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Era of great walls: dark side shaping the Sloan Great Wall

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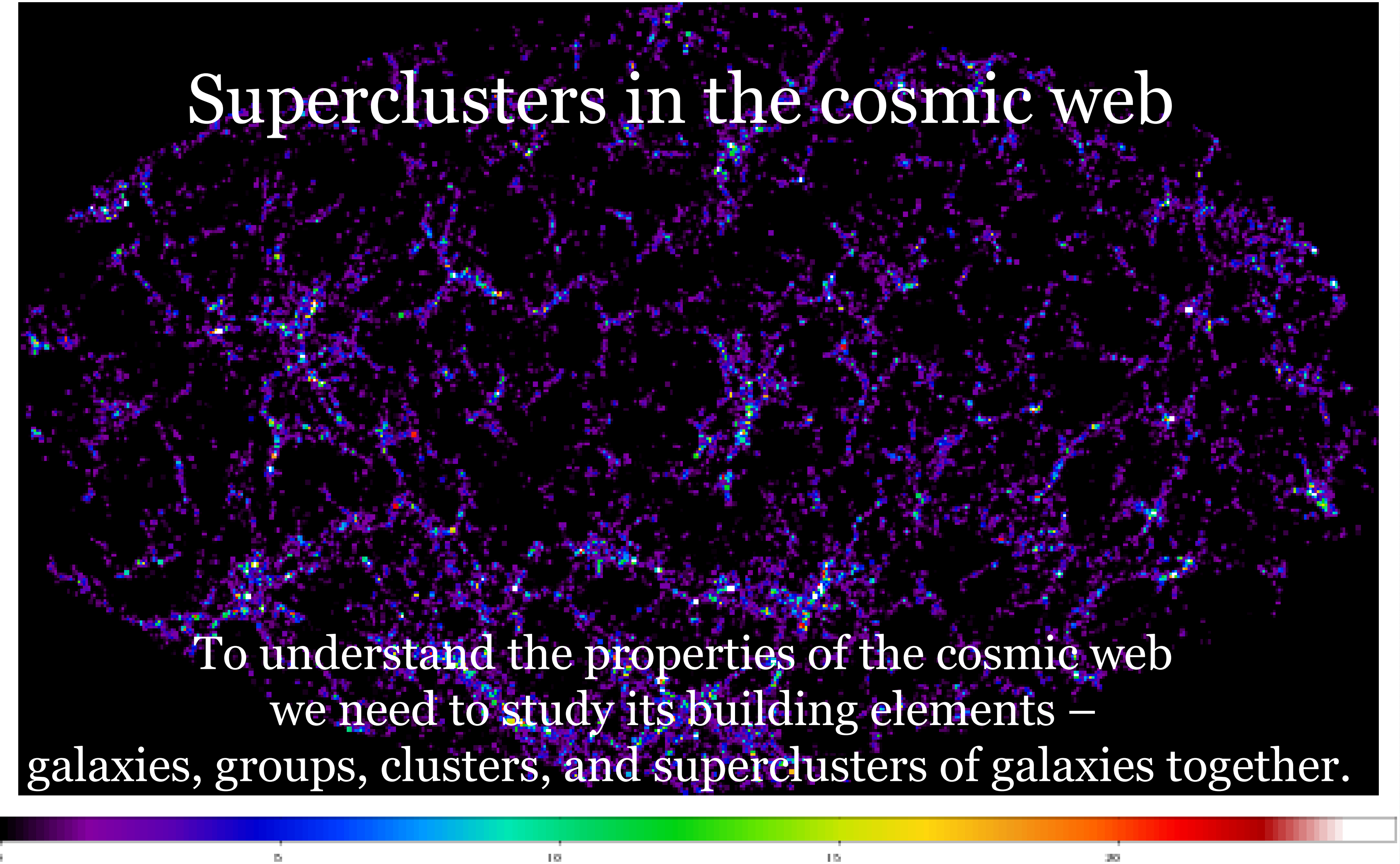
Superclusters in the cosmic web

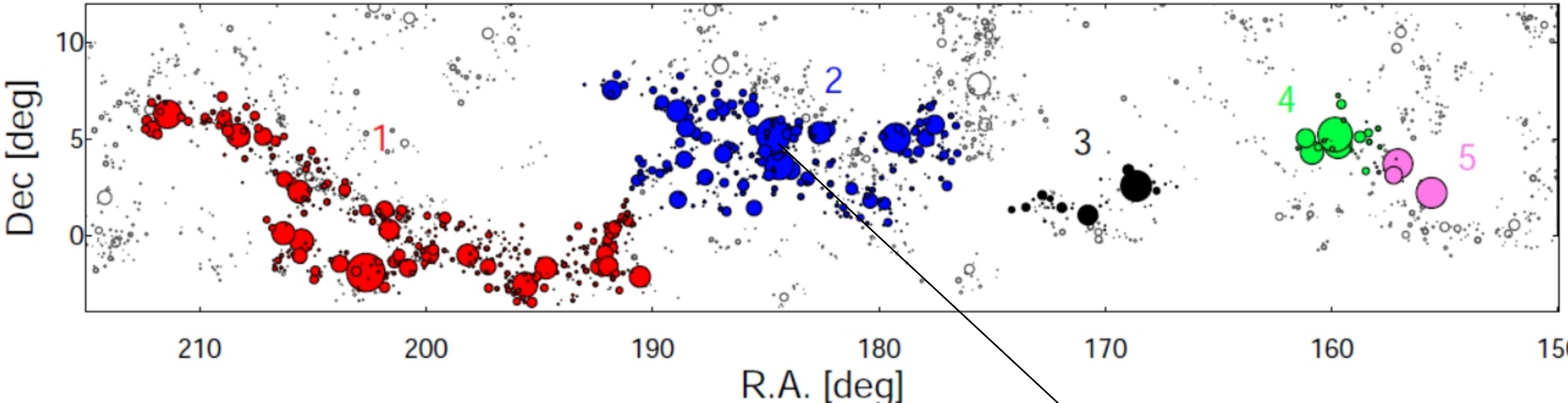


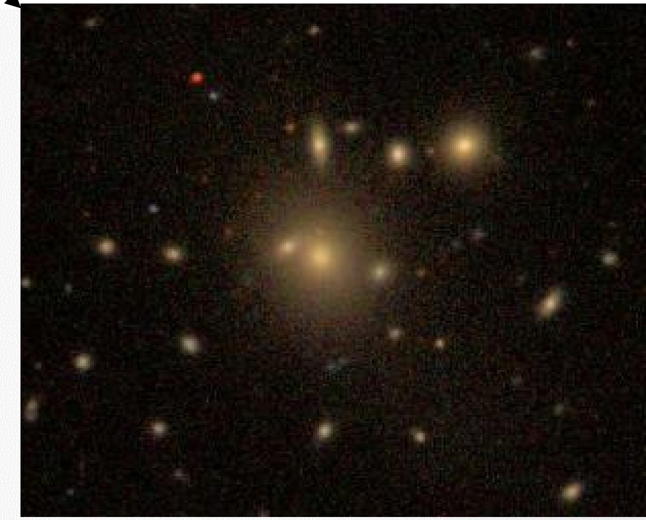
To understand the properties of the cosmic web
we need to study its building elements –
galaxies, groups, clusters, and superclusters of galaxies together.

Galaxy superclusters or their high-density cores – the largest objects in the dark matter and dark energy dominated Universe which may be collapsing now or in the future.

The study of the structure and dynamical state of galaxy superclusters gives us information about the largest possibly bound structures which helps to understand the evolution of the structure of the Universe at large scales, and the evolution of galaxies, galaxy groups, and filaments in dynamically active environment of collapsing supercluster.

The Sloan Great Wall





Vogeley et al. (2004), Gott et al. (2005)

see also Einasto et al. 2003, 2008, 2010, 2011, 2014

Park et al. (2012)

Sheth and Diaferio (2011)

Aims:

We determine the mass of the SGW superclusters;

Analyse the structure of the SGW superclusters and find their high-density cores;

Study the mass distribution in the core regions and compare it with the predictions of the spherical collapse model, to find whether the core regions of superclusters may be collapsing.

We need:

Data on superclusters and on galaxies, groups and filaments in them

Group masses, stellar masses of galaxies

Data:

Supercluster catalogue:

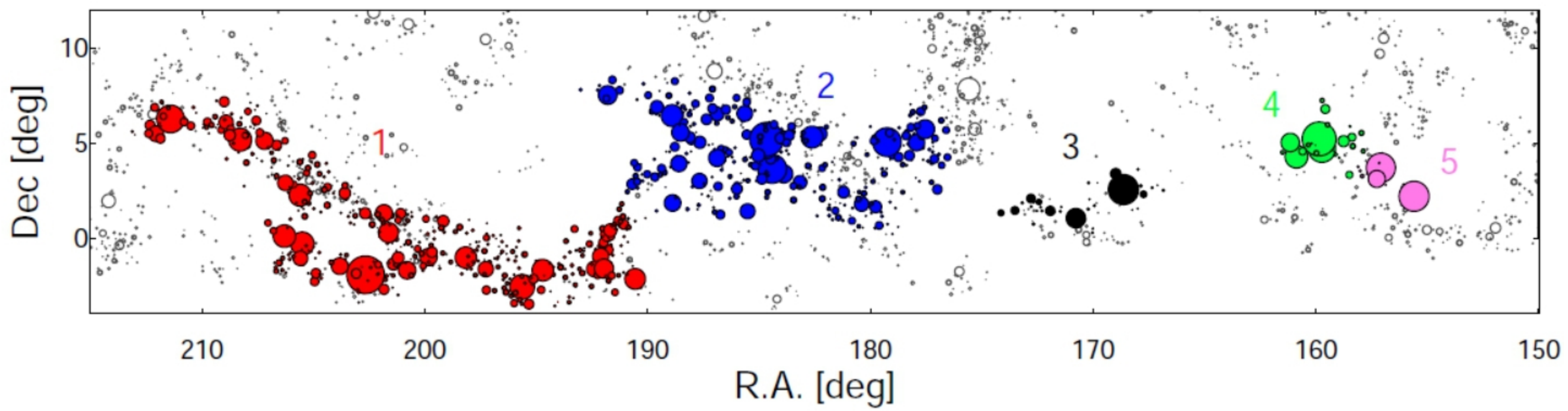
Liivamägi et al., 2012, A&A 539, A80

Group catalogue (with data on group masses and list of member galaxies):

Tempel et al. 2014, A&A 566, A1

Stellar masses of galaxies: SDSS database

The Sloan Great Wall superclusters



(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
No.	Name	ID	N_{gal}	N_1	N^{gr}_{2-9}	N^{gr}_{10}	Dist.	Diam.	$D8_{max}$	Vol.	L_{tot}
1	SCl 027	202-001+008	3222	706	381	50	255.6	107.0	14.0	25.9	51.6
2	SCl 019	184+003+007	2060	456	274	33	230.4	56.4	15.0	14.4	29.2
3	SCl 0499	168+002+007	408	60	26	7	227.7	34.1	7.5	2.0	4.77
4	SCl 0319	159+004+006	245	30	23	3	206.2	21.4	7.5	1.4	2.16
5	SCl 1109	157+003+007	120	4	5	3	219.2	12.1	5.2	0.2	1.49
	SGW		6055	1256	709	96				43.9	89.22

The Sloan Great Wall superclusters: masses

(1) No.	(2) Name	(3) M_{dyn} $10^{15}h^{-1}M_\odot$	(4) M^g_{tot} $10^{15}h^{-1}M_\odot$	(5) M^* $10^{13}h^{-1}M_\odot$	(6) M^*/M^g_{tot}	(7) M^*_{tot} $10^{15}h^{-1}M_\odot$	(8) M^{*g}_{tot} $10^{15}h^{-1}M_\odot$	(9) M^g_{tot}/L $h\,M_\odot/L_\odot$
1	SCl 027	10.41	14.00	16.61	0.012	11.13	12.24	271
2	SCl 019	5.42	7.03	9.09	0.013	6.41	7.05	241
3	SCl 0499	1.41	1.74	1.69	0.010	1.15	1.27	365
4	SCl 0319	0.66	0.82	0.87	0.011	0.76	0.84	380
5	SCl 1109	0.56	0.63	0.69	0.011	0.29	0.32	423
	SGW	18.46	24.22	28.95	0.012	19.74	21.71	272

M_{dyn} = sum of group masses from Tempel et al. 2014

$M^g_{tot} = M_{dyn} + M_{faint\ groups} + M_{ICM}$

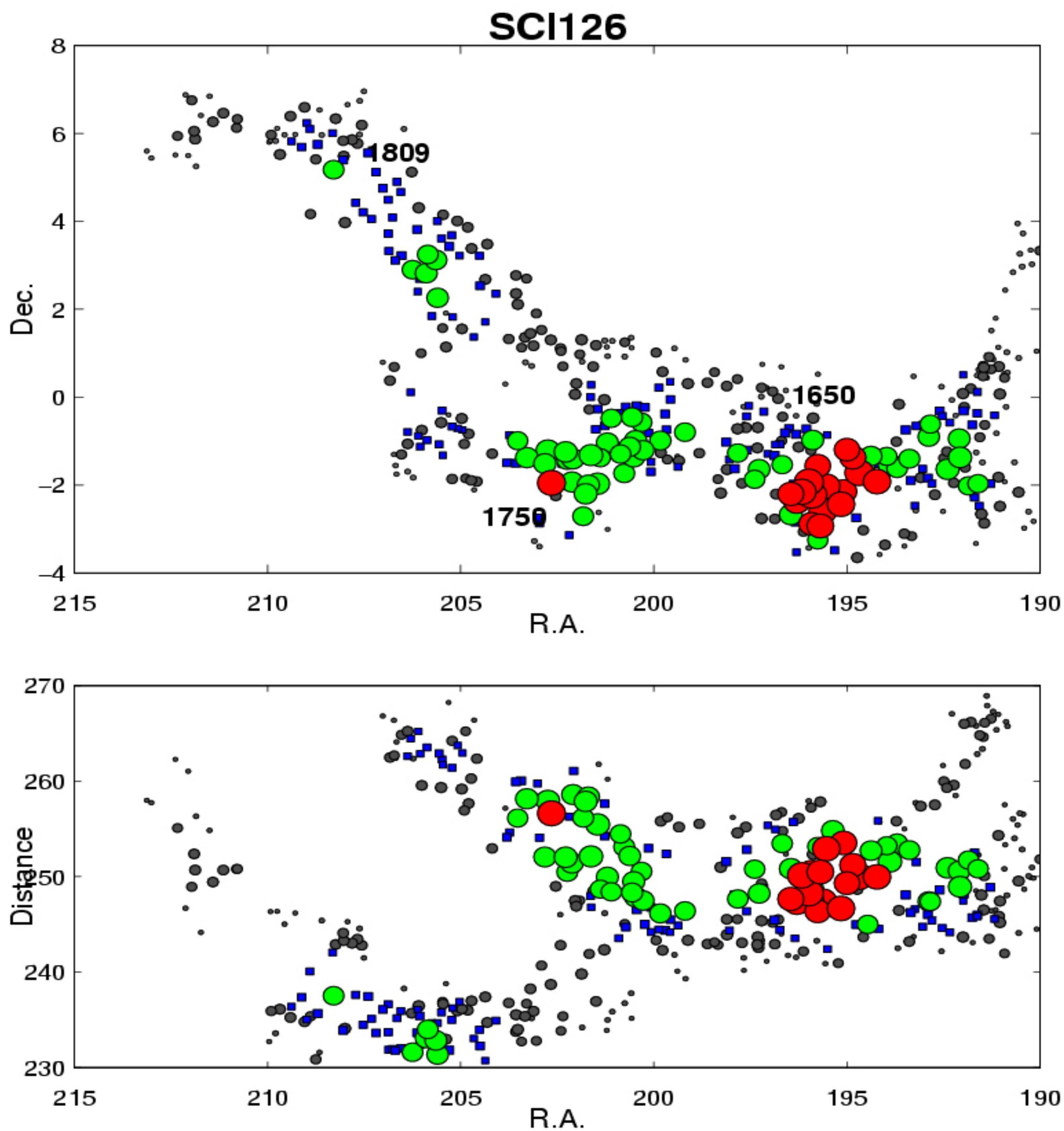
M^* = sum of stellar masses of galaxies

M^* / M^g_{tot} stellar mass fraction

M^*_{tot} = sum of halo masses from stellar masses of galaxies (Moster et al. 2010)

$M^{*g}_{tot} = M^*_{tot} + M_{ICM}$

SCl 027


SCl126
8
6
4
2
0
−2
−4
Dec.
1809
1650
1750
215
210
205
200
195
190
R.A.
270
260
250
240
230
Distance
215
210
205
200
195
190
R.A.

Structure of superclusters – normal mixture modelling

We search for components in superclusters.
Input data:
coordinates and distances of galaxy groups and
single galaxies (faint groups) in superclusters

Mclust package in R statistical environment

Component number for each group and single galaxy
Centre coordinates, size, mass, extent, mean luminosity
density for each component etc.

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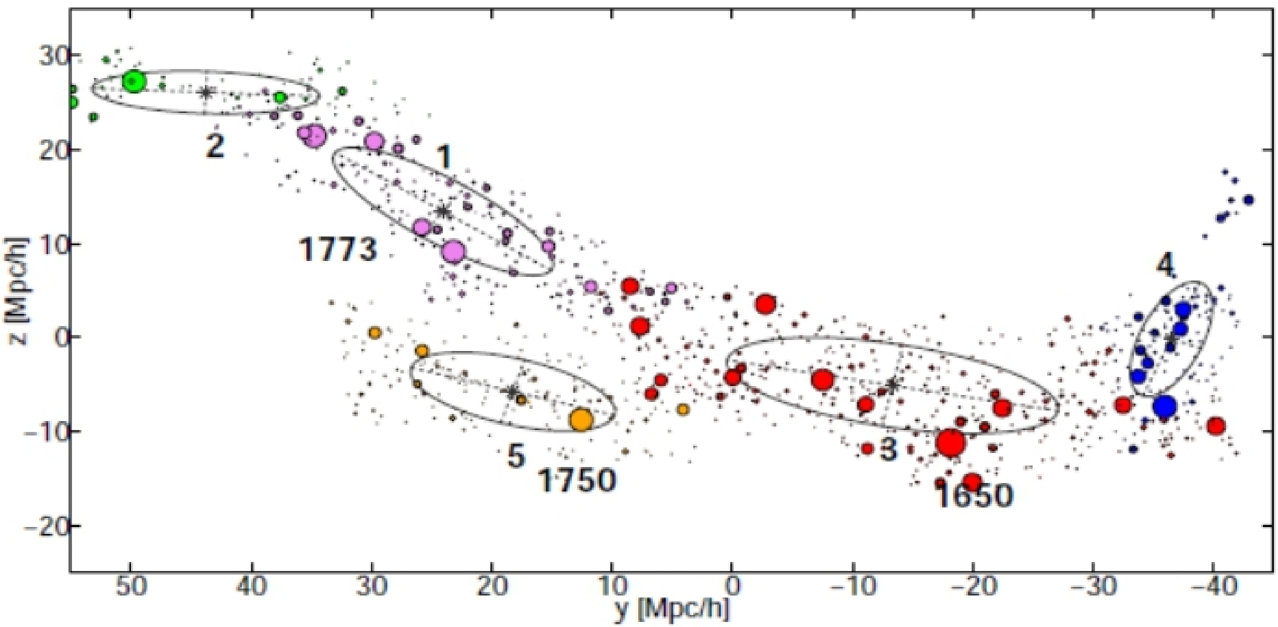

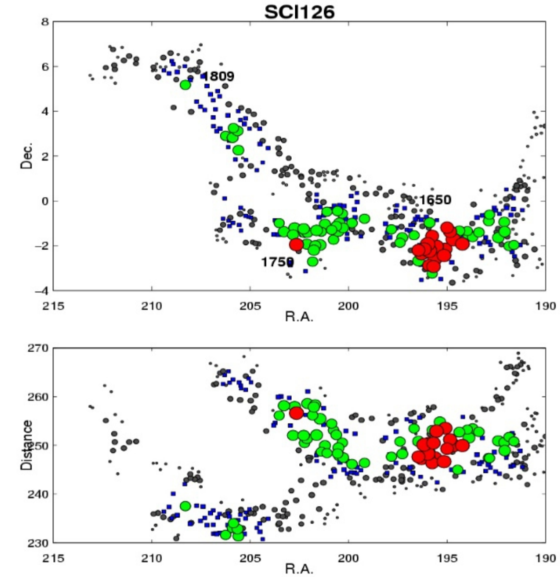

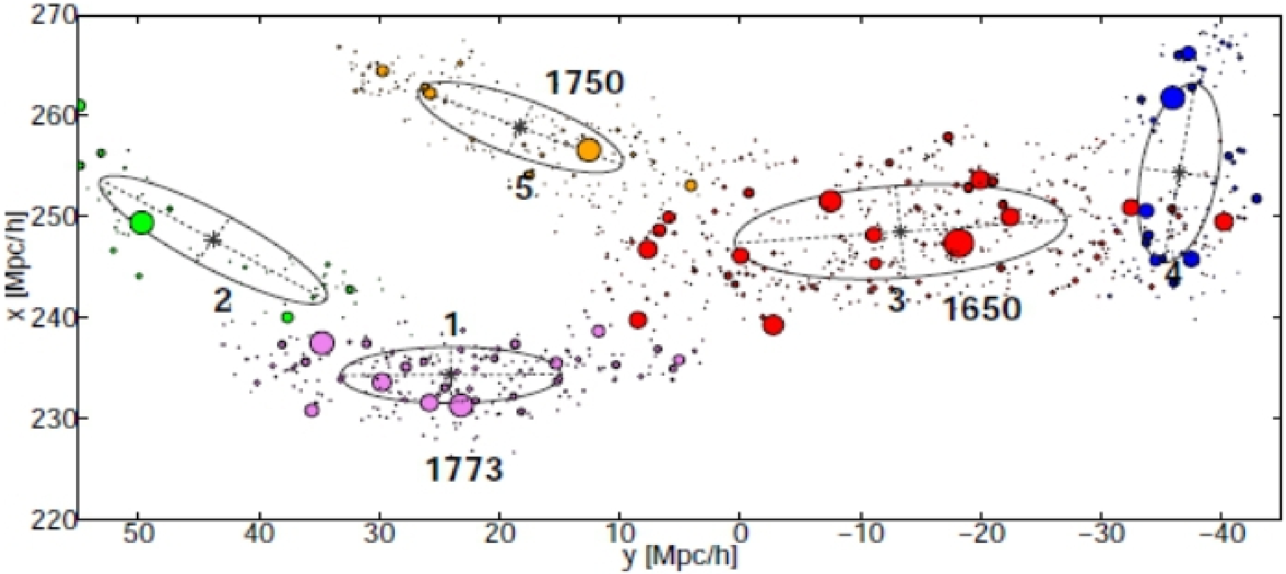

SCl 027 components: high-density cores (A1650, A1750, A1773), outskirts regions

Spherical collapse model

The spherical collapse model describes the evolution of spherically symmetric perturbation in an expanding universe under influence of the gravitational attraction (dark matter), and antigravity of the dark energy.

1. Turnaround: the collapse begins, $\Delta\rho = 13.1$
2. Future collapse: collapse in the distant future, $\Delta\rho = 8.73$

Mass of the structure:

$$M(R) = 1.45 \cdot 10^{14}\ \Omega_m\ \Delta\rho\ (R/\ 5\ h^{-1}\,\mathrm{Mpc})^3\ h^{-1}\,M_\odot$$

Gramann et al. 2015, Enn Saar

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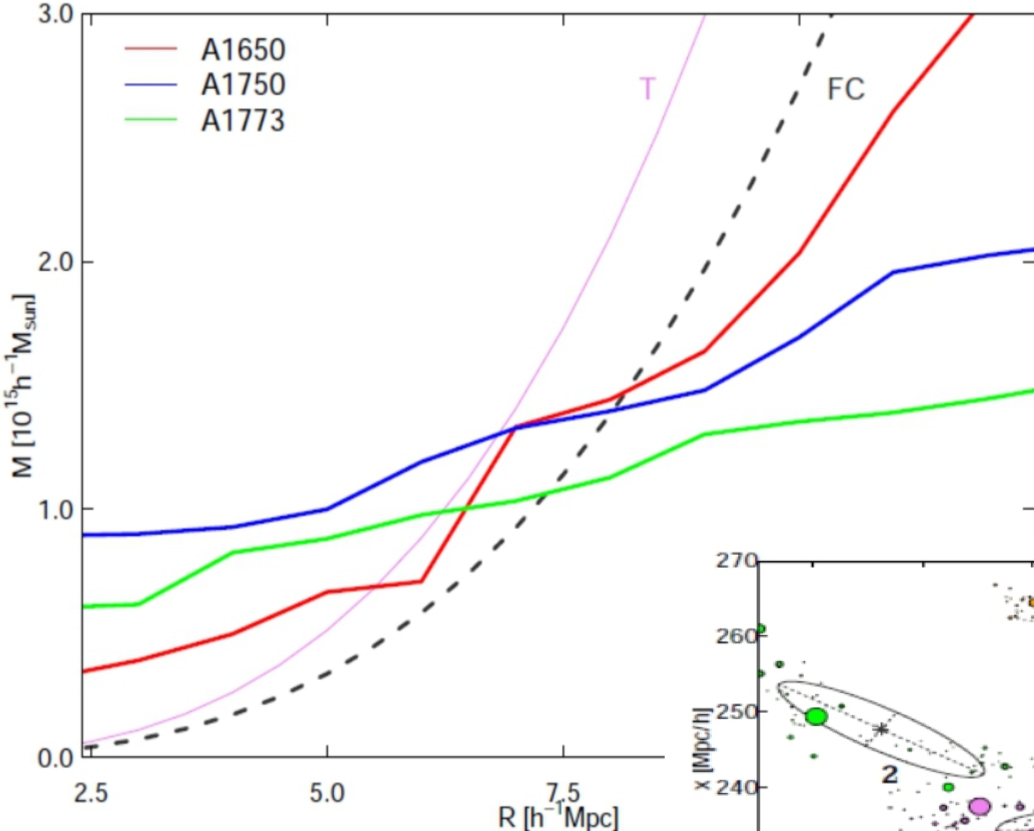
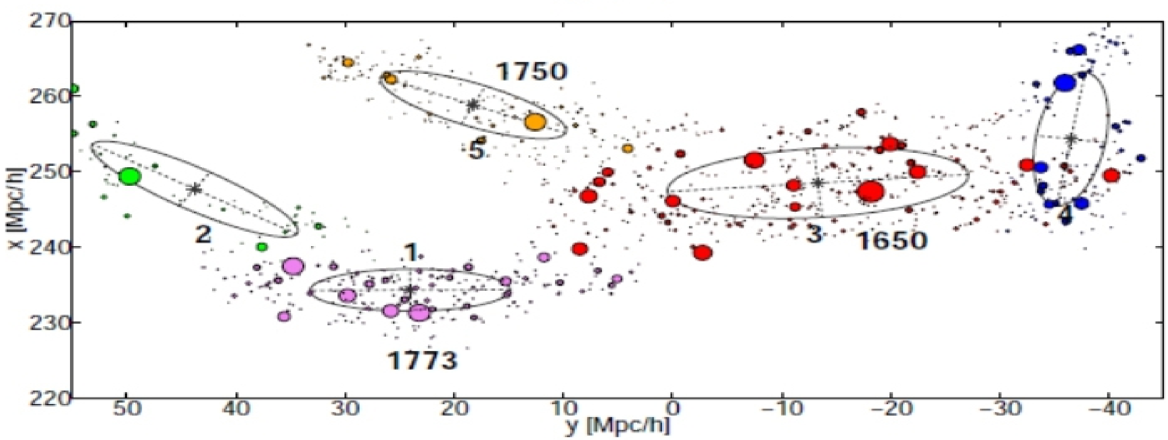


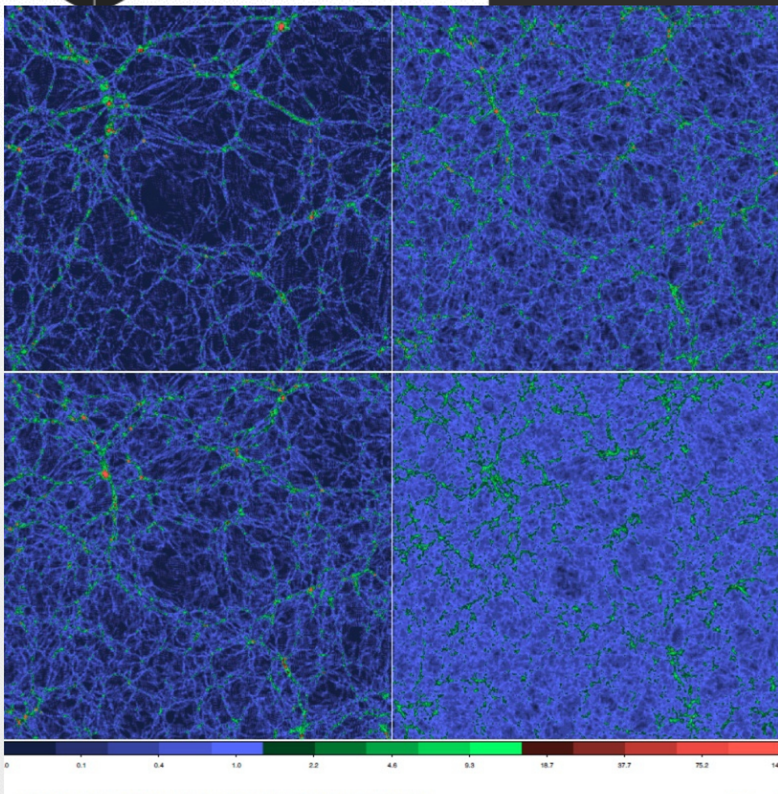
Mass distribution around rich clusters in high-density cores of SCl027

$$M = M_{gr,dyn} + M_{faint\ groups} + M_{ICM}$$

T – turnaround
FC - future collapse
spherical collapse model

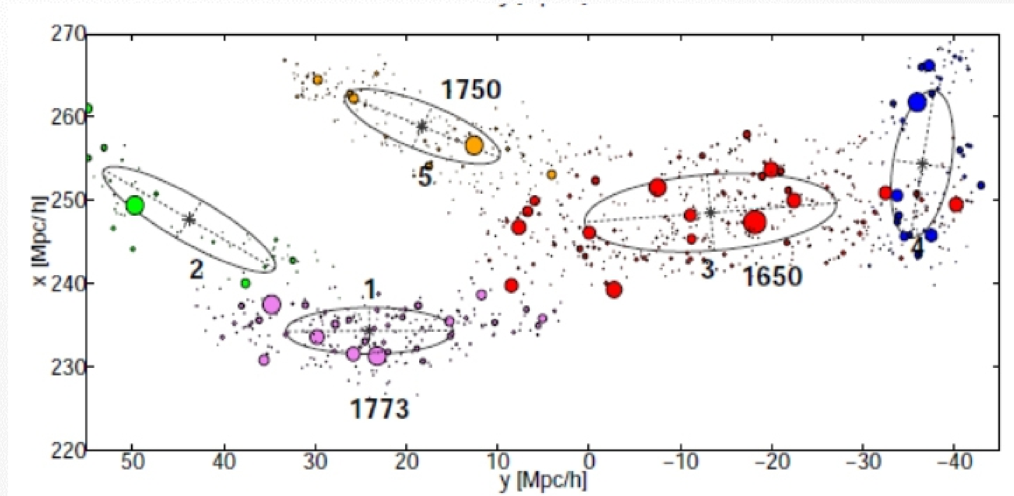


Central parts of the high-density cores (< 10 Mpc h^{-1}) or perhaps full core regions (30 – 60 Mpc h^{-1})– collapsing now or in the future

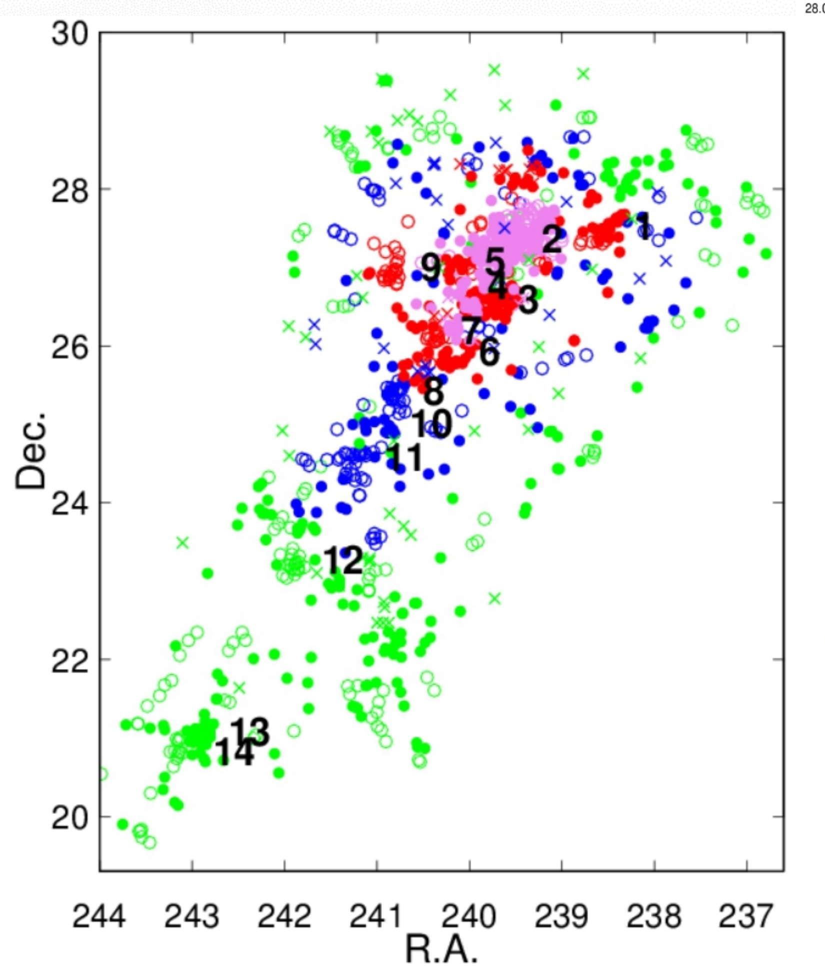


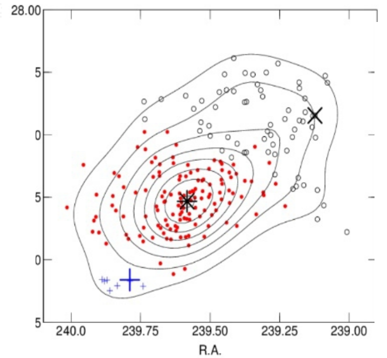
High-density peaks in the galaxy distribution (supercluster high-density cores) form in a very early Universe.

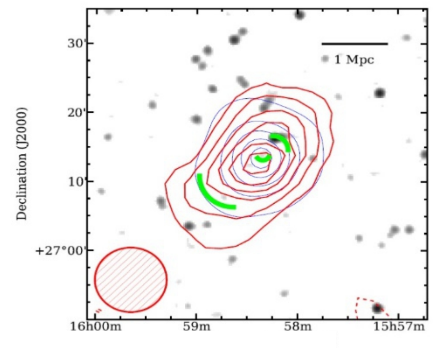
z = 0, 1, 5, 10, simulations by Einasto and Suhhonenko (2011)

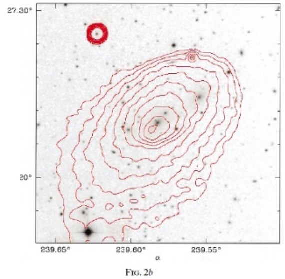


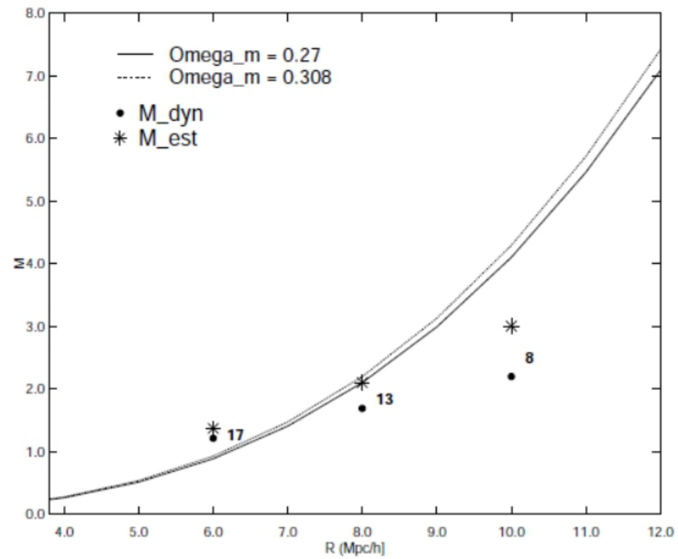
The sizes of the largest bound structures in the Universe:
Central parts of the supercluster cores (< 10 Mpc h^{-1})?
Full high-density cores
(30 – 60 Mpc h^{-1})?
Full superclusters?











SCl2142 – supercluster with the high-density, collapsing core and 50 Mpc/h straight main body, which orientation coincides with the orientation of the main cluster A2142

Superclusters with high–density, possibly collapsing cores: dynamically evolving environments to study and test the structure, dynamics, and evolution of superclusters and their group, filament, and galaxy content and evolution.

The sizes of possibly collapsing cores:
$\approx$10 Mpc h^{-1} or even 30 – 60 Mpc h^{-1}?

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Thank you!

References:

Einasto et al. 2016, A&A, in press (1608.04988)

Gramann et al. 2015, A&A, 581, A135

Liivamägi et al. 2012, A&A 539, A80
Tempel et al. 2014, A&A 566, A1

Einasto et al. 1975, Astr. Tsirkulyar 895, 2