre-biotic molecules, observed in the gas phase during star formation. Therefore, understanding ice formation is crucial to our knowledge of the chemistry of star forming regions. To study the formation and evolution of interstellar ices, we used observations from the existing literature for water and methanol ices in dark molecular clouds and a time dependent, gas grain chemical model. The model simulated the gas-grain chemistry covering broad astronomical physical conditions, typical of starless and star forming cores. The observations provided the guideline for constraining the physical parameters of the model and get to understand under what conditions icy mantles form. Here, two statistical/machine learning techniques were applied to analyze the simulated chemical abundances and their parameters in conjunction with the observations. Bayesian inference was employed to calculate the posterior probability of a parameter set to produce the observed abundances. Likelihood and prior probabilities were computed using nearest neighbor analysis with kd-trees, assuming spatial dependencies between observation sources and between simulated abundances and their parameter sets. Hierarchical clustering was employed as well, to group the simulated data points that are similar in terms of abundances and parameter sets that produced them. In these preliminary work, our results suggest that observations on water and methanol ices could be matched when the density is between 10^5 - 10^6 s^{-3}, the freeze out parameter between 10-30%, the non thermal desorption mechanisms are ON and the collapse acceleration factor higher than 1.5.

DCO^+ observations of a dark cloud : tracing the CO depletion

Pagani, Laurent (Observatoire de Paris & CNRS), A. Bourgoin, F. Lique

In a series of recent papers, I have shown how the deuterium chemistry of a pair of ions, DCO^+ and N_2D^+ could tell us a lot about dark clouds and prestellar cores, allowing to set upper limits on the age of the clouds and on the prestellar core formation duration. Prestellar cores themselves should form in no more than 0.5 My to avoid overproduction of deuterated species, which is not observed. The last application of this deuterium chemistry allows to retrieve the CO and N_2 abundance profiles in prestellar cores, where they are somewhat depleted. I will show how, by combining DCO^+, H_2D^+, N_2H^+ and N_2D^+ observations one can constrain the CO and N_2 abundance profiles where they are too weak to be observed (CO) or simply not observable (N_2). Applied to the L183 core, we derive an abundance drop by 400 for CO and only 20 for N_2. Recent GBT observations of both DCO^+ and N_2D^+ directly show the differential behaviour between the two parent species, confirming this analysis. Compared to an undepleted CO abundance of 1.5×10^{-4}, the CO depletion in the core is possibly larger than 2000, the highest depletion reported to date.

High resolution ammonia mapping of the candidate First Hydrostatic Core object Chamaeleon-MMS1

Väisälä, Miikka (University of Helsinki, Department of Physics), Harju, Jorma; Mantere, Maarit; Miettinen, Oskari; Sault, Robert; Walmsley, Malcolm; Whiteoak, John

Chamaeleon-MMS1 was mapped in the $NH_3(1,1)$ line and the 1.2 cm continuum using the Australia Telescope Compact Array, ATCA. The core was also mapped with the 64-m Parkes telesope in the $NH_3(1,1)$ and $(2,2)$ lines. Observations from *Herschel Space Observatory* and *Spitzer Space telescope* were used to help interpretation. The ammonia spectra were analyzed using Gaussian fits to the hyperfine structure, and a two-layer model was applied in the central parts of the core where the ATCA spectra show signs of self-absorption. An elongated rotating core with a steep velocity gradient ($\sim$ 20 km/s pc^{-1}) is seen in ammonia. The SED of the far-IR source is consistent with the protostellar class 0 stage. A string of 1.2 cm continuum sources is tentatively detected near the rotation axis. An hourglass-shaped structure is seen in ammonia at the cloud's average LSR velocity. The observed ammonia structure mainly delineates the inner envelope around the central source. The velocity gradient is likely to originate in the angular momentum of the contracting core, although influence of the outflow from the neighbouring young star IRS4 is possibly visible. Although this structure resembles a pair of outflow lobes, the ammonia spectra show no indications of shocked gas. However, the

two-layer model suggests the presence of a warm gas in this region, possibly owing to an embedded outflow. We conclude that the object has passed the first hydrostatic core phase.

Water and deuterated species in star forming regions

VASTEL, Charlotte (IRAP)

In addition to its dominant role in the cooling of warm gas and in the oxygen chemistry, water is a primordial species in the emergence of life, and comets may have brought a large fraction to Earth to form the oceans. Observations of deuterated water are an important complement for studies of H2O to understand how water forms and how it has evolved from cold prestellar cores to protoplanetary disks and consequently oceans for the Earth's specific, but probably not isolated, case.

Thanks to the advance of sensitive submillimeter receivers and to the launch of Herschel, it is now possible to carry out much more detailed radiative transfer analysis of HDO, H2O as well as D2O, with numerous transitions.

I will present the radiative transfer analysis as well as the chemical modeling performed in regions such as prestellar cores, low-mass protostars and high-mass protostars.

Dense cores and outflows in the S255 area of high mass star formation

Zinchenko, Igor (Institute of Applied Physics of the Russian Academy of Sciences), Liu Sheng-Yuan (ASIAA), Su Yu-Nung (ASIAA), Kurtz Stan (CRyA UNAM), Ojha Devendra Kumar (TIFR), Salii Svetlana (UrFU), Sobolev Andrej (UrFU), Trofimova Elena (IAP RAS), Zemlyanukha Peter (NNSU)

The well known site of massive star formation S255 consists of two main components (S255IR and S255N) separated by slightly over $1'$. While both components show evidence for cool, massive clumps, their evolutionary states appear to be quite different. This object represents an excellent laboratory for investigations of various stages of star formation. We have studied this area with single-dish instruments and interferometers (SMA, VLA and GMRT) at wavelengths from ~ 1 m to ~ 1 mm. Here we report in particular new SMA data for S255IR obtained at 0.8 mm in the compact configuration and at 1.3 mm in the very extended configuration (providing a sub-arcsecond angular resolution) as well as new 30m IRAM observations. The data reveal a new picture of dense cores and outflows in this area. Their structure, physical and chemical properties are discussed. Several unusual features are found.

2 Posters

X-factor in a prestellar cloud

Lubimov, Viktor (INASAN), Dmitri Wiebe

CO molecular emission is often used as a proxy for molecular hydrogen in the interstellar medium. To convert an observed CO line intensity into a column density of H_2 the so-called X-factor is used. Its canonical value is taken to be $2 \times 10^{20} cm^{-2} K^{-1} km^{-1} s$, however, the real value can be very different in various objects. In this contribution the X-factor evolution in a prestellar cloud is studied. Specifically, we simulate collapse of an isolated spherical molecular cloud taking into account self-gravity, heating and cooling processes, and an extensive network of chemical reactions. The chemical network includes about 400 species and nearly 3000 reactions. We vary the metallicity, the intensity of ultraviolet radiation field and mass of the cloud. A radiation transfer model is used to estimate the CO line intensity. In the process of collapse the X-factor varies by two orders of magnitude. For the solar metallicity the X-factor varies from 10^{20} to $10^{22} cm^{-2} K^{-1} km^{-1} s$ within 10^6 years. For the low metallicity (0.01 of the solar one) the conversion factor increases by an order of magnitude. When the UV background intensity is enhanced by a factor of 10, the X-factor decreases by an order of magnitude. We conclude that for a correct interpretation of observations with the conversion factor it is necessary to take into consideration both the local properties of the interstellar medium and radiation, and the evolutionary stage of a cloud.

Deuterium diffusion and enrichment in interstellar ices

Shmeld, Ivar (Ventspils International Radio Astronomy Centre), J. Kalvāns

We model the processing of interstellar ices by cosmic-rays and cosmic-ray induced photons on dust grains in dark molecular clouds. Gas, surface, and mantle (sub-surface ice) are the phases considered in our model. The mantle-phase is further divided into the volume-phase and the cavity-surface phase. Molecules in the volume are considered "frozen" and are inert, while molecules exposed to a cavity surface are considered mobile (within the cavity) and reactive, very much like the molecules in the outer-surface phase. The chemical radicals generated by CR-induced dissociation of molecules in the mantle are consumed by reactions in the cavity-phase. The diffusion of hydrogen and deuterium between the three ice phases is modelled. One of the poorly known parameters of the model is the diffusion coefficient D(H) of hydrogen species (H and H_2) in environments similar to interstellar ices. However, D for the deuterium isotope species D, HD and D_2 can be regarded as completely unknown. We run a series of simulations in order to investigate the relation between the average mantle-phase molecule enrichment with deuterium (R_D) and the diffusion coefficient of the deuterium species D(D) through the ice. We find that R_D does not correlate with D(D), at least within the constraints of the model used. R_D mostly (with a significant delay) correlates with the atomic D/H ratio in the gas-phase of the cloud.

Special Session Sp9

Stellar dynamics and celestial mechanics in modern astrophysics

1 Oral contributions

Did the R136 and NGC 3603 young star clusters form through single starbursts?

Banerjee, Sambaran (Argelander-Institut fuer Astronomie, University of Bonn, Germany), Pavel Kroupa

From kinematic data of very young, massive star clusters that appear to be in dynamical equilibrium, it is often inferred that such systems are examples of where the early residual gas expulsion did not happen or had no dynamical effect. The intriguing scenario of a star cluster forming through a single starburst has thereby been challenged. Considering the Large Magellanic Cloud's R136 cluster, the most cited one in this context, we perform direct N-body computations that mimic the early evolution of this cluster incorporating the gas-removal phase. Our calculations show that under plausible initial conditions which are consistent with observational data, a large mass fraction of a gas-expelled, expanding R136-like cluster should regain dynamical equilibrium by its current age. Therefore, the recent measurements of velocity dispersion in the inner regions of R136, which indicate that the cluster is in dynamical equilibrium, are consistent with an earlier substantial gas expulsion of R136 followed by a rapid re-virialization (in approx. 1 Myr). Furthermore, we show that an appropriately lower-mass initial gas-embedded cluster, subjected to similar conditions, can remarkably reproduce the observed properties of the Galactic NGC 3603 Young Cluster (NYC). With a single initial system undergoing gas-expulsion, we well reproduce (a) the observed mass and number density profile of NYC, (b) its measured central velocity dispersion and (c) its observed present-day mass function. These studies, therefore, strongly support the formation of the young clusters R136 and NYC through single starburst events despite their complex surroundings.

Capturing stars into massive black holes via accretion disks

Bekdaulet, Shukirgaliyev (Fesenkov Astrophysical Institute), Gareth Kennedy, with Stardisk and Silk road project teams

The high stellar densities in galactic centres, combined with an accretion disk around the massive black hole, mean that stars will inevitably interact with the disk. This interaction can cause stars to be captured into the disk and migrate inward in a process similar to planetary migration. In addition to growing the black hole, the final plunge of the star through the accretion disk and into the black hole will result in observable tidal disruption events and potentially gravitational waves. I will present results from the StarDisk model, developed as part of the Silk Road Project (NAOC), which includes the feedback of the gas disk on the stellar dynamics in a self-consistent way using GPU acceleration.

Galactic Star Cluster mass evolution. High performance star by star simulations.

Berczik, Peter (ARI, ZAH, Heidelberg, Germany), Andreas Just, Andreas Ernst, Rainer Spurzem

We carry out the large set of Galactic Star Cluster simulations (up to 5e5 Msol initial masses) using our high performance direct N-body code phi-GRAPE+GPU with the maximum possible numerical resolution (one particle one star) on the largest astrophysical GPU clusters. Our main goal was to investigate the cluster initial volume "filling" factor to the process of the cluster mass loss as well us the cluster whole lifetime. We also investigate the evolution of the present day Cluster Mass Function depending on the initial parameters of the clusters.

Self-selection of binaries in compact young clusters & associations

Boily, Christian (Strasbourg)

The effect of background stars on the internal properties are driven mainly by the tidal field exerted on the binaries. When the orbital time of binaries in the host cluster compares with the binary's formation time (early fragmentation, seed accretion) then such a binary may harden or be disrupted before it has had time to settle into its own equilibrium (two-body) configuration. In this contribution the correlation between binary properties and the host cluster formation history will be highlighted, contrasting single homogenous clusters, with a more chaotic formation history based on repeated mergers of stellar aggregates.

Nuclear Star Clusters formation

Capuzzo-Dolcetta, Roberto (Dep. of Physics, Sapienza, Univ. of Roma, Italy), Manuel Arca-Sedda, Mario Spera

There is evidence of the presence of Compact Massive Objects in galaxies over the whole Hubble sequence. very massive galaxies harbor massive and supermassive black holes, while fainter galaxies show the presence of resolved stellar nuclei (in ellipticals) and Nuclear Star Clusters (NSCs, mainly in spirals). The origin of these different mass aggregations is still uncertain. Some authors suggest a "dissipative" origin due to gas funneling to the galactic centre where form either a black hole or undergoes to instability and fragments into stars, while other authors suggest a "dissipationless" origin as due to massive stellar clusters migrating to the centres for dynamical friction. I this talk we refer of our N-body simulations confirming the validity of this latter hypothesis, and, in particular, we show simulations of the interaction of massive globular clusters with a massive black hole sitting in the galactic centre and its consequences on the formation of a NSC therein.

The history of comet impacts modulated by the solar motion

Feng, Fabo (Max-Planck Institute for Astronomy), C.A.L Bailer-Jones

The impact cratering record on the Earth and Moon shows that these bodies have been exposed to a varying asteroid and/or comet impact history for much or all of their existence. The comets, believed to originate in the Oort cloud, are generally on orbits which keep them outside of the inner solar system, but gravitational perturbations can put them on a collision course with the Earth. These perturbations arise in particular due to the Galactic tide and to stellar encounters, the influence of which vary with time as the Sun moves on its orbit around the Galaxy. In order to investigate this variation, and to see whether the solar orbit can predict explain the variations in the cratering record, we are building an end-to-end model for the variation of the expected comet impact flux. Adopting first a model for the Galactic tide, we have simulated the orbits of 10,000 comet orbits over the last 1 Gyr. We find that the flux of new comets which enter the "loss cone" (and so enter the inner solar system) is clearly modulated by the solar motion, mainly through variations in the vertical component of the tidal force. We then add the perturbation from 10,525 stellar encounters using the "improved impulse approximation". The significance of the perturbation of encounters are found to be comparable with that of the Galactic tide. The synergy effect of these two types of perturbations needs further study.

On the Formation and Dynamical Evolution of Ring Galaxies

Jiang, Ing-Guey (National Tsing Hua University, Taiwan), Yu-Ting Wu

The peculiar ring galaxies have been attractive due to that they are rare and special. The new generation of larger telescopes could bring this subject into a new era as much more distant galaxies could be observed. The newly discovered Auriga's wheel (Conn et al. 2011) is such an example that the collisional history seems to be witnessed and the ring velocities are observed. Motivated by these results, we use N-body simulations to model the formation and dynamical evolution of ring galaxies. The shapes and velocities of rings and the

corresponding relations with the formation processes will be addressed.

On the dissolution of open star clusters

Just, Andreas (ARI at ZAH), Andreas Ernst, Peter Berczik

It is still a matter of debate, which fraction of field stars in the Milky Way disc were born in open star clusters (OCs) and released to the field during the dissolution process. The new homogeneous catalogue of Kharchenko and Piskunov contains about 3000 OCs and provide an excellent basis for the re-analysis of the cluster formation history. From the dynamical point of view the mass loss timescale and their parameter dependences is one of the most uncertain quantity for quantifying the total release rate of stars by the OC system. Based on a large suite of direct N-body simulations including stellar evolution in a realistic Galactic tidal field, I will discuss two important aspects. First, the mass loss rate of extended OCs is independent on the particle/star number in contrast to the N-dependence of compact or globular clusters, where the evolution is driven by 2-body relaxation. Second, The mass loss rate depends dramatically on the initial extension of the OCs with respect to the tidal radius.

New parallel gravity integrator

Meiron, Yohai (KIAA)

We present a fully parallel implementation of a multipole-expansion technique, based on White (1983). The technique is suitable for systems with ellipsoidal-like shapes and are collisionless (or have a very long relaxation time). It is developed with galactic centers in mind, and collisional particles (such as supermassive black holes) could be added. The technique could also be used in tandem with a Monte Carlo method to simulate collisional systems. Since the force in this technique is derived from a (truncated) Lagrangian, the system conserves an energy-like quantity, independently of the truncation level; it is thus very easy to follow the integrator's accuracy and calibrate the step size. The implementation is written in C++ and uses the Thrust library for parallel acceleration, which can use a GPU when present, and otherwise utilizes multiple CPU cores with shared memory via OpenMP.

A review of regularization methods for the few-body problem

Mikkola, Seppo (Dept. of Phys. and Astronomy, University of Turku)

In few-body systems close approaches happen frequently. For accurate numerical simulations one must use regularization. I review concisely the various numerical methods from the celebrated Kustaanheimo-Stiefel transformation to the more recent approaches such as the logarithmic Hamiltonian (logH) and time-transformed leapfrog (TTL). In addition to the pure Newtonian few-body problem these methods can be efficiently used in other problems in which there are various external perturbations, including velocity dependent ones.

An application of High Performance GPU computing to understanding the process of violent mass segregation in star clusters.

Spera, Mario (Dep. of Physics, Sapienza, Univ. of Roma, Italy), R. Capuzzo-Dolcetta, Dep. of Physics, Sapienza, Univ. of Roma, Italy

The study of the evolution of intermediate N stellar systems is particularly suited to the use of hybrid computational platforms, composed by a number of multicore CPUs connected to Graphic Processing Units acting as computational accelerators. Such platforms seem optimal to implement direct summation codes exploiting, also, the precision of high-order time integration methods. In this frame, we developed a 6th order Hermite's integrator with block time steps, called HiGPUs (Capuzzo-Dolcetta, Spera & Punzo, 2012, JCP, 236, 580), in both a CUDA and an OpenCL version, which scale well up to hundreds of GPUs. After a short discussion of the compared performance when using nVIDIA and AMD GPUs, we present our results concerning the initial evolution of a star cluster ($128<N<1024$) characterized by stars of different masses, the presence of a central star-mass black hole, and embedded in the residual mother gas cloud, starting from "cold" to "warm" initial conditions. A violent mass segregation is obtained at different levels after the rapid formation of some clumps which merge in the deep overall collapse. The emerging, mass segregated, cluster is a joint result of violent relaxation and self gravitation.

Fokker-Planck and Monte Carlo - past and future

Spurzem, Rainer (National Astron. Observatory, Chinese Academy of Sciences (NAOC/CAS))

Fokker-Planck (FP) Models of star clusters originate from methods used in plasma physics. They have been extremely useful in the past to understand fundamental physical processes in gravothermal stellar systems (core collapse, mass segregation, even to some extent binary formation and evolution). The underlying approximations and some seminar results of the past will be reviewed, and currently used Fokker-Planck models discussed - and what they are good for in the age of NBODY/GPU supercomputers and supercodes. FP models come in different flavours, gaseous or momentum models, the orbit-averaged FP equation, and the Monte Carlo method to solve the underlying FP equation. Also these variants and their relative merits and problems will be discussed. As recent examples we show 2D FP models of axisymmetric star clusters around black holes and multi-mass studies of mass segregation in rotating clusters.

2 Posters

Planetary System in Star Clusters

Tsai, Maxwell Xu (National Astronomical Observatories, Chinese Academy of Sciences), Rainer Spurzem, M. B. N. Kouwenhoven

It is widely accepted that stars do not form in isolation, but result from the fragmentation of molecular clouds, which in turn leads to star cluster formation. Over time, clusters dissolve or are destroyed by interactions with molecular clouds or tidal striping, and their members become part of the general field population. Star clusters are thus among the basic building blocks of galaxies. Star clusters therefore sheds light on the exploration of planetary system formation. However, the proportion of planetary system varies significantly from different stellar systems. In the solar neighbor, where the typical relaxation timescale is larger than the cosmic age, at least 10% to 15% of Sun-like stars have planetary system with Jupiter-mass planets. By contrast, dense star clusters, charactered by frequent close encounters, have found very few planets within (Spurzem et al 2009). A study is devoted to investigate the role that environment plays for the morphology of planetary systems. Simulations using the package `NBODY6++` are conducted to generate a statistical results of encounter frequency and magnitude as a function of radius. We then import these results in terms of external forces to the package `MERCURY6` to test the stabilities of planetary systems with different initial conditions.

Simulations of the Young Stellar Disks at the Galactic Center

Ulubay Siddiki, Ayse (Istanbul University), Bartko, Hendrik; Gerhard, Ortwin

The supermassive black hole at the Galactic Center (GC) is surrounded by a group of young stars some of which seem to orbit the black hole on mutually inclined, and warped disks. We present simulations of such disks for parameters relevant both to the GC environment, and to other galactic nuclei. We account for the torques induced by the disk's self-gravity, and by a surrounding old star cluster. Our simulations suggest that: i) when the disk-to-black hole mass ratio M_d/M_bh $\sim$ 0.001, the disks precess without changing their inclinations considerably in both the purely self-gravitating model, and in the model where the star cluster torques are taken into account. ii) When M_d/M_bh $\sim$ 0.01, the disk breaks into parts which precess independently in the case of the purely self-gravitating disk model, and becomes disrupted when the star cluster torques are taken into account. iii) When M_d/M_bh $\sim$ 0.1, the self-gravity dominates the evolution of the disks, and the disks evolve without being disrupted, despite being broken. We also compare our models with the observations of the GC stellar disks and conclude that purely self-gravitating, low mass disk model agrees better with the data.

The Existence of Equilibrium Points of Galactic Systems with Binary Black Holes

Yeh, Li-Chin (National Hsinchu University of Education, Taiwan), Ing-Guey Jiang

Galactic systems with central binary black holes are investigated. The conditions of existence of equilibrium points, including Lagrangian Points and Jiang-Yeh Points (Jiang and Yeh 2006, Yeh and Jiang 2006) will be shown and presented.

Special Session Sp10

Chemo-dynamical galaxy evolution

1 Oral contributions

No traces of environmental effects in void galaxies

Cebrián, María (Instituto de Astrofísica de Canarias), Ignacio Trujillo

A variety of large-scale structures is found in our Universe - from groups of galaxies to walls, filaments and voids - offering different environments to test galaxy formation theories. Galaxies located in underdense regions (voids) of this large-scale structure are specially interesting since interactions or accretion effects in their formation should be minimal. Is this difference in their environment directly translated into a significant difference in their properties?

Using the NYU-VAGC catalogue we study a carefully selected sample of void galaxies distributed in 699 voids with radius between 10 and 19 h^{-1}Mpc. We compare effective radius, colour and Sérsic index from these galaxies with the properties of those galaxies surrounding and out of the voids, and hence formed in very different environments.

Our results show that there is no significant difference in colour, sizes and structural shapes between galaxies formed in cosmic voids and those in walls or filaments, suggesting that the environment does not make the difference in the formation history of these galaxies. We also find that neither the radius nor the position in the void affect any of the studied properties. In conclusion, void galaxies present the same properties as the galaxies assembled in more dense regions of the large-scale structure.

Chemodynamical Simulations and Galactic Archaeology

Kobayashi, Chiaki (Univ. of Hertfordshire)

Different elements are produced by different types of supernovae with different timescales. Therefore, formation and evolutionary history of galaxies are imprinted in their elemental abundance and isotope ratios. Now it became possible to combine hydrodynamical simulations and detailed chemical enrichment, and to predict elemental abundances of stars and gas as a functions of time and location. These simulations are the models that can be, and should be, compared with Galactic Archaeology surveys such as GAIA-ESO. In this talk, I will show different stellar populations in the Galactic bulge and disk in Milky-Way type galaxy simulations.

A Multi-Phase Chemodynamical N-Body/SPH Code of Galaxy Evolution

Liu, Lei (Astromomisches Rechen-Institut, Heidelberg University), Mykola Petrov, Peter Berczik, Rainer Spurzem, Gerhard Hensler

We present our newly developed multi-phase chemodynamic code for the modeling of galaxy evolution. Our code follows the evolution of multi components in a galaxy such as stars, molecular (cold) clouds and diffuse (hot/warm) gas. The dark matter halo is modeled as a static potential well. Stars are treated as collisionless N-body particles. Hot/warm gas is described using the smoothed particle hydrodynamics method. Cold molecular clouds are modeled with a sticky particle scheme. Stars are formed inside these clouds determined by the Jeans instability criterion. Their feedback by means of mass and energy release to the surrounding cold clouds or to the hot/warm medium is included by different processes, depending on the stellar mass, namely, stellar winds and supernovae type II by massive stars, planetary nebulae and supernovae type Ia from intermediate-mass stars, respectively. These different mass loss processes enrich the interstellar medium inherently with

specific yields, nitrogen, oxygen, and further α elements by supernovae type II, iron by supernovae type Ia, and carbon and nitrogen by planetary nebulae. The two gas components (hot/warm gas and cold clouds) can exchange mass and element abundances as well as energy through heat conduction, leading to condensation and evaporation. In addition, momentum exchange between the continuous hot gas and clouds is allowed for their different dynamics. Cold clouds can coagulate and interact with hot/warm gas dynamically by means of drag, both leading to momentum exchange and energy dissipation. Currently our code supports various hardware accelerators for SPH and gravity calculation (SSE extension of CPU, GPU, GRAPE card, FPGA board). A dwarf galaxy model is evolved for 1 Gyr, some preliminary results (evolution of mass, energy, chemistry, star formation rate, etc.) are exhibited.

A multi-phase particle integrator for the formation of galaxies

Monaco, Pierluigi (Universita' di Trieste), G. Murante, D. Goz

We will present latest results obtained with a version of Gadget-3 where star formation and stellar feedback are implemented with a sub-resolution effective model (MUlti-Phase Particle Integrator) where each particle is treated as a multi-phase system, described by a system of equations that is integrated on-the-fly. Energy from massive stars is given in the form of both thermal energy and kinetic energy. Thermal feedback is remarkably efficient, but a form of kinetic feedback is necessary to have late infall of galaxy that forms a disc. Chemical evolution of several elements is followed in detail. In Milky Way-like halos our code is able to form galaxies with B/T as low as $\sim$0.2 and flat rotation curves even at modest mass ($\sim$1e6) and force (500 pc) resolution. We will present results on resimulations of 1e12 Msun halos and small cosmological volumes, showing predictions for the evolution of the main galaxy properties (B/T ratios, stellar masses, gas masses, SFRs, metallicities and metallicity gradients).

Chemo-dynamical modelling techniques for our Galaxy and its dwarf companions: from the theory of orbits to the synthesis of stellar populations.

Pasetto, Stefano (University College London), Pasetto, S.; Chiosi, C.; Kawata, D.; Grebel, E. K.; Bertelli, G.; Fujita, Y.

We present an innovative technique to study the stellar content of simulated chemo-dynamical systems. A novel theoretical framework is developed to account for the evolution of a gravitationally bounded system (e.g., a single globular cluster, a single galaxy or a group of interacting galaxies) and its connection with observable quantities is explored. Once a synthetic system is evolved in isolation, accounting for the temporal evolution of its phase-space and at least a metallicity index, we are able to synthetize its stellar population and project it on an observable space. If the temporal evolving device fully accounts for a self-interacting and chemo-dynamical evolution of the system, on a smoothed particle hydrodynamics (SPH) or adaptive-mesh-refinement (AMR) base, then our technique is able to synthetically generates in a fast and efficient way the colour-magnitude diagrams probability distribution function (CMD-PDF). If the system under exam is orbitally evolved in interaction with a secondary companion, a new theoretical approach is developed to account for the role of the dissipative phenomena in the star formation process (i.e., ram pressure, Kelvin-Helmholtz and Rayleigh-Taylor instabilities, and tidal forces). The impact of each of external processes leave a signature on the synthetically generated CMD. Full details on the technique are presented in Pasetto et al 2012a,b.

Radial migration and flows in chemo-dynamic models

Schönrich, Ralph (Hubble Fellow, OSU)

Combined models of chemical evolution and Galactic dynamics are key to understanding the imprints of dynamical processes in Galactic discs. It has been chemical evolution models that provided the first observational proof of radial migration. On the other hand dynamic processes affect the chemistry of a Galaxy and cannot be neglected when we try to understand chemical evolution. I will focus on a discussion of the observational imprints of radial gas flows and what they teach us about Galactic physics. Further I will discuss recent advances in the analytic modelling of galactic discs.

2 Posters

The Spiral - S0s transition in galaxy groups

Mazzei, Paola (INAF-Osservatorio Astronomico di Padova), A. Marino, R. Rampazzo, L. Bianchi, D. Bettoni, G. Galletta

We are investigating the evolution of galaxies in groups by combining multi-wavelength photometric and 2D kinematic observations. We use smooth particle hydrodynamical simulations (SPH) with chemo-photometric implementation which provide dynamical, morphological information, and the spectral energy distribution (SED) at each evolutionary time, to trace back their evolution. We present the evolution of two S0s with ring/arm-like structures: NGC 1533 and NGC 3626. Simulations well match their observed SEDs, surface brightness profiles as well as the kinematic peculiarities which may be explained in term of halo-halo impact parameters. The driver of the "rejuvenation" in the rings is a major merger of halos, initially just composed of dark matter and gas. Ring/arm-like structures in their galaxy disks are transient features during the evolution of the merging episode, while peculiar kinematic features depend on halos impact parameters. Furthermore, our models allow us to draw, for the first time, the transition trough the green valley in the near-UV-r color versus the M_r absolute magnitude diagram. At least one mechanism leading the evolution of S0s in groups appears gravitational in origin i.e. unrelated to the intra-group hot medium impact.

Models of late type galaxy evolution: 1-D versus 2-D

Mineikis, Tadas (Vilnius University), Vladas Vansevičius

Isolated disk galaxies are perfect places to study quiescent star formation process on galactic scale. Star formation on large scales is highly complex due to non-linearity of processes involved (e.g. star formation feedback, molecular cloud formation, etc.) but it is of central importance for understanding of galaxy evolution. Recent surveys (e.g., Spitzer LVL, Galex NGS) provided wealth of data on spatially resolved disk galaxies. Nevertheless, these data need computationally effective 2-D disk models for the analysis. To fill in this gap we created fast and robustly parameterized 2-D disk evolution models. The 2-D models are able to model azimuthally varying star formation history of disk galaxies. Simulation results provide spatially resolved color-magnitude diagrams of stars or surface brightness distributions. We demonstrate that 2-D disk galaxy models averaged azimuthally follow 1-D models based on Kennicutt-Schmidt relation between star formation and gas density. 2-D models allow more sophisticated physical parameterization of star formation process, better time and spatial resolution and better understanding of star formation in disk galaxies.

Collisionless stellar hydrodynamics as an efficient alternative to N-body methods

Nigel, Mtchell (Institute of Astrophysics, Univ. of Vienna), G. Hensler, E. Vorobyov

Grid codes are less easily but more appropriately applicable to gas dynamics with gas physics because adaptive-mesh refinement (AMR) techniques allow higher spatial resolutions where desired. However when extending astrophysical simulations also to a collisionless component as stars or dark matter, Smooth Particle Hydrodynamics (SPH) codes are advantageous for the implementation of an N-body approach, while the particle-mesh technique used in mesh codes has a series of significant scientific and technical limitations. In order to overcome this drawback we extended the massively parallel AMR code FLASH for the use of the collisionless Boltzmann moment equations as a means to model collisionless material as a fluid on the mesh. This approach which we term 'collisionless stellar hydrodynamics' enables us to do away with the particle-mesh approach and since the parallelization scheme is identical to that used for the hydrodynamics, it preserves the excellent scaling of the FLASH code already demonstrated on peta-flop machines. We find that the classic hydrodynamic equations and the Boltzmann moment equations can be reconciled under specific conditions, allowing us to generate analytic solutions for collisionless systems using conventional test problems.

The survival of tidal dwarf galaxies

Ploeckinger, Sylvia (Inst. of Atrophysics, Univ. of Vienna), G. Hensler, S. Recchi, P. Kroupa, N. Mitchell

We present 3D hydrodynamic simulations on the evolution of tidal dwarf galaxies. These supposedly dark matter free dwarf galaxies are not isolated objects but on orbits around the barycenter of their merging host galaxies. The simulation box is set up on this orbit and all external effects such as ram pressure stripping by

the ambient hot halo gas as well as a tidal field, including accelerations caused by the centrifugal and Coriolis force and by an external gravitational potential in addition to the self-gravity of the TDG. Energy feedback and yields from Supernovae and stellar winds are included and the metallicity of both the gaseous phase (H, He, C, N, O, Ne, Mg, Si, S, Ca, Fe and X) and the stellar population is traced.

The fate of heavy elements in dwarf galaxies - the role of mass and geometry

Recchi, Simone (Univ. of Vienna, Inst. of Astrophysics), Gerhard Hensler

Energetic feedback from Supernovae and stellar winds can drive galactic winds. Dwarf galaxies, due to their shallower potential wells, are assumed to be more vulnerable to this phenomenon. Metal loss through galactic winds is also commonly invoked to explain the low metal content of dwarf galaxies. My main aim in this presentation is to show that galactic mass cannot be the only parameter determining the fraction of metals lost by a galaxy. In particular, the distribution of gas must play an equally important role. I perform 2-D chemo-dynamical simulations of galaxies characterized by different gas distributions, masses and gas fractions. The gas distribution can change the fraction of lost metals through galactic winds by up to one order of magnitude. In particular, disk-like galaxies tend to loose metals more easily than roundish ones. Consequently, also the final metallicities attained by models with the same mass but with different gas distributions can vary by up to one dex. Confirming previous studies, I also show that the fate of gas and freshly produced metals strongly depends on the mass of the galaxy. Smaller galaxies (with shallower potential wells) more easily develop large-scale outflows, therefore the fraction of lost metals tends to be higher.

Special Session Sp11

Rocks in our solar system

1 Oral contributions

Estimation of trajectory and orbital parameters of Chelyabinsk bolide

Gritsevich, Maria (Institute of Mechanics and Faculty of Mechanics and Mathematics, Lomonosov Moscow State University, Michurinskii prt. 1, 119192 Moscow, Russia; Finnish Geodetic Institute, Geodeetinrinne 2, P.O. Box 1), Vinnikov Vladimir

This study is concerned with estimation of trajectory and orbital parameters of Chelyabinsk bolide. This body entered Earth atmosphere on 15-th February of 2013. Bright bolide and it's trail were detected by multiple various recorders ground based, airborne and spaceborne. Obtained observations were sufficient for analysis and estimation of bolide trajectory including entry coordinates and velocity vector, with consequent reconstruction of possible orbits of this object. In contrast to reconstructions, independently carried out by other research groups, our investigation was accented on computing meteoroid dynamics from the required minimum of observational data. This approach to reconstruction is justified, since scientific community can't always rely on very lucky events, such as satellite photo coverage of bolide [1], observations at zenith vantage points and clear weather, allowing to rebuild trajectory from movements of distinct shadows [2]. We discuss the significance of major errors originating from optical distortions of the recording devices, resulting in perturbed directions in triangulation and the scale of smaller errors introduced by the atmosphere itself. It's indisputable that each footage from additional geographical location increase the overall precision of resulting estimation, but, due to the nature of errors and the least squares technique itself the improvements are quite limited. Bibliography 1. http :// cimss.ssec.wisc.edu/goes/blog/archives/12356 2. Zuluaga, J.I. and Ferrin, I., "A preliminary reconstruction of the orbit of the Chelyabinsk Meteoroid.", ArXiv e-prints, arxiv:1302.5377 February 2013.

Meteorite-producing Fireballs: uncovering secrets of the Solar System

Gritsevich, Maria (Finnish Geodetic Institute)

Meteorites represent a low-cost opportunity for probing the cosmic matter that reaches the Earth's surface. In this talk we are discussing meteor observations and what kind of information we could extract with account for underlying physical processes and their mathematical description.

EISCAT_3D: a new tool for solid body research

Heinselman, Craig (EISCAT Scientific Association)

The EISCAT_3D radar, presently in a preparatory phase of development, will provide unique capabilities and significant flexibility for a number of different areas of research. The system will comprise a high power (10 MW) core site for transmission/reception and multiple receive-only sites for vector velocity determination. Like the present EISCAT systems, EISCAT_3D will support a number of interesting measurement options in the areas of meteor and asteroid measurements. This talk will present EISCAT_3D and discuss some of these capabilities.

Chebarkul event as part of the Chelyabinsk event

Kletetschka, Gunther (Charles University), Mls, Jiri; Nabelek, Ladislav; Hruba, Jolana; Marian, Takac;

Analysis of the available photographic data revealed details about the final disposition of the largest fragment that landed into lake Chebarkul. We performed magnetic survey of the area, measured depth, and collected samples of ice, and lake sediment. We created scenarios of landing along with microspherules distribution.

Physical properties of Chelyabinsk meteorites - implications on parent body

Kohout, Tomas (Department of Physics, University of Helsinki / Institute of Geology, Academy of Sciences of the Czech Republic), Gritsevich, Maria; Grokhovsky, Victor; Yakovlev, Grigory

Bulk and grain density, porosity, and magnetic susceptibility of 44 Chelyabinsk (LL5) meteorites were measured. The meteorites included both bright and dark lithology and their masses were in range of 1.2 to 300 g. Mean bulk (3.29 g/cm3) and grain (3.47 g/cm3) density and porosity (6%) matches LL fall range reported in Consolmagno et al., 2008. The mean magnetic susceptibility (logarithm of mass susceptibility in 10-9 kg/m3 = 4.51), however, is in-between mean values reported for L (4.87) and LL (4.10) falls in Rochette et al. 2003. This suggest that the amount of metallic iron is in the intermediate L/LL range and higher than in other LL chondrites). All above mentioned parameters are consistent through whole mass range and does not differ significantly among bright and dark lithology and brecciated samples with significant amount of impact melt. This suggests that the Chelyabinsk meteorite parent body was rather homogenous in its composition despite its brecciated nature.

Meteorite spectral measurements in Vis-NIR with related analysis

Pentikäinen, Hanna (University of Helsinki), Antti Penttilä, Karri Muinonen, Teemu Hakala, Jouni Peltoniemi, Maria Gritsevich, and Tomas Kohout

The composition of Near-Earth Objects (NEOs) is still largely undetermined due to scarce flyby missions and low-resolution ground-based spectroscopy at the visible and near-infrared wavelengths. Spectrometry of meteorites can be a complementary source of information considering that unweathered meteoritic "falls" are almost pristine samples of their parent bodies. Additional radiative-transfer modeling of meteorite spectra may present a way to interconnect meteorite measurements with actual NEO spectroscopy.

We have measured reflectance spectra (350-2500 nm with a zenith angle of reflection range of ±60 degrees) of centimeter-size pieces of 18 different meteorites. The measurements were carried out with the Finnish Geodetic Institute Field Goniospectrometer (FIGIFIGO) (Suomalainen et al., Sensors 9, 2009). Principal Component Analysis (PCA) was performed on the spectra. The analysis suggests that the principal components of the data can separate undifferentiated ordinary chondrites from differentiated achondrites.

Our measurements expand the database of reflectance spectra of 26 meteorites obtained by Paton et al. (JQSRT 112, 2011). The spectra of meteorites found in both data sets are consistent. Furthermore, we offer a phenomenological single-scatterer (Muinonen and Videen, JQSRT 113, 2012) radiative-transfer model for the measurements. Our intention is to further expand the database of meteorite spectra and develop the joint radiative-transfer model in the future.

Statistical Study of Fragments Distribution for Košice Meteorite

Vinnikov, Vladimir (Moscow Aviation Institute), Maria Gritsevich, Juraj Tóth

This work is concerned with the study of optimal statistical description for mass distribution of meteorite samples. Such description can hint on initial projectile properties and physical parameters responsible for underlying fragmentation processes. If recovered meteorite collection is statistically sufficient, one can propose a reliable model well applicable to more general cases when the input parameters are incomplete. We have found that the sample plots have familiar shape, which can be fitted by several distributions, including normal, logistical and other continuous sigmoid cumulative functions. To estimate goodness of fit for the selected theoretical distributions we used various chi-squared tests. We found that bimodal distributions are often more suitable than their unimodal counterparts. Another approach to statistical study deals with the cumulative number of fragments instead of their mass fraction. We assume both approaches useful and consider a number of

known statistical functions, including the log-normal, the Weibull, the Graddy, and the Gilvarry distributions. The considered distributions can provide some additional information on the projectile. Assuming plausibility of bimodal lognormal or bimodal Grady distributions we found a number of fragmentational events taken place. Such conclusion hints on a primary singular prefragmentation of the body and the consequent atmospheric entry of independent fragments with respective residual masses.

StreakDet data processing and analysis pipeline for space debris

Virtanen, Jenni (Finnish Geodetic Institute), Karri Muinonen, Mikael Granvik, Laura Immonen, Johanna Torppa, Jonne Poikonen, Jussi Lehti, Jyri Näränen, and the StreakDet team

During the past decades, the near-Earth space has become densely populated by man-made objects. It has been estimated that our space activities have left behind a population (active satellites as well as debris) of over 300,000 objects larger than 1 cm. Only some 15,000 have been tracked and catalogued, leaving the vast majority of the objects unknown. The European Space Agency's Space Situational Awareness (SSA) Programme, started in 2008, aims at detecting, predicting, and assessing the risk to life and property due both man-made and natural objects as well as space weather. One of the three main areas of the programme is survey and tracking of objects in Earth orbit. The present project contributes to the efforts by describing novel algorithms for processing optical observations of space debris.

First, we put forward a streak detection algorithm that classifies satellite or debris streaks using the Principal Component Analysis, including Bayesian classifiers and K-nearest-neighbor classifiers as essential components. We shall apply the algorithm to synthetic optical observation for space debris. Second, we consider the space-debris orbital inversion problem via the concept of Bayesian inference and demonstrate the applicability of our statistical orbital analysis software to Earth-orbiting objects.

2 Posters

Taiwan Elegant Meteor and TLE Network (TWEET)

Bing-Xun , Wu (National Central University, Taiwan), Shinsuke Abe, Hung-Chin Lin, Chi-Sheng Lin

Lulin Meteor System (LMS) has started regular observation since December 2009 at Lulin observatory in Taiwan. Three cameras towards north, east, and south are carried out using high sensitive CCD-TV cameras (Watec and Mintron) with wide field of view CCTV lens, which are recorded in video rate controlled by the software UFOCapture. Several sets of the camerea system were installed in many locations in Taiwan. Now we have nine meteor observing sites and about twenty cameras. The longitude of our sites is about120°E and the latitude is about 24°N, so we have more chance to observe the meteors the radiant points of which are in the south hemisphere.

If we have more location to observe meteors, we can use triangulation method to analyze meteors. We got 655 geminids to in December, 2012. 186 pairs of them were recorded by at least two locations. We use UFOAnalyzer to get the geocentric velocity. Most of their velocity are about 33-41km/s, semi-major axis are about 1.2-1.5AU (average is about 1.7AU). The parent body of Geminids is asteroid 3200 Phaethon and its semi-major axis is 1.271 AU. The meteors' data are close with Phaethon.

The weather of Taiwan is Subtropical marine climate. It usually rains during the typhoon and plum rain season. We aslo can record Transient Luminous Events (TLEs), and have triangulation data. So we will know the accurate and precise location of TLEs. We can check the radar data to analyze with them.

In this year, we held several workshop to invite more high school teachers and fans of astronomy. We will continue to estabilish more meteor observatories and have some teaching material for high school students.

Taiwan Elegant Meteor and TLE Network (TWEET) Forum

Spectroscopic Study of Comet 9P/Tempel 1

de Almeida, Amaury (University of São Paulo), E. Picazzio, S.M. Andrievsky , I.V. Lukyanyk, V.V. Kleshchonok, A.A. de Almeida, K.I. Churyumov, V. L. Afanasiev, L.S. Chubko

We present the results of exploration of the spectra of comet 9P/Tempel 1, observed on Mount Pastukhov (Russia), using the SCORPIO spectrograph (www.sao.ru/hq/lsfvo/devices/scorpio/scorpio.html), attached to the 6-m BTA telescope (www.sao.ru/Doc-en/Telescopes/bta/descrip.html). The observations took place 2.5 months before collision of the copper nosed impactor of the Deep Impact spacecraft. The physical parameters of C2, C3 and CN molecules in the near nucleus region of the cometary atmosphere of 9P/Tempel 1 were determined. The energy distributions and brightness profiles in the selected emission lines along the spectrograph were constructed using Shulman's model (www.astro.iag.usp.br/ picazzio/appendix-1.pdf). The presence of the cometary luminescence continuum (non-solar-origin) in the spectra of the comet was confirmed.

MONITORING OF NEAR EARTH OBJECTS AT THE TERSKOL OBSERVATORY

Godunova, Vira (ICAMER Observatory), Volodymyr Tarady, Oleksandr Sergeev, Maksym Andreev, Volodymyr Reshetnyk

Beginning in 1996, the facilities of the Terskol Observatory (the Northern Caucasus, 3100 m asl) have been heavily used for studies of Solar System small bodies. The available small and medium-sized telescopes provide good enough opportunities for precise astrometric, photometric, and spectroscopic observations of these objects. In addition, many advances in this field came from the development and use of specific instruments and techniques. A special attention is given to the detection and monitoring of potentially hazardous objects - Earth-approaching asteroids and comets. In particular, spectra of asteroids have been obtained by using a low-resolution imaging spectrograph attached to the Zeiss-600 telescope. Objects were observed down to V magnitude of 15, with individual exposure times of 10-30 s; their spectra were recorded over the wavelength range from 300 to 900 nm. Appropriate data-analysis techniques allow us to determine spectral types of asteroids. Precise astrometric data acquired during observations of these objects at Terskol are routed directly to the IAU Minor Planet Center for analysis. In this paper, the different aspects of monitoring and study of near-Earth objects will be presented; the results and some findings will be discussed. This work has been supported by the NASU-RFFR project # 63-02-12 (12-02-90444).

PHYSICAL PROPERTIES OF METEOROIDS BASED ON RADAR MEASUREMENTS

Gritsevich, Maria (FGI), Johan Kero, Jenni Virtanen, Csilla Szasz, Takuji Nakamura, Jouni Peltoniemi, and Detlef Koschny

We introduce a novel approach to reliably interpret the meteor head echo scattering measurements detected by the 46.5 MHz Middle and Upper atmosphere (MU) radar system near Shigaraki, Japan. The data reduction steps include determining the exact trajectory of the meteoroids entering the observation volume of the antenna beam and calculating meteoroid mass and velocity as a function of time. The model is built using physically based parametrization. The considered observation volume is narrow, elongated in the vertical direction, and its area of greatest sensitivity covers a circular area of about 10 km diameter at an altitude of 100 km above the radar. Over 100000 meteor head echoes have been detected over past years of observations. Most of the events are faint with no alternative to be detected visually or with intensified video (ICCD) cameras. In this pioneering study we are focusing on objects which have entered the atmosphere with almost vertical trajectories, to ensure the observed segment of the trajectory to be as complete as possible, without loss of its beginning or end part due to beam-pattern related loss of signal power.

The structure and fragmentation of Chelyabinsk meteorite

Grokhovsky, Victor (Ural Federal university), Yakovlev Grigori, Maksimova Alevtina, Gizzatullina Rozalia

Members of UrFU's Meteorite expedition collected more than 500 individual fragments of the Chelyabinsk meteorite at the first week after the fall. Samples have been found in the snow along the fireball trajectory direction from village Baturinskii to Travniki. Fragments smaller than 1 cm were collected not far from Emanzhelinka. Larger fragments can be found 25 kilometers to west. In this place the biggest fragment weights 1807 g (from those that are known) and was found on February 23. Likely, meteoroid fragmentation was multiple and there was a cluster of fragments before point of deceleration. Meteoroid structure and very low mechanical strength explain fragmentation to over 100000 fragments. All fragments can be divided into two groups: Bright and dark. Bright substance was identified as LL5 S4. There are numerous thin shock-melt veins present in the bright meteorites and fragmentation occurred along these veins. Structural features were

studied using OM and SEM with EDS unit. The contents of metal Fe(Ni,Co), troilite FeS and porosity were determined using SIMAGIS image analysis system. Porosity of light fragments is more than 10% and this value is overestimated because of material crumbling out. This work was supported in part by RFBR No 13-05-96045-r-ural-a and the Federal Grant-in-Aid Program "Human Capital for Science and Education in Innovative Russia" (Governmental Contracts No. 14.740.11.1006).

More on the fascinating Almahata Sitta story

Hoffmann, Viktor (Dep. Geo- and Environmental Sciences, Univ. Munich, Dep. Geosciences, Univ. Tuebingen, Germany), Funaki M., Torii M., Yamamoto Y., Kodama K., Mikouchi T., Hochleitner R., Kaliwoda M., Zolensky M.

The famous Almahata Sitta meteorite (AS, fall 2008 in North Sudan) was classified as a polymict ureilite. More systematic studies on the AS fragments reported the finding of a range of different ureilite types but also of other meteorite lithologies such as enstatite and ordinary chondrites, at least one carbonaceous chondrite (Bencubbinite) and a unique chondrite of a new type not known before [1,2,3,4]. AS is in some way comparable to the Kaidun meteorite [5], and it became clear that 2008 TC3 represents a secondary rubble pile asteroid. We have the unique and extraordinary chance to work in our laboratories on fresh material from a meteorite which has a direct link to a known asteroid. Consequently, reconstructing the evolution of the asteroidal body and trying to link the various lithologies to their respective primary parent bodies is a really fascinating goal. In our contribution we will review the results of our investigations by magnetic and mineralogical means, and Micro Raman Spectroscopy which we have performed on a range of AS lithologies[6]. References [1] Jenniskens P., et al., 2009. Nature, 458, 485-488. [2] Jenniskens P., Shaddad M., 2010. Meteor. Planet. Science, 45, Spec. Iss. Almahata Sitta. [3] Bischoff A., et al., 2010. Meteor. Planet. Science, 45, 1638-1656. [4] Bischoff A., et al., 2012. 75th Meteor. Soc. Conf., #5053. [5] Zolensky M., 2003. Chem. Erde, 63, 185-246. [6] Hoffmann V., et al., 2012. Antarct. Meteor. Conf., NIPR 2012.

Estimates for velocity and deceleration of the largest Chelyabinsk fragments and conclusions for the impact sites

Lyytinen, Esko (Finnish Fireball group), Maria Gritsevich

We have analyzed Chelyabinsk fireball trajectory using available video and satellite records of the event. Besides deriving the general entry trajectory and the corresponding previous solar system orbit of the meteoroid, we paid special attention to the two front fragments and have derived reliable velocity, and deceleration data, as well as final ground location for these two individual fragments. In particular, the results confirm one of these fragments have impacted into the Chebarcul lake.

Call for observation of asteroid 2012 FZ23 and its association with delta Chamaeleontids (IAU#107)

Rudawska, Regina (IMCCE – Observatoire de Paris), Jeremie Vaubaillon, Peter Jenniskens

Introduction: This poster addresses the topic of meteoroid stream parent body in relation to meteor showers observed in the southern hemisphere. We suggest that the future investigations need to be directed to the observations in southern hemisphere. We carry out a further search to investigate the possible genetic relationship of the asteroid 2012 FZ23 with southern meteor shower δ Chamaeleontids.

Simulation: The 2012 FZ23 asteroid is a good candidate for a dormant comet. The Tisserand parameter for the orbit has a value of 2.283, which indicates a comet-like orbit. Diameter of the asteroid is in the range of 1.33-2.66 km. The model of generation and evolution of meteoroid stream in the Solar System is taken from [2]. Meteoroid stream formation was investigated for an epoch of ejections between 1000 B.C. and 2012 A.D. Next, the orbits of ejected meteoroids were integrated to year 2050.

Results & Conclusions: We have investigated the orbital evolution of meteoroid stream originated from the asteroid 2012 FZ23. We found that the radiant position of the simulated particles looks similar to the radiant of δ Chamaeleontids. First notice about IAU#107 shower comes from 1975 [1]. Since then there is no other informations about this stream. The most distinct difference between the simulated stream and the δ Chamaeleontids is in the solar longitude, possibly due to precession.

If the asteroid was active in the past, it might be a parent body for a meteor shower observed on the southern hemisphere. Observations in the southern hemisphere are limited. Thus, we suggest that southern streams should become high-priority targets for further new observation campaigns.

References

1. Gartrell, G., Elford, W. G., 1975, Australian Journal of Physics, 28, 591
2. Vaubaillon, J., Colas, F., Jorda, L., 2005, Astronomy and Astrophysics, 439, 751

Special Session Sp12

A fresh look at the stellar initial mass function

1 Oral contributions

New insights into the non-universality of the IMF

Bertelli Motta, Clio (University of Heidelberg, ZAH - Institute of Theoretical Astrophysics), Ralf S. Klessen, Paul C. Clark, Simon C. O. Glover, Anna Pasquali

In the last couple of years, there has been growing evidence for a non-universal IMF. In particular, observational data of early-type elliptical galaxies exhibit spectral features that suggest that the IMF in these systems may be more bottom heavy (i.e. contain a greater portion of the total mass in low-mass stars) than the standard Kroupa or Chabrier IMF. Comparisons between the mass-to-light ratios (based on dynamical data) and stellar population models would also seem to support this picture. Several theoretical studies have tried to determine which physical processes can influence the shape of the IMF. We performed smoothed-particle hydrodynamics (SPH) simulations of a star formation region that probe the sensitivity of the IMF to the conditions of the parent cloud. In our study we look at varying the turbulent properties of the gas, such as the Mach number and type of turbulence, and also study clouds that are exposed to different background radiation fields and cosmic ray fluxes.

Constraining the IMF via galaxy mass determinations

Cappellari, Michele (University of Oxford)

I review constraints to the stellar initial mass function (IMF) and its variation among different galaxies, provided by measurements of the galaxies stellar masses.

Testing mass distribution of binaries from magnitude difference of visual binary stars.

Chulkov, Dmitry (INASAN), Trushin D., Isaeva A.

Significant fraction of stars in our Galaxy comprises binary systems. Masses of stars in binary system are exhaustively determined by either two of four parameters: mass of primary component M_1, mass of secondary component M_2, total mass $M_{tot} = M_1 + M_2$ and mass ratio $q = \frac{M_2}{M_1}$. We consider several distinct ways to assign the masses of binaries proposed by Kouwenhoven et al. (2008):

1. Random Pairing (RP) Masses of both components are generated independently from universal Initial Mass Function (IMF).

2. Primary Constrained Pairing (PCP). The mass M_1 of primary is generated from IMF. The mass of secondary M_2 is determined from additional mass ratio distribution $f(q)$.

3. Split Core Pairing (SCP). Total mass M_{tot} of binary system is generated from IMF, while individual masses are calculated with mass ratio distribution $f(q)$.

Magnitude difference /*deltam* is a parameter reflecting luminosity ratio for a given binary. It is known for a vast number of visual binary stars. Here we attempt to find out pairing mechanism of binary stars and mass distribution from their observable Δm distribution. We investigate visual binaries catalogues and consider respective observational biases to build /*deltam* distribution. Then natural assumption for visual binaries is presumed that stellar evolution occurs irrespective of other component, therefore we may use reliable single star interpolation formulas estimating stellar luminosity as a function of stellar mass and age (Hurley et al., 2000). Finally, series of Monte-Carlo simulations are carried out in order to select the appropriate mass distribution meeting the observed /*deltam* distribution. Different IMFs and $f(q)$ are considered.

Our results show preference for Primary Constrained Pairing (PCP) and excess of twin binaries composed of two stars with identical mass.

Stellar Populations and The Initial Mass Function of ALHAMBRA Early-Type Galaxies

Diaz-Garcia, Luis Alberto (CEFCA), Javier Cenarro

The universality of the stellar Initial Mass Function (IMF) is a recurrent matter of debate. In the last years, a growing number of studies reveal that massive ellipticals seem to be better explained using a bottom-heavy –rather than a top-heavy– stellar Initial Mass Function (IMF), what has a direct impact in the inferred stellar masses, ages and metallicities of these galaxies. We present first results on the stellar population analysis for a sample of Early-Type galaxies up to z$\sim$1 in the ALHAMBRA photometric survey (Moles et al. 2008; 20 optical top hat filters plus J, H and Ks), allowing us to face how and when these galaxies were formed and have evolved throughout cosmic time, taking the IMF as a free parameter. The analysis has been performed making use of a generic code developed by our team to study and recover the main parameters of old stellar populations, including the IMF.

Baby elliptical galaxies or non-universal IMF slopes?

Ferre-Mateu, Anna (IAC), Vazdekis, A. and de la Rosa, I.

The debate on the possible variations of the IMF for explaining several aspects of ETGs evolution uses to peak almost every decade. The most recent contributions point towards a bottom-heavier IMF for more massive galaxies.

We present an analysis about the biased results that can be obtained when adopting a standard, universal IMF, such as the questionable existence of ETGs with no contributions of old stellar populations. We have quantified the impact of varying the IMF slope and shape into various stellar population properties. We find that galaxies are rejuvenated and get more massive as we steepen the slope of a Salpeter-like power-law IMF. However, this trend is milder if we consider a Kroupa-like multi-segmented IMF. In addition, we find that by tuning each IMF slope according to the central velocity dispersion of the galaxy, the derived SFHs tend to be more similar for ETGs of different masses, presenting a common pattern that involves a varying amount of recent residual star formation.

Probing the stellar IMF with strong gravitational lensing

Ferreras, Ignacio (UCL), P. Saha, D. Leier

Strong gravitational lensing can be used to constrain the surface mass distribution over galaxy scales. Choosing lenses with small Einstein radii allows us to probe the baryon dominated central regions of early-type galaxies. By comparing lensing masses with high spatial resolution imaging, using the Hubble Space Telescope, one can obtain a highly accurate estimate of the M/L. In addition, spectroscopic data combined with state-of-the-art population synthesis models provide a method to constrain the Initial Mass Function, removing the inherent degeneracies expected from the age and metallicity distribution of the underlying stellar populations. In Ferreras et al. 2010 (MNRAS, 409, L30), we showed that the lens in the Einstein Cross (a low-mass bulge) was compatible with a standard Kroupa-like IMF. In this contribution, we present ongoing work aimed at exploring the systematic trend towards a bottom-heavy IMF in massive early-type galaxies.

Systematic variation of the Stellar Initial Mass Function of Early-type Galaxies from a Variety of Spectral Features

La Barbera, Francesco (INAF-OAC), I. Ferreras, A. Vazdekis, I.G. de la Rosa, R.R. de Carvalho, M. Trevisan, J. Falcon-Barroso, E. Ricciardelli

The stellar Initial Mass Function (IMF) is a key ingredient for any galaxy formation and evolution scenario, and more fundamentally, for any theory of star formation. Using a sample of 24,781 nearby (z<0.1) early-type galaxies (ETGs) from the SDSS-based SPIDER survey, we are performing a systematic census of the (unresolved) IMF in luminous ETGs. The SDSS spectra are combined in velocity dispersion bins, ranging from 100 to 300 km/s. We present the analysis of a variety of spectral indices, combining gravity-sensitive features, with spectral indices that are sensitive to the leading individual element abundances (Mg, TiO, Na, Ca), as well as age and metallicity. Going beyond a simple test of non-universality of the IMF, our work points to a clear trend between IMF slope and central velocity dispersion in ETGs, with a standard Kroupa/Chabrier IMF at ∼100km/s evolving towards a bottom-heavy function at high galaxy mass.

Bottom-heavy initial mass function in a nearby compact $L^\star$-galaxy

Läsker, Ronald (MPIA Heidelberg), Remco van den Bosch, Glenn van de Ven, Ignacio Ferreras, Francesco La Barbera, Alexandre Vazdekis, Jesús Falcón-Barroso

We present orbit-based dynamical models and stellar population analysis of a low-redshift ($z = 0.116$) early-type galaxy (ETG) which, for its moderate luminosity ($4.7 \times 10^{10} L_\odot$), has an exceptionally high velocity dispersion ($360\,\mathrm{kms}^{-1}$). We aim to determine the central black hole mass, the i-band stellar mass-to-light ratio, and the low-mass slope of the initial mass function (IMF). Combining the constraints from HST imaging and long-slit kinematic data with the those from fitting the SDSS spectrum with stellar population models of varying IMF, we show that this galaxy has a high fraction of low-mass stars, significantly higher even than implied by a Salpeter IMF. We exclude a Chabrier/Kroupa as well as a unimodal (i.e. single-segment) IMF, while a bimodal (low-mass tapered) shape is consistent with the dynamical constraints. Thereby, our study demonstrates that a very bottom-heavy IMF can exist even in an $L^\star$ ETG.

Radial IMF variation in early-type galaxies

Martín-Navarro, Ignacio (Instituto de Astrofísica de Canarias), Alexandre Vazdekis, Jesús Falcón-Barroso

The initial mass function (IMF) has critical implications in the framework of galaxy formation and evolution and it is assumed to be universal. However, judging from the strengths of several features, there is evidence that massive early-type galaxies seem to show a much larger fraction of dwarf stars. By measuring the strengths of these IMF sensitive indices, we have been able to trace the radial IMF variations in a sample of early-type galaxies. In addition, we have studied the dependence of the radial IMF profile with some fundamental galaxy parameters, such as local velocity dispersion or surface brightness, to better understand the mechanism departing the IMF from being universal.

The new estimates of the initial mass function in compact stellar systems

Podorvanyuk, Nikolay (Sternberg Astronomical Institute, Moscow State University), Igor Chilingarian, Ivan Katkov

We present new estimates of the stellar initial mass function (IMF) in massive compact stellar systems which have not been affected by dynamical evolution. These estimates were made by new technique that determines low-mass end slope of the present day stellar mass function (PDMF) of unresolved stellar populations using pixel fitting of spectra integrated along line of sight. This method achieves precision of ∼0.1 in MF slope value and hence outperforms classical IMF determination techniques which use direct star counts in open clusters and HII associations. We note that biases may be introduced to the MF measurements from integrated light spectra by significantly non-solar abundance ratios.

ESO325–G004: A massive elliptical galaxy with a lightweight IMF

Smith, Russell (University of Durham), John Lucey (Durham)

Recent evidence suggests that massive ellipticals formed stars with an initial mass function (IMF) which is "heavier" than that of the Milky Way, perhaps due to an excess of low-mass stars. An IMF which varies systematically with galaxy properties would have wide-ranging implications both for star-formation physics and for interpreting extragalactic observations, so it is important to test these results carefully. I will present the results for ESO325–G004, a very massive elliptical which, at $z = 0.034$, is also the closest-known strong gravitational lens galaxy. We have recently measured the redshift of the lensed background galaxy, and hence secured the mass of the elliptical inside the Einstein radius. Because the lens is so close, the Einstein radius is small compared to the effective radius, and the lensing mass is dominated by stars. Hence lensing, with only a small correction for dark matter, provides the *stellar* mass-to-light ratio. Combined with age constraints from high-S/N spectroscopy, the lensing mass firmly excludes a "heavyweight" IMF in *this* $\sigma = 340\,\mathrm{km\,s^{-1}}$ elliptical. An IMF similar to that in the Milky Way is consistent with the observations. Is this galaxy simply an outlier among massive ellipticals in having a Milky-Way-like IMF? Or does it point to tension with the methods that prefer heavier IMFs? Upcoming VLT observations of dwarf-star-sensitive spectral features in ESO325–G004 should be able to answer this question by the time of the meeting.

[NB: I have submitted an identical abstract for symposium S4. In the event that I get a talk at both, then the Sp12 talk will have more technical detail, for the more specialist audience.]

The XLENS Project: The X-Shooter Lens Project: Do more massive Early-type Galaxies have more internal dark matter or a steeper IMF ?

Spiniello, Chiara (Kapteyn Institute), M.Barnabè, L.V.E.Koopmans, S.C.Trager

Recent observations indicate that the internal dark-matter (DM) fraction of massive Early-Type galaxies (ETGs) increases rapidly with galaxy mass, although more and more hints for a varying initial mass function (IMF) have been suggested where the low-mass end of the stellar IMF steepens with galaxy mass. With the X-Shooter Lens Survey (XLENS) we can, for the first time ever, disentangle between the two scenarios. With XLENS we are able to unambiguously separate the stellar from the dark-matter content of galaxies and, for the first time, constrain the normalization and shape of the low-mass end of the IMF, through combined lensing, dynamical and spectroscopic stellar population analysis (SSP). We developed a fully self-consistent modeling of the stellar and DM mass component in lens galaxies (Barnabè et al. 2012) that allows stellar masses to be measured directly from only lensing and dynamics without any assumption on the IMF. Having two independent constraints on the stellar mass, one from the fully self-consistent joint lensing+dynamics (L&D) analysis, and the other from spectroscopy and SSP modeling, allows us to disentangle IMF slope variations from internal DM variations. In this talk, I will present the first XLENS preliminary studies on two massive ETGs showing the power of our survey for understanding the interplay of stellar and dark mass in massive ETGs.

Is the Initial Mass Function universal?

Tortora, Crescenzo (ITP - Universität Zürich)

I will discuss the recent claims for systematic variations in the stellar initial mass function (IMF) carrying out a complete inventory of the different observational evidences. This includes literature results, as well as our own new findings from combined stellar-populations synthesis (SPS) and Jeans dynamical analyses of data on ~ 4500 early-type galaxies (ETGs) from the SPIDER project (Tortora et al. 2013). I focus on the mass-to-light ratio mismatch relative to the Milky Way IMF, $\delta_{\rm IMF}$, correlated against the central stellar velocity dispersion, $\sigma_\star$. A strong correlation between $\delta_{\rm IMF}$ and $\sigma_\star$ is found, for a wide set of dark matter (DM) model profiles. These results are robust if a uniform halo response to baryons is adopted across the sample. The overall normalization of $\delta_{\rm IMF}$, and the detailed DM profile, are less certain, but the data are consistent with standard cold-DM halos, and a central DM fraction that is roughly constant with $\sigma_\star$. For a variety of related studies in the literature, using SPS, dynamics, and gravitational lensing, similar results are found. Overall, we find that multiple independent lines of evidence appear to be converging on a systematic variation in the IMF, such that high-$\sigma_\star$ ETGs have an excess of low-mass stars relative to spirals and low-$\sigma_\star$ ETGs. Finally, future prospects will be discussed.

MILES stellar population synthesis models with varying IMF and abundance ratio.

Vazdekis, Alexandre (Instituto de Astrofísica de Canarias)

Massive early-type galaxies are known to show an excess of Magnesium over Iron in comparison to the scaled-solar abundance pattern. Also there is evidence that their spectra are better fitted with a bottom-heavy IMF. We present stellar population synthesis models with varying IMF and α-elements enhancement, which are built on the basis of the MILES stellar spectral library with the aid of theoretical stellar atmospheres. We show the differential effects of varying these parameters on the spectra to facilitate the study of these objects.

The IGIMF in dwarf late-type to massive early-type galaxies

Weidner, Carsten (Instituto de Astrofisica de Canarias), Pavel Kroupa Jan Pflamm-Altenburg Alexandre Vazdekis

Recent observational studies found evidence for non-universal galaxy-wide stellar initial mass functions (IMF) in late-type dwarf galaxies as well as massive early-type Ellipticals. Interpreting this trend with the integrated galactic stellar initial mass function (IGIMF) theory, it follows that galaxies which formed with SFRs > 10 $M_\odot$ yr^{-1} would have had top-heavy IMFs. In particular, elliptical galaxies ought to then have higher M/L ratios as a result of the overabundance of stellar remnants compared to a stellar population that formed with a canonical IMF. Indeed, the empirical M/L ratios of elliptical galaxies change with velocity dispersion in agreement with the IGIMF theory. On the other end of the galaxy mass spectrum, dwarf galaxies with star formation rates below 10^{-1} $M_\odot$ yr^{-1} are showing a deficit of O stars in countable populations.

2 Posters

Metallicity effects on the derivation of age, mass, and extinction of unresolved star clusters.

de Meulenaer, Philippe (Vilnius University), Donatas Narbutis, Tadas Mineikis, Vladas Vansevicius

The determination of the physical parameters (age, mass, extinction, and metallicity) of star clusters based on broad-band optical integrated magnitudes (UBVRI, SDSS) is complicated by two problems: the degeneracy between the parameters and the stochastic sampling of stellar masses. In this contribution, we present a method that allows to derive the age, mass, and extinction of star clusters having undefined metallicity. We also present how the availability of UV (GALEX) or NIR (2MASS) broad-band observations allow to reduce considerably the uncertainty on the derived parameters. The method is applied on a star cluster sample of the Andromeda galaxy.

Using synthetic spectra to construct Population Synthesis Models for IMF studies

Orsi, Maia (Liverpool John Moores University)

One way to investigate the process of galaxy formation and evolution is to study the properties of their stellar populations using population synthesis models (PSMs). Recent spectroscopic studies of massive elliptical galaxies claim to find indications for a non universal stellar initial mass function (IMF). They made use of the equivalent widths of infrared absorption features that are sensitive to the low mass star population. I have been investigating the use of synthetic spectral libraries derived from model atmosphere calculations to construct PSMs for IMF studies. Theoretical libraries have the advantage to cover a larger parameter space compared to empirical ones, and to enable investigations of the differential effects of varying individual chemical abundances. I have explored the suitability of different theoretical spectral libraries in the optical and infrared by comparing the modelled equivalent widths to observations of individual stars. I will show examples of this comparison with some of the best available spectral libraries: Phoenix (Allard et al., 2010) and Munari (2005). The goal of this study is to understand where we are standing with the use of synthetic libraries for stellar population modelling.

Special Session Sp13

Starburst galaxies now and then with ALMA

1 Oral contributions

The FIR properties of Lyman break galaxies at z∼3 and above

Bremer, Malcolm (University of Bristol), Luke Davies, Elizabeth Stanway, Matt Lehnert

In order to determine the dust at star formation properties of the most ubiquitous population of sources that are currently studied at z>3, Lyman Break Galaxies, we have used private and public data to derive their mid and far-IR SEDs. We selected samples on stellar mass, extinction corrected SFR and UV brightness and obtained detections across multiple wavelengths allowing us to accurately determine the FIR luminosities, dust temperatures and total SFRs (unobscured and obscured) for the first time in unlensed z∼3 LBGs. We show that the UV spectral slope correctly predicts for FIR luminosity and obscured SFR, but not in those reddest LBGs with largest predicted SFRs. We show that the LBGs are 'typical' galaxies (rather than unusual unobscured starbursts) for their redshift, falling on the z∼3 main sequence for star formation and likely represent the low end of the high redshift FIR luminosity function traced by SMGs at the high end.

The effect of the Cosmic Microwave Background in high-redshift (sub-)millimeter observations

da Cunha, Elisabete (MPIA Heidelberg), Brent Groves (MPIA), Fabian Walter (MPIA), Roberto Decarli (MPIA), Axel Weiss (MPIfR), Chris Carilli (NRAO), Emanuele Daddi (CEA Saclay), David Elbaz (CEA Saclay), Rob Ivison (ROE, Univ. Edinburgh), Roberto Maiolino (Univ. Cambridge), Dominik Riechers (Cornell Univ.), Hans-Walter Rix (MPIA), Mark Sargent (CEA Saclay), Ian Smail (Durham Univ.)

We discuss the effect of the cosmic microwave background in (sub-)millimeter observations of cool gas and dust in high-redshift galaxies. The CMB has two main effects on the observed (sub-)millimeter continuum emitted by dust grains and on the carbon monoxide (CO) line emission of these galaxies: (i) it provides an additional source of (both dust and gas) heating; (ii) it is a non-negligible background against which the line and continuum emission are measured. We show that these two competing processes affect the way we interpret the dust and gas properties of the galaxies using spectral energy distribution models. We quantify these effects and provide correction factors to compute what fraction of the intrinsic dust (and line) emission can be detected against the CMB as a function of frequency, redshift and temperature. We discuss implications of these effects on the derived properties of high-redshift galaxies from (sub-)millimeter data. Specifically, the inferred dust and molecular gas masses can be severely underestimated if the CMB effects are not properly taken into account.

The forbidden side of the high-redshift universe

Decarli, Roberto (MPIA), F. Walter

The study of the properties of the interstellar medium in high-z (z>3) galaxies is hindered by the fact that most of the relevant diagnostics are based on rest-frame emission lines which are shifted in the mid-IR bands,

where sensitive spectroscopy is out of reach for present-day instrumentation. A new way to overcome this limitation is offered by fine-structure forbidden emission lines of the same ISM tracers (neutral and ionized oxygen and carbon, ionized nitrogen). These lines enter the (sub-)mm transparent windows of the atmosphere when redshifted beyond z∼3, and are now detectable thanks to substantial upgrades in the available facilities (e.g., the extended VLA or the Plateau de Bure Interferometer) and to the advent of the Atacama Large Millimeter Array (ALMA). I will report on 1) the first survey of [NII]205um in high-z galaxies; 2) the detection of [CII]158um in the most distant quasar (z=7.1) and in one of the most distant sub-mm galaxies (z=5.2); and 3) the sensitive upper limits on [CII] emission from Ly-alpha emitters at z>6. By building up on these results, we will be able to directly probe ionization states, densities, temperature, abundances of the star-forming gas in high redshift galaxies.

Star Formation Laws in Extreme Starbursts

Garcia-Burillo, Santiago (OAN-Spain)

The observational study of star-formation laws is central for revealing the key physical processes that determine the efficiency of the star-formation phenomenon in different population of galaxies. In particular it is still debated whether a universal recipe is applicable to normal galaxies and extreme starbursts. Molecular gas surveys, traced by CO lines, have presented evidence that normal galaxies and mergers (LIRGs, ULIRGs and SMGs) occupy different regions in the molecular gas mass versus star-formation rate plane. These results suggest the existence of a bimodality in star-formation laws, where normal galaxies show 4–10 longer depletion time-scales compared to mergers. Galaxy mergers and interactions can provide the gravity torques able to funnel the gas to galaxy centers and trigger starbursts. On the contrary, secular evolution processes can determine the SFR of galaxies dubbed as falling on the "main sequence" of star-forming galaxies. Recent HCN surveys have also found a similar duality in the star-formation laws of the dense molecular phase in galaxies that is further reinforced if we account for the likely different conversion factor for HCN in extreme starbursts and for the unobscured star-formation rate in normal galaxies.

We will discuss the observational evidence supporting/refuting the evidence of bimodality in 'global' star-formation relations obtained with different tracers of molecular gas in normal galaxies and extreme starbursts. Spatially-resolved KS laws obtained with interferometers like ALMA in normal galaxies and extreme starbursts can help disentangling the key factors of star formation on 'critical' (smaller) spatial scales.

High-z star formation as traced by molecular gas and dust

Hodge, Jacqueline (MPIA)

Recent years have seen remarkable progress in our understanding of high-z star formation, much of it thanks to the successful surveys in the rest-frame optical/UV. I will review the complementary progress made via observations of the cool gas and dust in high-z galaxies, highlighting recent results from current centimeter/(sub-)millimeter interferometers and touching on future prospects with the full ALMA.

ALMA Cycle 0 observations of nearby luminous infrared galaxies using high density molecular gas tracer

Imanishi, Masatoshi (Subaru Telescope/NAOJ), Kouichiro Nakanishi

We present the initial results of our ALMA Cycle 0 observations of six nearby luminous infrared galaxies at HCN(J=4-3), HCO+(4-3), and HNC (4-3) transition lines. Data of five sources have been delivered to us, and we found the following initial results. (1) HCN-to-HCO+ flux ratios tend to be higher in ultraluminous infrared galaxies (with and without obvious AGN signatures in infrared spectra) than a starburst-dominated galaxy with modest infrared luminosity. (2) In the nearest galaxy, rotating dense gas is detected, and the dense gas emission is the strongest at the position where active starbursts are present, reinforcing the scenario that stars are formed from dense molecular gas.

Starburst galaxies in the ALMA era

Pannella, Maurilio (CEA-Saclay), David Elbaz, Emanuele Daddi and the GOODS-Herschel collaboration

Using the deepest existing Herschel images of the GOODS-Herschel key project we now know that distant (U)LIRGs (luminous and ultra-luminous IR galaxies, $L_{IR} > 10^{11}$, 10^{12} $L_{\odot}$) are, contrary to the local ones, scaled-up versions of normal spirals with larger gas fractions. The finding of a tight correlation between

the star formation rate of galaxies and their stellar mass up to at least z∼3, suggests that ULIRGs at high redshift are mainly typical massive star forming galaxies where gas infall regulates star-formation. Hence IR luminosity is not an efficient criterion to identify extreme phases of star formation at high redshift, and to look for their physical origin. By mean of a stacking analysis of high-resolution UV restframe HST/ACS imaging for samples of galaxies on and off the Main Sequence in the SFR-M_* plane, I will present first results that point toward a discriminant role, at all cosmic times, of the IR surface brightness (star formation compactness) in differentiating between the diverse modes of star formation, i.e. quiescent (Main Sequence) versus starburst mode. ALMA will obviously be crucial in directly probing the morphology (and specifically the compactness) of star formation at high redshift. Our Cycle 1 program for a sample of Main Sequence and Starburst ULIRGs at z∼2 will provide us with a first in-depth look at this fundamental topic.

The state and mass of the molecular gas in starburst galaxies: observations and theory in the age of ALMA

Papadopoulos, Padelis (Cardiff University)

Far/UV and optical photons or something else warms the molecular gas in merger/starbursts? Can we at long last measure molecular gas mass in such galaxies with some confidence? Can we use the state of the dense gas in star-forming galaxies to infer their star-formation mode across cosmic epoch and even constrain their stellar IMF? Could some of the emergent new ISM physics be incorporated in current galaxy formation models and lend them some predictive power? Answers, more questions, and possible directions in the age of ALMA.

ALMA observations of a strongly star-forming merging system at z = 4.7

Stefano, Carniani (University of Florence), Alessandro Marconi

I will present ALMA observations of BR 1202-0725 at z=4.7, the first high redshift object observed during the Science Verification phase. BR 1202-0725 is a system composed of a sub-millimeter galaxy (SMG) and a quasar (QSO) at a projected distance of ∼24 kpc, experiencing very strong star formation. BR 1202-0725 is thus an ideal system to test the coevolution of black holes and their host galaxies for the contemporaneous presence of a SMG and a QSO which represent two distinct phases in galaxy evolution. I will present the kinematical analysis of the [CII] 150 μm emission line showing the presence of a rotating gas disks in both galaxies, which have allowed dynamical measurements of the host galaxy masses. I will discuss these results suggesting that strong star formation might be not only merger induced but also fueled by accretion of pristine gas and/or dynamical instabilities within the massive gaseous disks. I will also discuss the relation between BH and host galaxy mass in the case of the QSO, outlining ALMA potential in studying the cosmological evolution of BH-galaxy relations.

Chemical modelling of starburst galaxies

Viti, Serena (UCL)

In light of the importance of molecules as tools to disentangle the different gas components as well as the different energetics of a galaxy, I will present a latest suite of 1D and 3D PDR models as well as star forming gas chemical models and their applications to starburst galaxies.

With such models it is possible to investigate the geometry, the star formation rate, the ionization fraction and the chemical abundances in starbursts. In this talk I will present some preliminary results on the Antenna Galaxy and NGC1068.

2 Posters

Tracing the history of starbursts in LIRGs

Vaisanen, Petri (SAAO), Zara Randriamanakoto, Rajin Ramphul, Abiy Tekola, Alexei Kniazev, Andres Escala, Jari Kotilainen, Seppo Mattila, Stuart Ryder

We present the goals and a status update with recent results of an on-going program to study in detail the SF characteristics, stellar and super star cluster populations, metallicity gradients, as well as ISM inflow and outflow kinematics of a sample of 40 nearby LIRGs. Recent highlights include off-nuclear starbursts in multiple

mergers, extreme populations of super star clusters driving galaxy scale winds, and differentiated abundances in a blue compact galaxy.

Special Session Sp14

LOFT, the large observatory for X-ray timing

1 Oral contributions

GRB science with LOFT

Amati, Lorenzo (INAF - IASF Bologna), on behalf of the LOFT/GRB Working Group

Despite the huge advances occurred in the last 15 years, the GRB phenomenon is still far to be fully understood. LOFT, possibly in combination with other GRB experiments flying at the same epoch, will give us useful and unique clues to some of these still open issues. Indeed, the detection and characterization of the GRB X-ray prompt emission by the WFM, joined with 1 arcmin source location accuracy, a dedicated trigger logic / data modes and the capability of transmitting the GRB position to ground within 30s, will allow us to investigate the properties of the circum-burst environment, thus getting further clues on the nature of the progenitors, to provide stringent tests for the emission mechanisms at play, to increase the detection rate of high-z GRBs w/r, to shade light on the population of X-ray Flashes (XRFs) and sub-energetic events. While the GRB science with the WFM will come almost for free, the contribution from the LAD, consisting in the possible characterization of the X-ray afterglow emission up to 30 keV, will critically depend on the follow-up capabilities and policies of the mission.

Variability as a probe of the central engine in AGNs: the LOFT perspectives

De Rosa, Alessandra (INAF/IAPS)

The variability of Seyfert galaxies in the X-ray energy domain represents a powerful tool to probe the regions around the supermassive black hole on all scales. In particular, using tomography and reverberation of the Fe line, the accretion flow around the SMBH can be mapped in a number of ways, providing direct checks on the geometry of the innermost emitting and reprocessing regions. LOFT, with its extremely high throughput and CCD-class spectral resolution, will open a whole new domain of X-ray spectral-timing analysis. Thanks to its sensitivity and broad energy range (2-50 keV), LOFT will be able to determine with very high signal to noise and accurate continuum subtraction the profile the Fe K-lines in AGN and its variability in response to flares, revealing the orbital motion of individual blobs and finally providing BH mass and spin.

Status of the LOFT Mission

Feroci, Marco (INAF)

The Large Observatory For x-ray Timing (LOFT) mission concept is one of the 5 candidates for the third launch opportunity (M3, 2022-2024) as Medium Size mission of the ESA Cosmic Vision programme. LOFT is designed to exploit the diagnostics of very rapid X-ray flux and spectral variability that directly probe the motion of matter down to distances very close to black holes and neutron stars, as well as the physical state of ultradense matter. These prime science goals will be addressed by a payload composed of a Large Area Detector (LAD) and a Wide Field Monitor (WFM). The LAD is a collimated (<1 degree field of view) experiment operating in the energy range 2-50 keV, with a 10 m2 peak effective area and an energy resolution of 200-260 eV at 6 keV. The WFM will operate in the same energy range as the LAD, enabling a simultaneous monitoring of a 4-steradian wide field of view, with an angular resolution of <5 arcmin and energy resolution

of <350 eV (6 keV). For short transient events (e.g., GRBs) arcmin-localization is computed onboard and transmitted to the ground within 30 seconds after the trigger time. The LAD and WFM experiments will allow to investigate variability from submillisecond QPO's to years long transient

outbursts. The mission is currently completing a nearly 3-year long phase A study. In this paper I will report the current status of the project and the current baseline mission design.

Using LOFT to uncover the QPO mechanism in X-ray binaries

Ingram, Adam (Anton Pannekoek Institute), Chris Done

Low frequency quasi-periodic oscillations (QPOs) seen in many black hole and neutron star binaries have the potential to be very powerful diagnostics of the inner accretion flow. However, this potential cannot be realised without a quantitative model for the QPO. It has recently been shown that the same truncated disc/hot inner flow geometry which is used to interpret the spectral transitions can also directly produce the QPO from Lense-Thirring precession of the hot inner flow. This model gives a unique prediction in its iron line signature: a tilted flow illuminates different azimuths of the disc as it precesses. The iron line arising from this rotating illumination is blue shifted when the flow irradiates the approaching region of the spinning disc and red shifted when the flow irradiates the receding region of the disc. This gives rise to a characteristic rocking of the iron line on the QPO frequency which is a necessary and sufficient test of a precession origin. I show that LOFT will allow us to measure this effect with precision, thus providing definitive evidence for (or against) the Lense-Thirring model. I also show how strong field effects such as light bending will effect this signature as observed by LOFT.

Discovery of New Accreting Millisecond Pulsars with LOFT

Patruno, Alessandro (Astronomical Institute A. Pannekoek, University of Amsterdam)

The rapid rotation of millisecond pulsars can help to constrain the equation of state of ultra-dense matter provided that the neutron star overtakes a spin frequency of about 1000 Hz. However, the fastest spinning millisecond pulsar found so far rotates at about 700 Hz which is way too slow to place meaningful constraints on the neutron star EoS. There is an emerging observational evidence, supported by new numerical calculations, that the fastest spinning neutron stars are accreting millisecond pulsars which are still accreting from a low mass companion star. Unfortunately, only a few systems of this kind have been discovered so far. Which are the prospects for the detection of many new systems of this kind with LOFT and how likely will it be to discovery the first sub-ms accreting pulsar ?

Modeling pulse profiles of accreting millisecond pulsars and X-ray bursts

Poutanen, Juri (University of Oulu)

I will review the techniques to model pulse profiles accreting millisecond pulsars and X-ray bursts. I will also report on the exercise the LOFT Dense Matter Working Group has performed on comparison of various codes. LOFT's abilities to measure neutron star masses and radii from the pulse shapes will be reviewed.

Constraining the physics of acceleration and radiation processes in the relativistic jets of Blazars with LOFT

Tramacere, Andrea (ISDC Data Centre for Astrophysics and Astrononomical Observatory of the University of Geneva), Imma donnarumma, Sara Turriziani, Luigi Costamante

Among blazars, High Energy Peaked BL Lac objects (HBLs) are the most efficient accelerators, showing the fastest variability. The X-ray band plays a crucial role, sampling the synchrotron emission by the freshly accelerated and rapidly cooling highest-energy electrons responsible also for the inverse Compton emission in the TeV band. With its unprecedented effective area (10 m^2), and its broad spectral window (2-30 keV), the LOFT Large Area Detector (LAD) will allow to study the X-ray spectral shape of HBLs above 10 keV with a high spectral accuracy and integration times below the typical variability time scales. This will provide a unique tool to disentangle acceleration dominated states, from states at the equilibrium, giving solid constraints on the

competition between acceleration and cooling, and on the stochastic component of the acceleration mechanism. Flaring episodes from these objects can easily be revealed by the Wide Field Monitor (WFM), and used to trigger pointed observations with the LAD, that, thanks to its unprecedented timing capability, will allow to detect (if present) the X-ray counterpart of the very fast TeV variability, shedding light on the nature of X-TeV connection. Moreover, the possibility to extract X-ray light curves above 10 keV, with a temporal sampling comparable to that at TeV energies, will show if the X-TeV correlation is compatible with the predictions from homogeneous one-zone models, or if more complex scenarios are needed.

Mapping the extreme: X-ray reverberation with LOFT

Uttley, Phil (University of Amsterdam)

The high time-resolution and high-throughput offered by LOFT will allow us to measure energy-dependent time delays in X-ray binaries down to the sub-microsecond level. Combined with the CCD spectral-resolution offered by the revolutionary LAD detectors, this unprecedented capability will allow us to use the light-travel time echoes in these systems to 'reverberation map' the regions with the strongest space-time curvature and strongest magnetic fields in the universe. I will show how X-ray reverberation measurements of X-ray binary systems with LOFT will enable us to map the innermost structure of accretion flows, observe directly the light-bending effects of strong-gravity, measure black hole masses and spins and constrain the neutron star equation of state.

Overview of the LOFT Science

van der Klis, Michiel (University of Amsterdam), on behalf of the LOFT Consortium

The LOFT science case focuses on a number of key science objectives in the areas of dense matter and strong field gravity to be attained using supermassive and stellar mass black holes (BH) and neutron stars (NS). These proposed investigations are ambitious and lead to quantifiable mission requirements as they are all based on proven phenomenology: thermonuclear and accretion driven pulsations and seismics of NS, broad iron lines from the relativistic plasma flows near compact objects and quasi-periodic fluctuations at the relativistic orbital, epicyclic and precession frequencies of these same flows. The mission requirements flowing down from these objectives: solid-state quality spectral resolution (200-260 eV over 2-30 keV) at a throughput well over an order of magnitude higher than any previous mission (10 m^2 of effective area) allow to measure NS masses and radii to the accuracy required to constrain the equation of state of supranuclear density matter, and to observe the predicted signatures of strong field gravity in the motions of matter close to BH and NS. These same requirements enable a much wider range of investigations on a wide range of other types of objects, on other aspects of BH and NS physics, and even on other aspects of dense matter and strong gravity less easily quantified. They also open up an enormous discovery space that will no doubt open up new avenues for high energy astrophysics that can be suspected, but not now foreseen.

Tidal disruptions at hard X-rays and LOFT forecasts

Walter, Roland (ISDC), Marek Nikolajuk

Two tidal disruption events have been detected at hard X-ray in early 2011. The disruption of a star, detectd by Swift, generated a jet and strong Doppler boosted emission. The disruption of a super-Jupiter, detected by INTEGRAL, followed the expectrations from hydrodynamical simualtions. LOFT will provide the all-sky monitoring necessary to detect such events and the enormous effective area necessary to probe the flow of matter passing through the last stable orbit. LOFT can constrain both the masses of the disrupted objects and the masses of usually quiet massive black-holes.

LOFT and the neutron star equation of state

Watts, Anna (University of Amsterdam)

One of LOFT's primary science goals is to constrain the neutron star equation of state by measuring mass and radius to within a few percent. LOFT will employ three main techniques to achieve this goal.

The first involves pulse profile modelling of burst oscillations (brightness asymmetries that develop during thermonuclear bursts on the surfaces of accreting neutron stars). As photons propagate out of the deep potential well, relativistic effects encode information about mass and radius in the shape of the resulting pulsations. The second technique is to search for extremely rapidly rotating neutron stars, to exploit constraints

resulting from break-up limits. Accreting neutron stars are prime candidates for rapid rotation due to accretion-induced spin-up, but such stars may only be weak or intermittent accretion-powered pulsars due to fluctuations in the magnetic channeling process. LOFT will enable highly sensitive searches for pulsations from the many accreting neutron stars whose spin rates are not yet known. The third technique is to search for quasi-periodic oscillations associated with global seismic vibrations triggered by magnetic explosions on magnetars. Oscillations detected in giant flares from these sources have opened up the field of neutron star asteroseismology, but these large events are extremely rare and attempts to use the vibrational frequencies to constrain the dense matter equation of state have been hampered by the limited dataset. LOFT will be sensitive to oscillations in the more frequent intermediate flares.

I will give an overview of how X-ray timing techniques can be used to constrain the dense matter equation of state and discuss the results expected from LOFT over its mission lifetime. I will also illustrate how LOFT will complement both laboratory-based experiments and other astronomical investigations of the neutron star equation of state.

2 Posters

Timing and spectral characteristics of Dwarf Novae with LOFT

Balman, Solen (Middle East Technical University)

I will present some expected spectra from LAD and/or WFM of selected Dwarf novae during outburst and quiescence comparing novae with different types. In addition, plausible study of timing features QPOs and band limited noise expectations will be discussed.

Special Meeting SM4

ASTRONET Meeting

1 Posters

Liverpool Telescope 2

Bode, Michael (Liverpool John Moores University), Chris Copperwheat

The Liverpool Telescope is a fully automated 2m robotic telescope owned and operated by Liverpool John Moores University and based on La Palma. We are currently conducting a feasibility study for 'Liverpool Telescope 2': a 4m class successor telescope which will come into operation at the beginning of the next decade. This new facility will be dedicated to time domain astrophysics, with a particular emphasis on transient science. As we enter the era of synoptic surveys there is a high demand for follow-up spectroscopy of a transient Universe we are finding to be increasingly diverse, and this demand will only increase with the advent of the larger surveys such as LSST and Pan-STARRS 4. The flexibility of a dedicated robotic telescope makes it ideal for this science programme. Robotic telescopes are particularly powerful tools for the follow-up of rapidly fading transients, such as the counterparts of Gamma-ray bursts. Our concept for Liverpool Telescope 2 is that it will be an agile, lightweight and fast-slewing facility with a world-leading response time, to catch such transients even closer to the explosion. This capability could also allow us to identify and study more exotic sources, such as the electromagnetic counterparts of aLIGO detections.

The Observatorio Astrofísico de Javalambre (I): a New Astronomical Facility for Large Sky Surveys

Cenarro, A. Javier (CEFCA), the J-PAS collaboration

The Observatorio Astrofísico de Javalambre (OAJ) is a new astronomical facility at the Sierra de Javalambre, in Teruel, Spain. The site, at 2000 m altitude, has superb astronomical characteristics in terms of median seeing (0.71" in V band), fraction of clear nights and darkness, with no noticeable man-made light contamination, a feature quite exceptional in continental Europe. From its inception, the purpose of the OAJ is to carry out large sky multi-filter surveys with robotic telescopes, being equipped with two unique telescopes of unusually large fields of view and their corresponding panoramic instrumentation. First OAJ operations started in 2012 and the whole infrastructures are expected to be completed along 2013.

The Observatorio Astrofísico de Javalambre (II): The Javalambre Survey Telescope and J-PAS

Cenarro, A. Javier (CEFCA), the J-PAS collaboration

The centerpiece of the Observatorio Astrofísico de Javalambre (OAJ) is the Javalambre Survey Telescope (JST) an innovative Ritchey-Chrétien, alt-azimuthal, large-etendue telescope with an aperture of 2.55 m and 3 deg (diameter) field of view. The JST will host a unique panoramic camera at the cassegrain focus, JPCam, with a mosaic of 14 large-format (9.2k x 9.2k) CCDs that covers 5 deg^2. Therefore, the dedicated JST and JPCam, with an effective etendue of 26.5 $\mathrm{m}^2\,\mathrm{deg}^2$, will be amongst the most powerful telescope/instrument combinations for all kind of astrophysical surveys until the arrival of the 8.1m LSST, expected in 2022. The scientific cornerstone of the OAJ is the Javalambre-PAU Astrophysical Survey (J-PAS), a project that will image 8500 deg^2 with JST and JPCam. The survey is optimized to measure the radial scale of the Baryonic Acoustic Oscillations using a carefully selected set of narrow-band filters. Scheduled to start in 2015, J-PAS will use 54 contiguous filters with 145 Åwidth (but spaced about 100 Åapart) in the range 3700–9100 Å, plus 5 broad band filters, and will reach a 5σ, 3 arcsec aperture magnitude depth of AB=22.5-23.5, depending on the

wavelength. J-PAS will provide a low-resolution (R∼50) spectrum for every pixel of the sky, what promises important breakthroughs in many areas of Astrophysics.

The Observatorio Astrofísico de Javalambre (III): The Javalambre Auxiliary Survey Telescope and J-PLUS

Cenarro, A. Javier (CEFCA), the J-PAS collaboration

Also at the Observatorio Astrofísico de Javalambre (OAJ), the Javalambre Auxiliary Survey Telescope (JAST) is a Ritchey-Crétien, german-equatorial telescope of 83 cm primary mirror with a field of view (FoV) of 2 deg. JAST will be primarily equipped with a large format camera, T80Cam, which includes a low-noise 10.5kx10.5k CCD providing a useful FoV of 2deg^2. Starting in 2013, the Javalambre Photometric Local Universe Survey (J-PLUS) will cover with T80Cam the same sky area of J-PAS, using 12 filters in the optical range. The J-PLUS filter set is particularly defined to carry out the photometric calibrations for J-PAS, including 4 Sloan filters (g,r,i,z), 6 filters of 200-400 Åwidth, centered on key absorption features for stellar classification and stellar population studies, and 2 narrow-band filters in common with the J-PAS filter set which cover the [OII]/λ3727 and Hα/λ6563 lines. Both the filter definition and the survey strategy allow J-PLUS to conduct a wide range of challenging scientific programmes.

The OPTICON Common TAC for Transnational Access to Medium Sized Telescopes.

Davies, John (UKATC), Rene Oudmaijer (University of Leeds),

Since semester 2010B the EU-FP7 OPTICON project has allocated EU funded observing time on a suite of European operated 2-4m telescopes via a single time allocation committee.This has provided a prototype for a Europe-wide telescope network should the operating agencies wish to co-ordinate their observatories in this way. We will summarise the TAC methodology, indicate some lessons learned and present statistics on the number, nationality and success rates of the various user communities.

Observations of NEOs as a task for small and medium-sized telescopes

Godunova, Vira (ICAMER Observatory)

In consideration of the importance of finding and studying of Earth-approaching objects, which can represent an impact hazard to our planet, one of the priorities of ground-based astronomy must be assigned for discovery and monitoring of these objects. Many advances in this field come from the development and use of specific instruments and techniques. Small- and medium-aperture telescopes, equipped with additional tools and sensitive CCD cameras, still are able to provide good enough opportunities for long-term astrometric, photometric, polarimetric, and other observations. By way of illustration, the decades of successful research at the Terskol Observatory have yielded new data and findings in this field. The telescopes Zeiss-2000 and Zeiss-600 have been heavily used for follow-up astrometry and spectroscopy of Earth-approaching asteroids and comets. A special attention is given to the taxonomic classification of potentially hazardous asteroids because in most cases their physical properties are previously unknown. In this paper, the observational programmes, which can be run on small and medium-sized ground-based telescopes, will be discussed.

Europlanet – Coordinating Europe's Planetary Science Community towards Horizon2020 and Beyond

Gritsevich, Maria (FGI; Europlanet), Anita Heward (Europlanet, europlanet-eu.org), Steve Miller (UCL; Europlanet, s.miller@ucl.ac.uk)

Since 2005, the Europlanet project has provided European's planetary science community with a platform to exchange ideas and personnel, share research tools, data and facilities, define key science goals for the future and engage stakeholders, policy makers and European Citizens with planetary science. Its annual meeting, the European Planetary Science Congress (2013), has developed into the major meeting in Europe for planetary science, attracting researchers and representatives of industry and space agencies from around the world. Europlanet has been supported by the European Union as a Coordination Action under Framework 6 and a Research Infrastructure in Framework 7. Since January 2013, Europlanet has begun a new phase, evolving into a voluntary organisation of planetary institutes and laboratories linked by a Memorandum of

Understanding. Europlanet continues to be active in raising the profile, the efficiency and the productivity of European planetary science. EPSC 2013, which will take place at University College London in September, should be the largest meeting to date. In the build-up to Horizon 2020, Europlanet is bridging a crucial gap between a series of enormously productive missions, and new and exciting challenges for Europe's planetary scientists. These strategic aims should feed into the wider context of ASTRONET's Science Vision and Infrastructure Roadmap.

Strategic projection of the Calar Alto Observatory.

Jesus, Aceituno (Centro Astronomico Hispano Aleman A.I.E), D. Barrado, D. Galadi, S. Pedraz

Strategic projection of the Calar Alto Observatory.

Integration of the Byurakan Astrophysical Observatory (BAO) in the European astronomy

Mickaelian, Areg (Byurakan Astrophysical Observatory (BAO), Armenia)

Armenian astronomers are rather integrated in the international and European astronomical communities. There are 17 IAU members and 18 EAS members from Armenia. The Armenian Astronomical Society (ArAS) is one of the 25 EAS affiliated members. The Armenian Virtual Observatory (ArVO) is a member of the International Virtual Observatory Alliance (IVOA). Recently Armenia also joined the UN COPUOS (Committee for Peaceful Uses of the Outer Space) and is going to establish Armenian Space Agency (ArSA). The International Centre for Relativistic Astrophysics Network (ICRANet) has recently started works for establishment of its regional office in Armenia. We have started a series of the Byurakan International Summer Schools (BISS) for regional and European students with involvement of a number of European lecturers. Already 4 such events have been organized in 2006, 2008, 2010 and 2012. Viktor Ambartsumian International Prize is one of the important international astronomy awards. Based on all these, Armenia is going to establish an IAU Regional Office for Astronomy Development (ROAD) in frame of the IAU Strategic plan 2011-2020. ASTRONET is a part of decadal planning, particularly for Europe. As the Armenian astronomy is tightly connected to the European one, we are going to participate in all ASTRONET activities. The BAO largest 2.6m telescope may serve as part of the European telescopes community, particularly in frame of OPTICON. Some other possible modern usage of BAO-2.6m: 1) Specific programs related to objects discovered in BAO, 2) Feeding of a larger (8-10m) telescope (test observations before accomplishment of the project on a larger telescope), 3) Using its geographical location (longitude), where very few medium-size and big telescopes are present (e.g. for afterglows of gamma-ray bursts or tracking asteroids, etc.), 4) Given that Byurakan is a very dry site, IR receivers may be rather efficient and BAO-2.6m may be used for MIR astronomy. Thus, Armenian astronomy

Peculiarities of sources with low-frequency steepness radio spectrum

Miroshnichenko, Alla (Institute of Radio Astronomy of the NAS of Ukraine)

We present the analysis of the physical parameters of the galaxies, quasars and optically unidentified objects with low-frequency steepness radio spectrum at the decameter band.

Telescopes and Instrumentation at Calar Alto observatory

Montoya, Luz María (CAHA), et al.

We present the diversity of astronomical instrumentation and telecope facilities available at Calar Alto observatory. TBC

Usage of world-wide facilities in transient observations

Roy, Rupak (Aryabhatta Research Institute of observational sciencES (ARIES), Nainital, India)

Astronomy is no more a subject which can be flourished at the backyard as a leisure. Few organizations like ASTRONET, COSPAR, IAU are actively engaged to fascinate the younger generation in this field of science.

This in effect is creating new opportunities for the newcomers to pursue the same as their carrier. Similar work, but over a relatively small scale is also being carried out by the communities like AAS and ASI. New researches in Astronomy and Astrophysics are revealing the universe is a great detail. Use of cutting-edge technologies along with data-sharing now became the prime-key to produce the leading scientific outputs. This is at least well accepted for transient-research. In this contribution I will highlight the research-works on transients like Supernovae and GRBs over last fifteen years in India where astronomers from different parts of the world joined-together and came-up with exciting results.

Trajectory and orbital parameters estimation for Chelyabinsk Bolide

Vinnikov, Vladimir (Moscow Aviation Institute), Gritsevich Maria

This article is concerned with estimation of trajectory and orbital parameters of Chelyabinsk bolide. This body entered Earth atmosphere on 15-th February of 2013. Bright bolide and it's trail were detected by multiple various recorders ground based, airborne and spaceborne. Obtained observations were sufficient for analysis and estimation of bolide trajectory including entry coordinates and velocity vector, with consequent reconstruction of possible orbits of this object. In contrast to reconstructions, independently carried out by other research groups, our investigation was accented on computing meteoroid dynamics from the required minimum of observational data. This approach to reconstruction is justified, since scientific community can't always rely on very lucky events, such as satellite photo coverage of bolide [1], observations at zenith vantage points and clear weather, allowing to rebuild trajectory from movements of distinct shadows [2]. We discuss the significance of major errors originating from optical distortions of the recording devices, resulting in perturbed directions in triangulation and the scale of smaller errors introduced by the atmosphere itself. It's undisputable that each footage from additional geographical location increase the overall precision of resulting estimation, but, due to the nature of errors and the least squares technique itself the improvements are quite limited. Bibliography 1. http :// cimss . ssec . wisc . edu / goes / blog / archives /12356 2. Zuluaga, J.I. and Ferrin, I., "A preliminary reconstruction of the orbit of the Chelyabinsk Meteoroid.", ArXiv e-prints, arxiv:1302.5377 February 2013.

Special Meeting SM5

GREAT Meeting

1 Oral contributions

Conference Report: First Results from the Gaia-ESO Survey, Nice, F, Apr 2013

Bonifacio, Piercarlo (Obs Paris, Paris, F)

See conference website.

School Announcement: The Galaxy, Stellar Composition and Dynamics, Tenerife, Sep 2013, IAC, Tenerife, E, Sep 2012

Garzon Lopez, Francisco (IAC, La Laguna, E)

See school website.

School Report: The Art of the Observational Campaigns, IAC, Tenerife, E, Sep 2012

Garzon Lopez, Francisco (IAC, La Laguna, E)

See school website.

Workshop Report: Stellar analyses in the Gaia-ESO Survey: towards the first Data Release, AIP, Potsdam, D, Sep 2012

Korn, Andreas (Upsalla, S)

See workshop website.

School Report: GREAT Astrostatistics School, Alicante, Jun 2013

Sarro, Luis Manuel (UNED, E)

See school website.

Workshop Report: Gaia and Exoplanets: GREAT Synergies on the Horizon, Nov 2012, Torino, Italy

Sozzetti, Alessandro (Upsalla, S)

See workshop website.

Welcome and GREAT Programme News

Walton, Nicholas (Institute of Astronomy, University of Cambridge, UK)

Status update for the GREAT ITN and ESF programmes

2 Posters

Structure of the second Galactic quadrant based on homogeneous distances of O and B type stars

Kaltcheva, Nadia (University of Wisconsin Oshkosh), Valeri Golev/St Kliment Ohridski University of Sofia

Intermediate-band uvby-beta photometry is used to derive precise homogeneous photometric distances for a large sample of OB-associations and young open clusters. The implication of various calibrations in terms of fundamental stellar parameters on the overall delineation of the spiral structure in the second Galactic quadrant is discussed.

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