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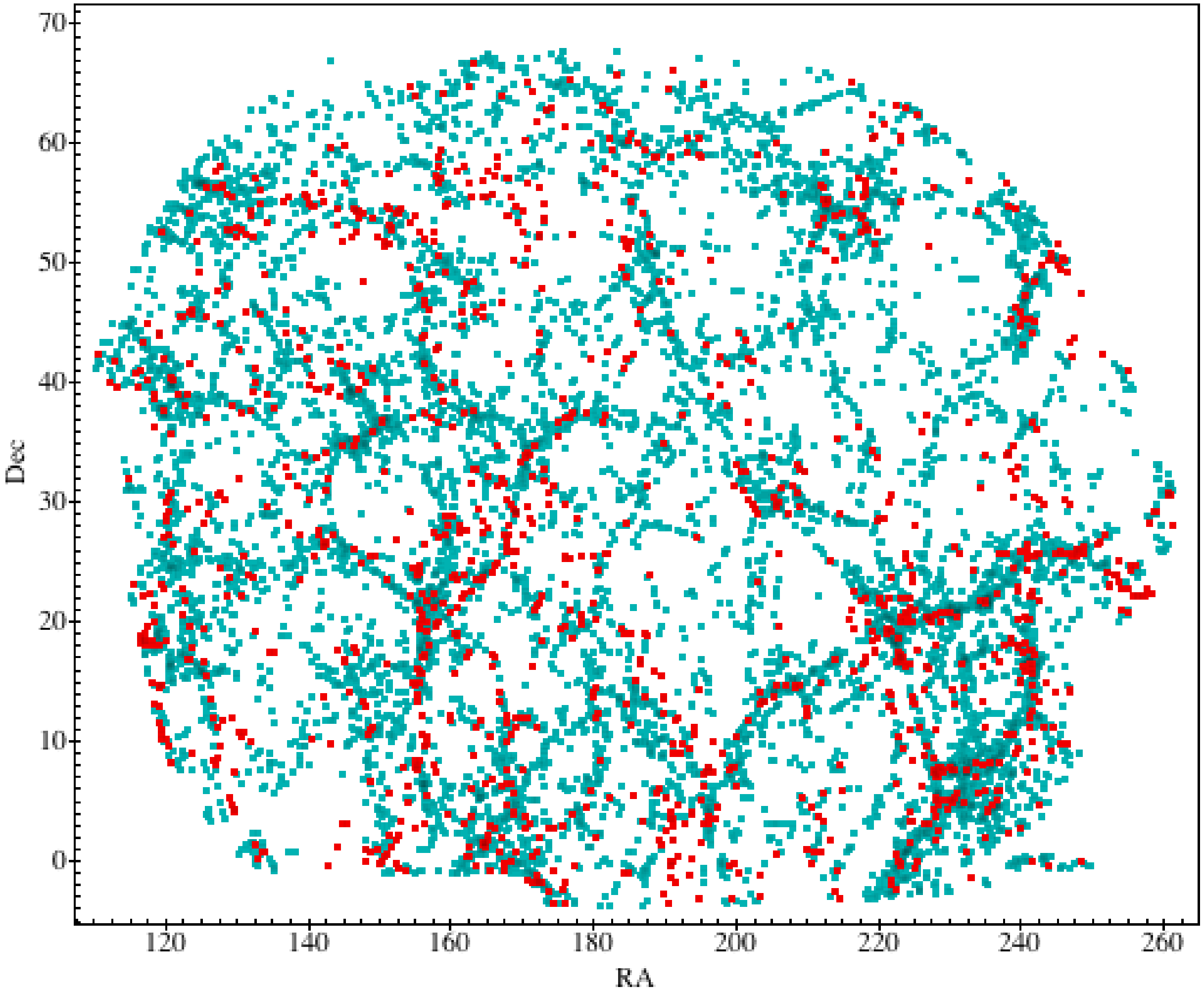
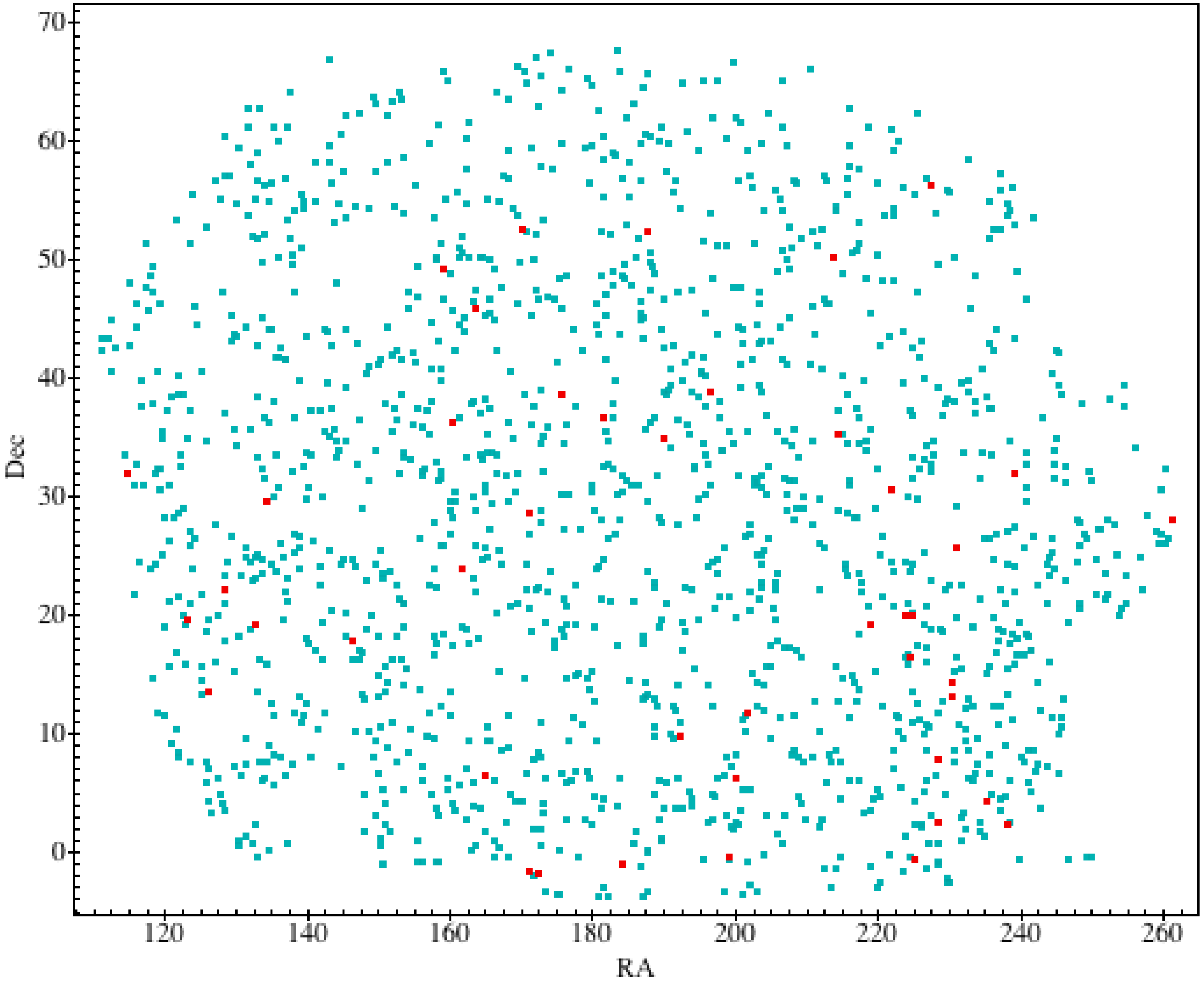
Density evolution of galaxies

Antti Tamm (Tartu Observatory)

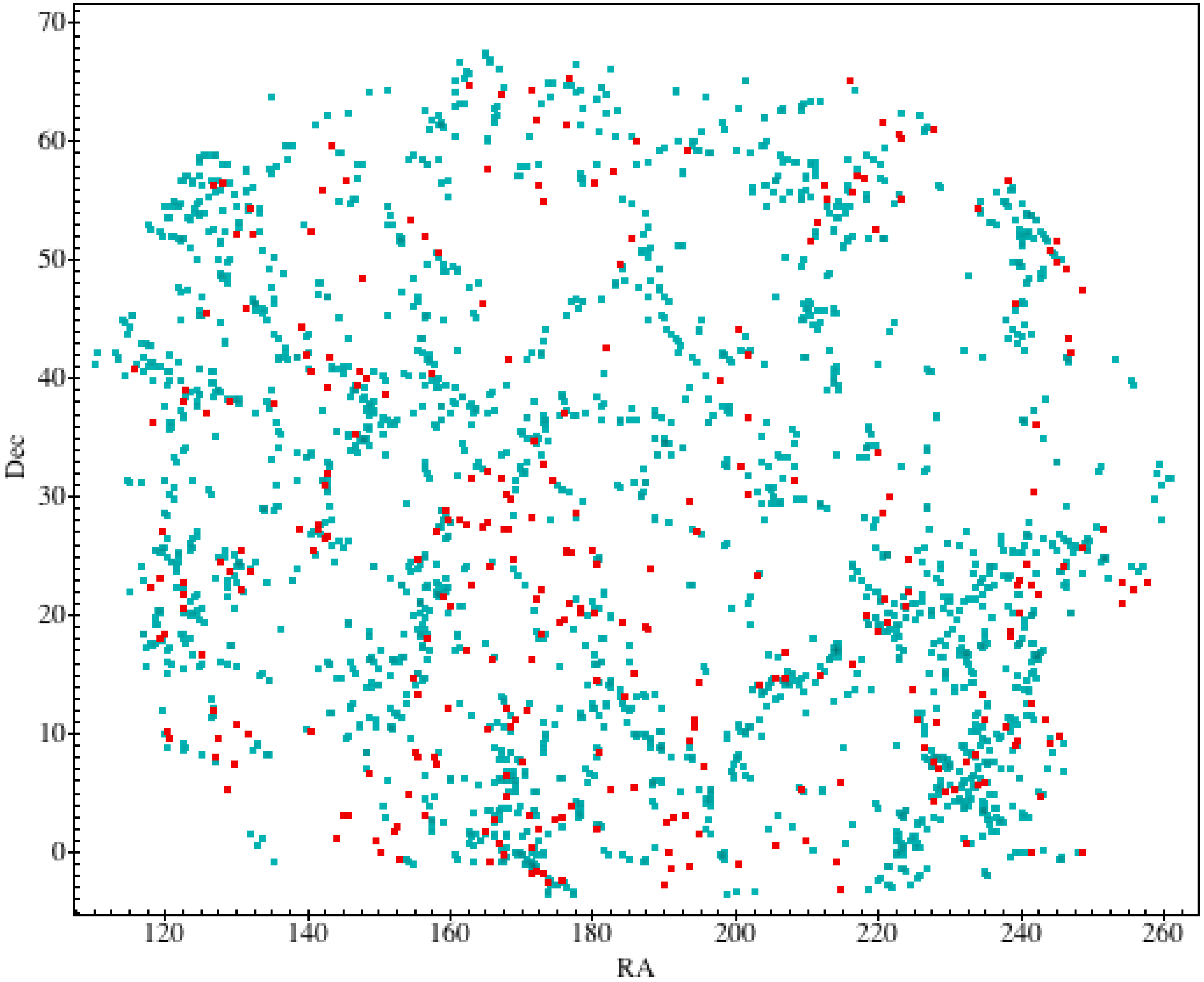


SDSS
$0.04 < z < 0.05$



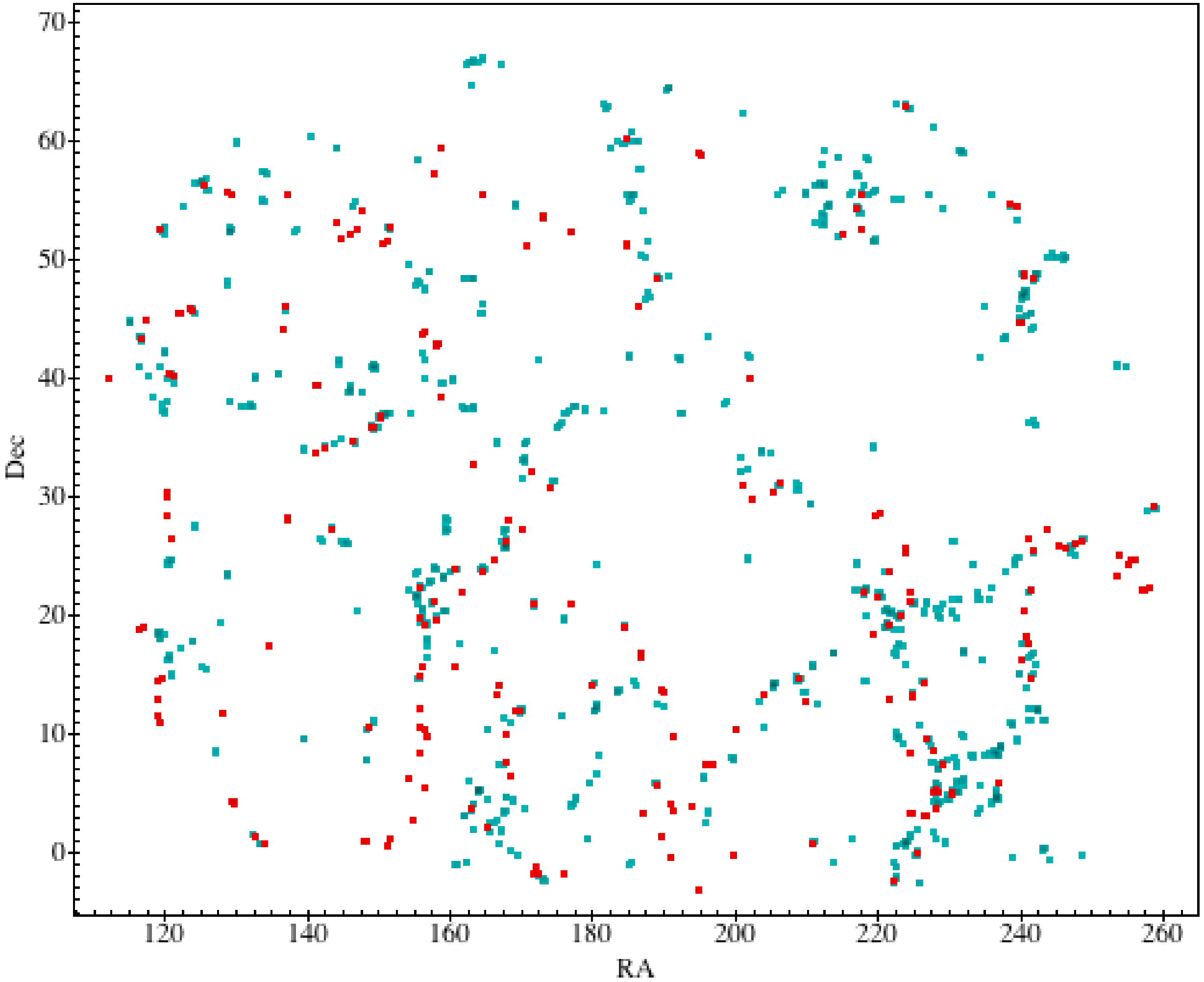
SDSS
$0.04 < z < 0.05$

density < mean



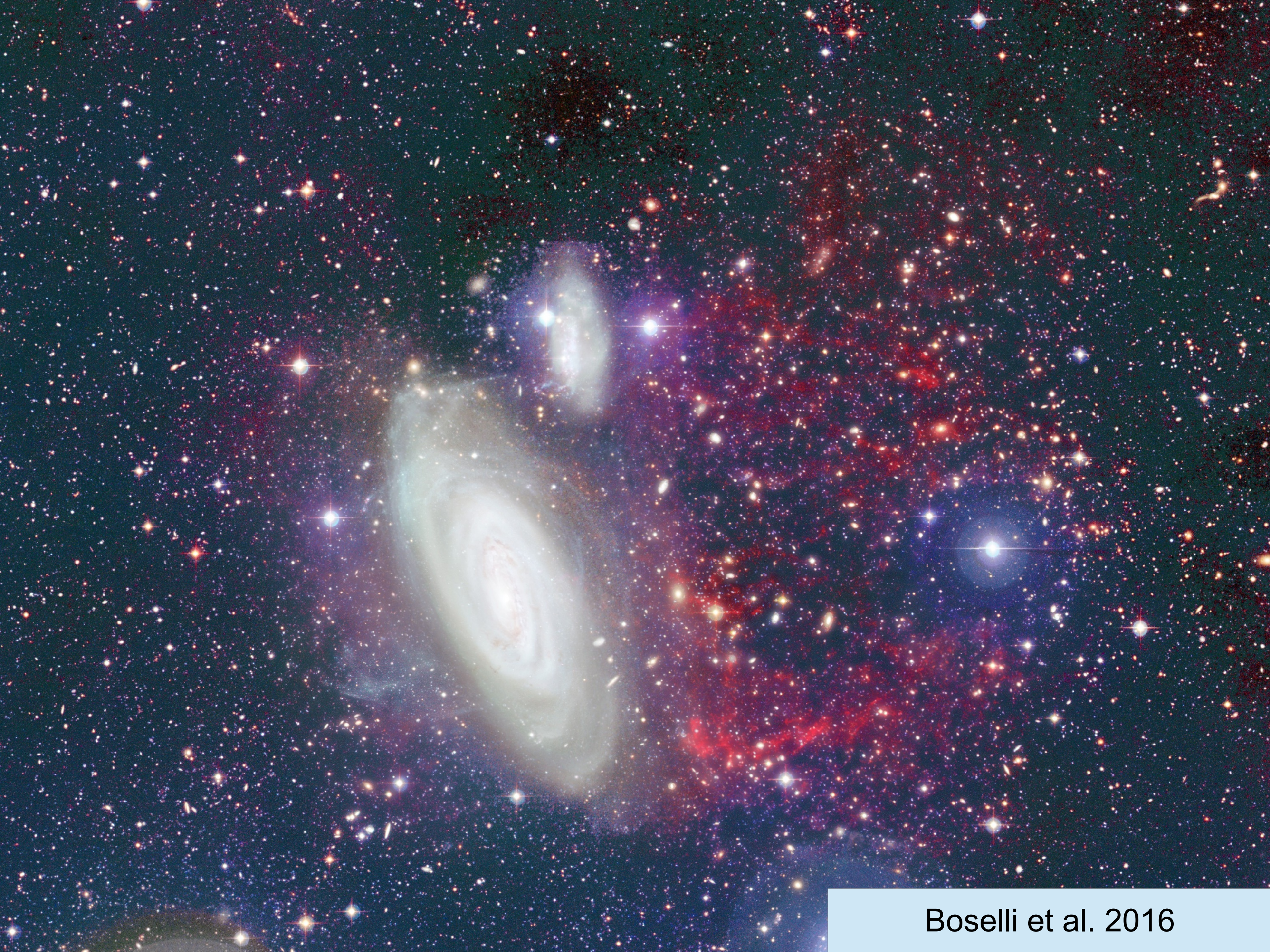
SDSS
$0.04 < z < 0.05$

density ≈ 10 × mean



SDSS
$0.04 < z < 0.05$

density ≈ 100 × mean



Boselli et al. 2016

morphology-density relation,

colour-density relation,

mass-density relation etc.

- Dressler (1980)
- Einasto & Einasto (1987)
- Kauffmann et al. (2004) – SDSS
- Baldry et al. (2006) – SDSS
- Park et al. (2007, 2009) – SDSS
- Bamford et al. (2009) – SDSS + Galaxy Zoo
- Poudel et al. (2016) – SDSS + GAMA

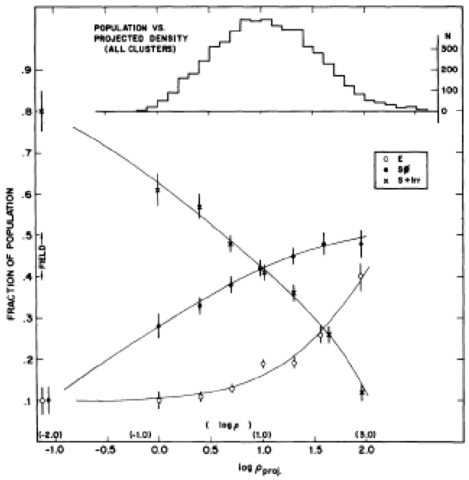


FIG. 4.—The fraction of E, S0, and S+I galaxies as a function of the log of the projected density, in galaxies Mpc^{-2}. The data shown are for all cluster galaxies in the sample and for the field. Also shown is an estimated scale of true space density in galaxies Mpc^{-3}. The upper histogram shows the number distribution of the galaxies over the bins of projected density.

demonstrates that the populations change smoothly with density over five orders of magnitude, from 10^{-2} to 10^{3} galaxies Mpc^{-3}.

The advantage afforded by the use of density instead of radius as the independent parameter in the study of population gradients is illustrated in Figure 5. The population gradients in six moderately irregular clusters have been determined as a function of surface density and as a function of radial distance from the centroid of the galaxy distribution. The gradients are much more striking when the density is employed as the independent parameter, which indicates that the local density enhancements represent real physical associations and that populations are largely a function of local rather than global conditions.

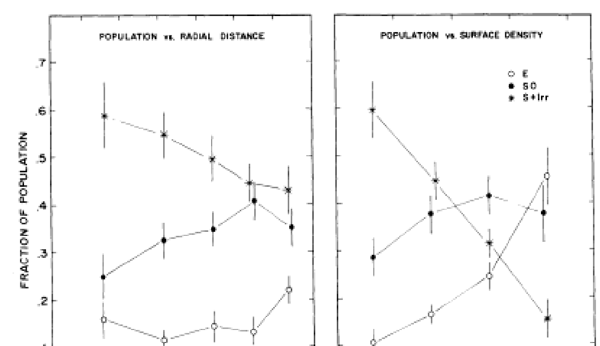
The data of Figure 4 and subsequent diagrams have not been corrected for contamination by field galaxies, which constitute a fraction of the population running from about 40% at $\log \rho_{\mathrm{proj}} = 0.0$ to less than 5% at $\log \rho_{\mathrm{proj}} = 2.0$. Using the "observed" proportions 50/35/15 for S+I/S0 E, as discussed in § II, it can easily be shown that the field introduces a negligible error in the determination of the proportions at each density. The densities themselves have been corrected to reflect the density of the local region with the field removed.

It is interesting to note that the Oemler data fit well onto the relationship of Figure 4. The representative populations "spiral rich," "spiral poor," and "cD" are close to the proportions at projected densities of 0.5, 1.5, and 1.8, respectively.

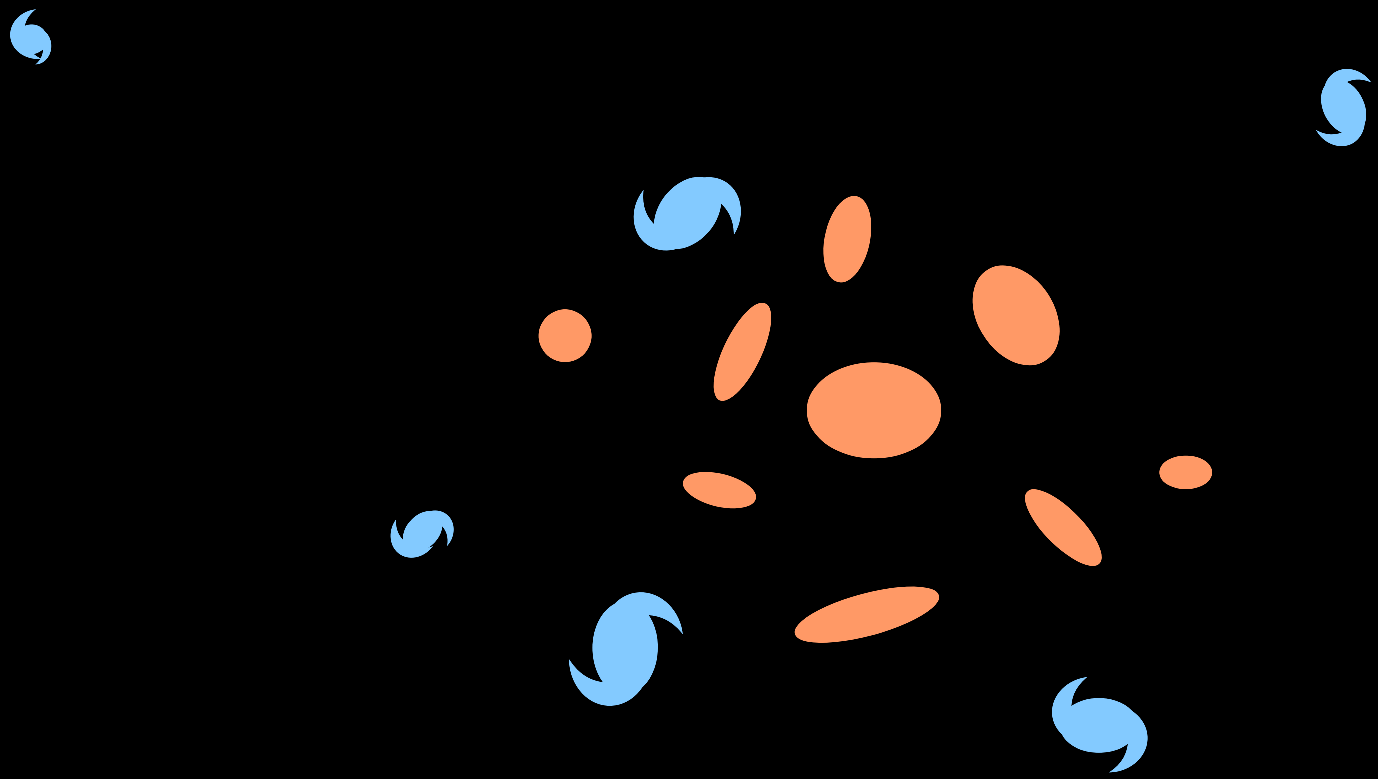
Analyses of individual clusters indicate that the relation between population and density holds within individual clusters as well as, on the average, from cluster to cluster. Since, as will be shown, this relationship holds among clusters of different morphology (i.e., regular or irregular, concentrated or diffuse), it is clearly basic in the understanding of cluster populations.

b) Discussion

Spitzer and Baade (1951) first suggested that cluster S0 galaxies result when disk gas is removed from



TT2016



- morphology & colour (SSFR) depend on galaxy mass
- galaxy mass depends on the environment
- observational data strongly depend on distance (redshift)
- depending on the spatial scale, you can find void, filament, and cluster galaxies with a given environment density
- how to access the genuine effect of the environment on a galaxy?

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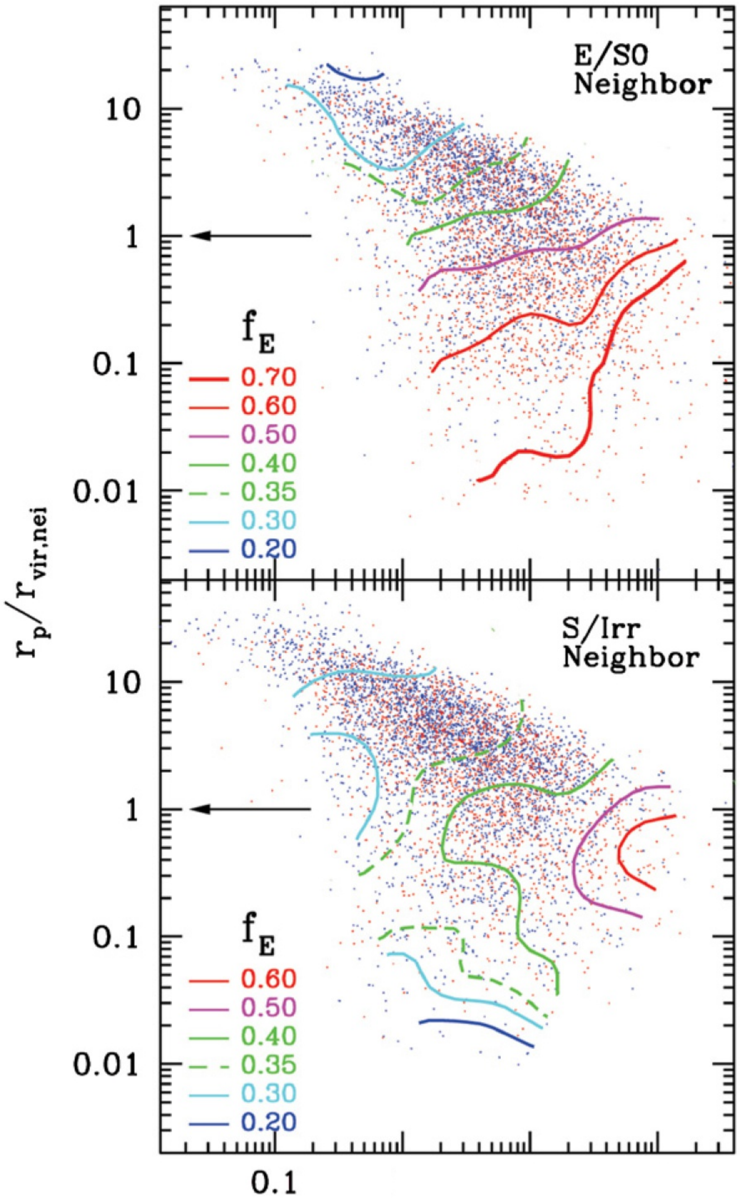
- how to access the genuine effect of the environment on a galaxy?

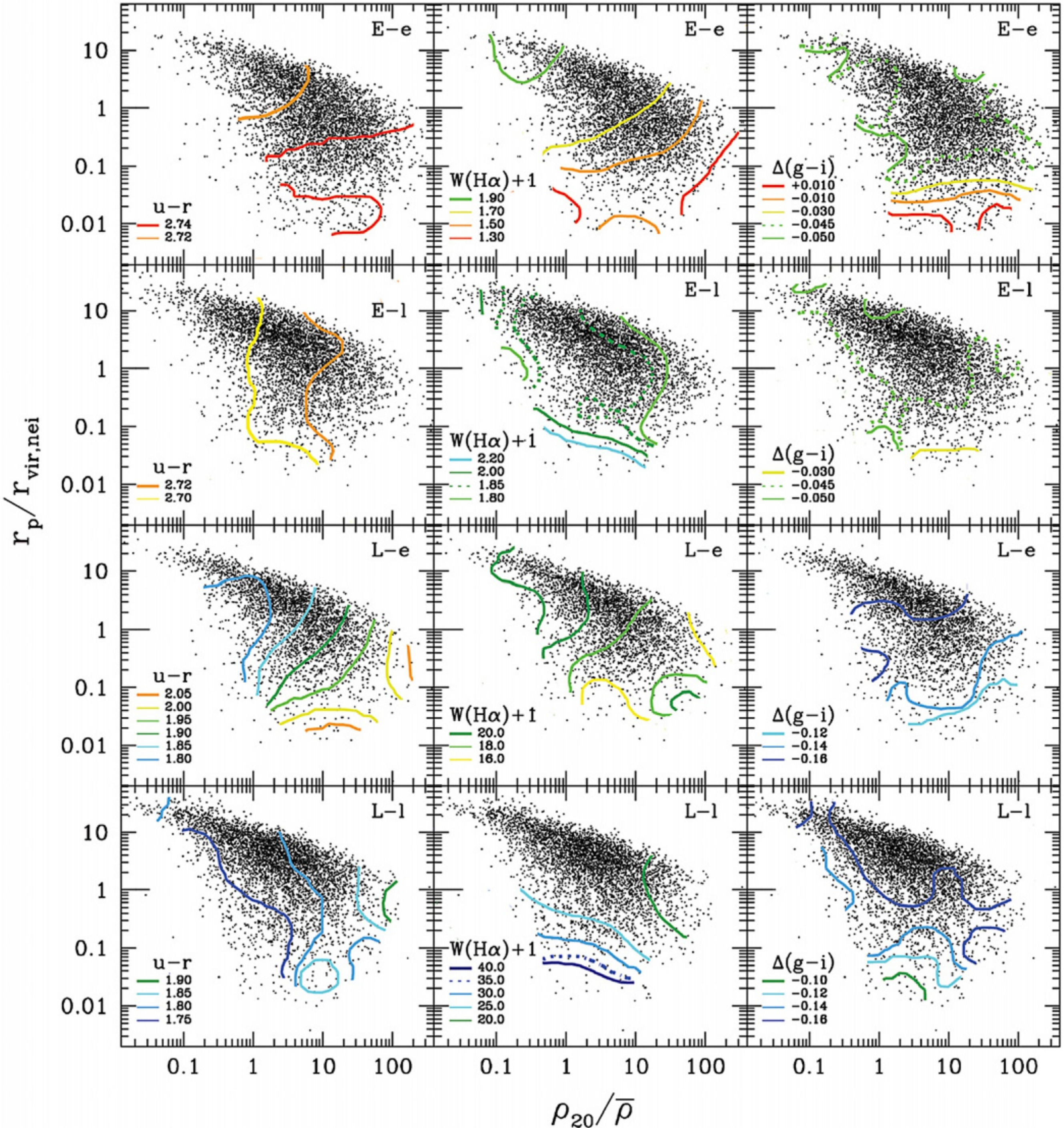
.... very carefully!

Park & Choi (2009):

$-19.5 > M_r > -20.5$

Nearest neighbour affects more than environment density.





Park & Choi 2009

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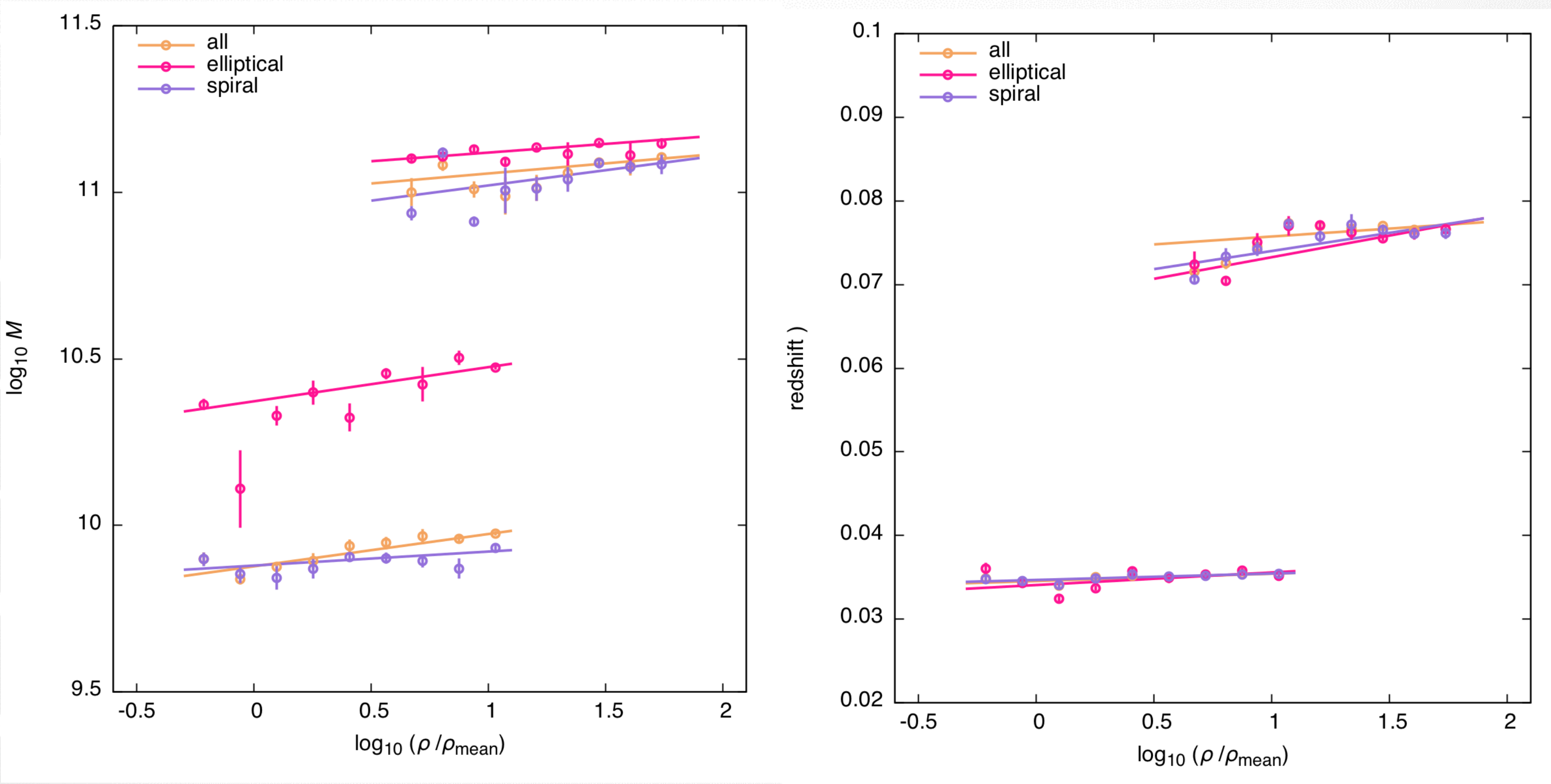
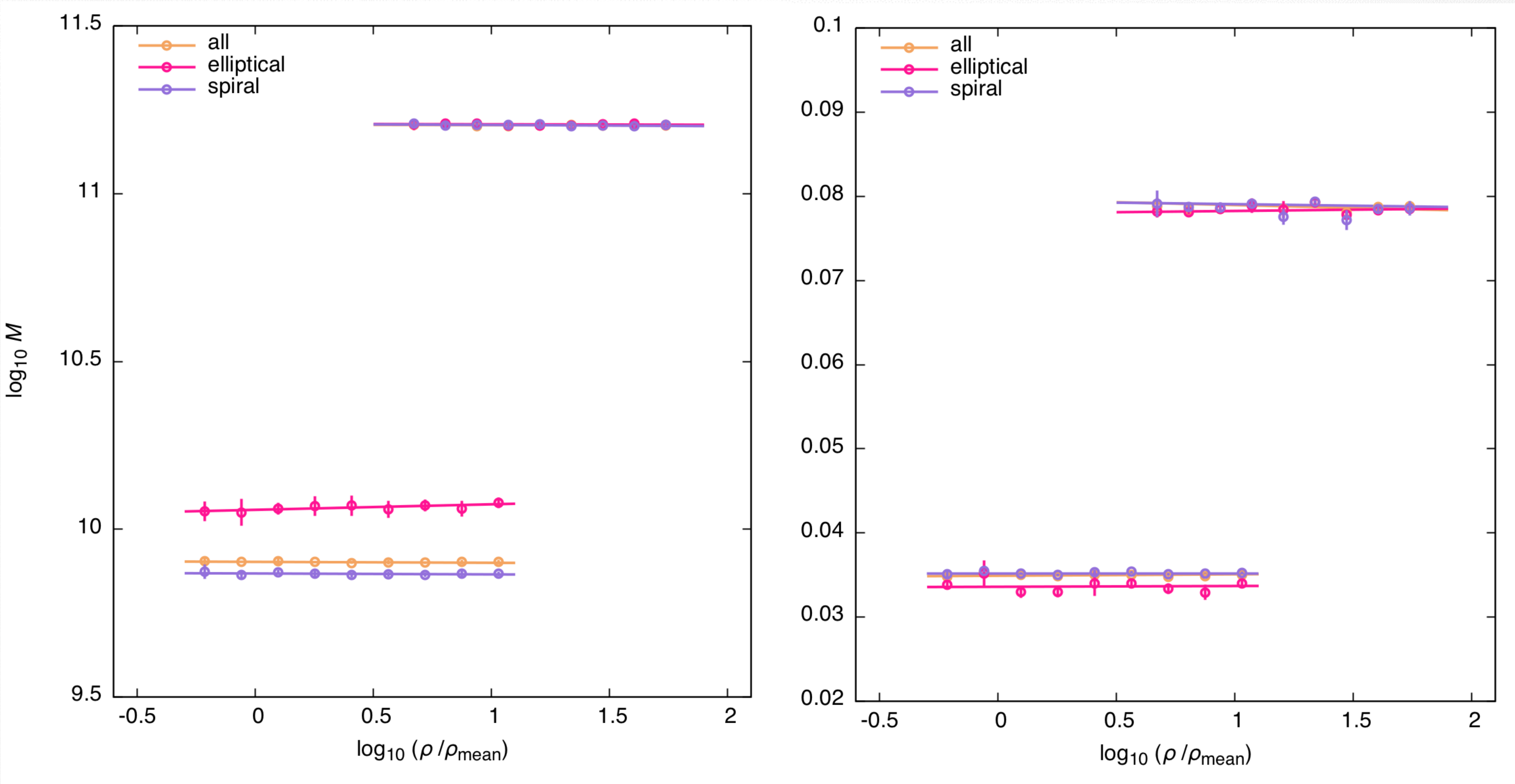
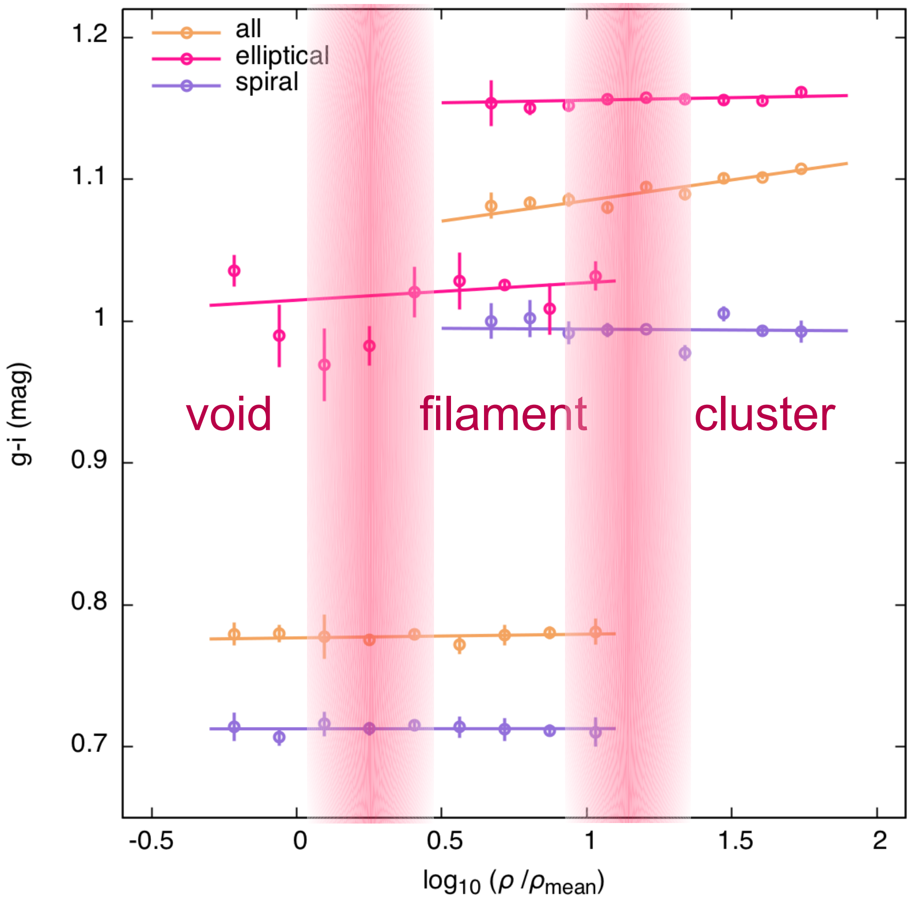


Stellar mass and redshift before weighting



Stellar mass and redshift after weighting



Our analysis:

- SDSS
- Luminosity-function-corrected smoothed luminosity density
- Weighting by stellar mass & distance (redshift)

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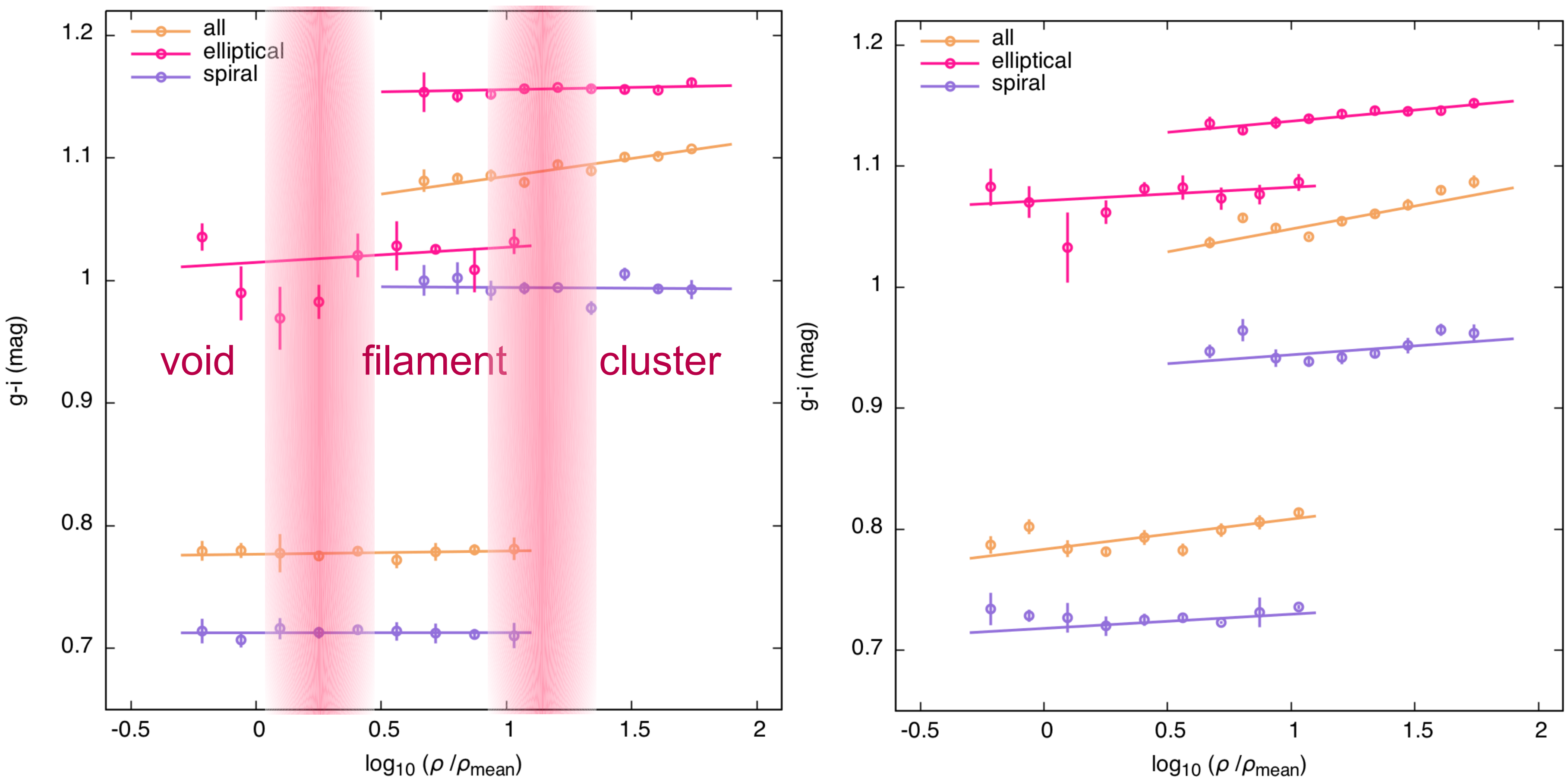
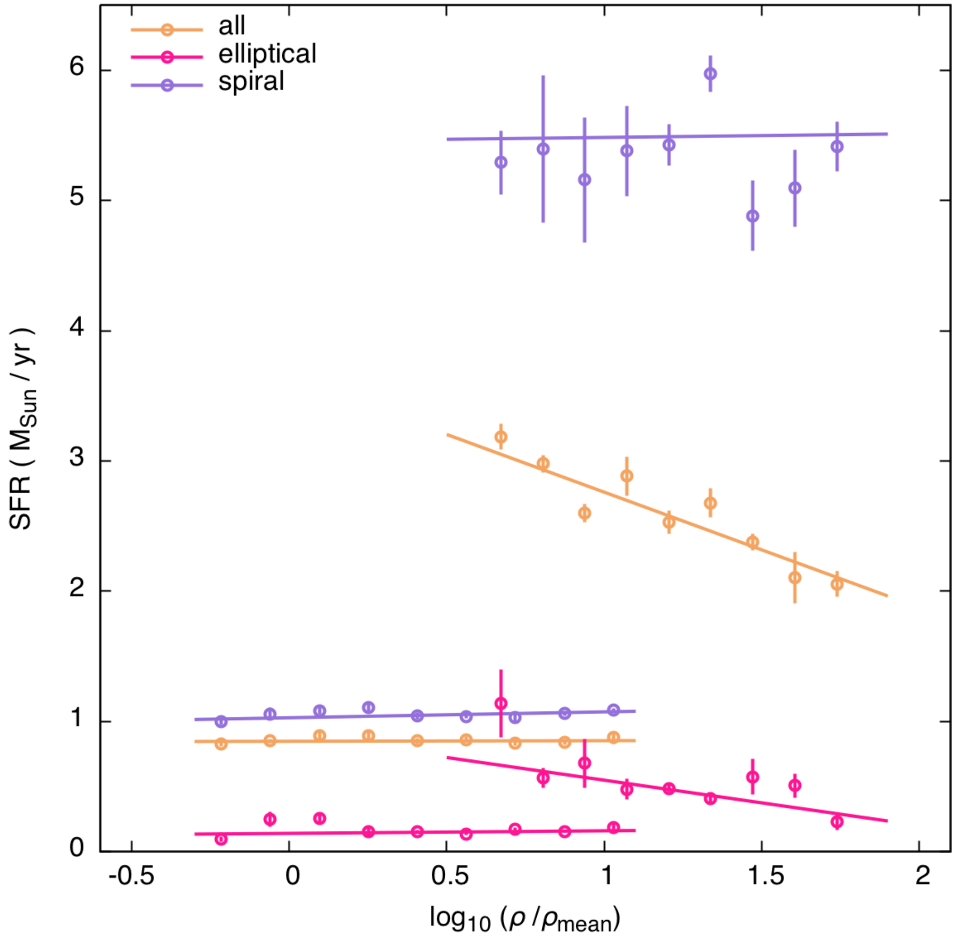
Colour after weighting



Colour after and before weighting



Our analysis:

- SDSS
- Luminosity-function-corrected smoothed luminosity density
- Weighting by stellar mass & distance

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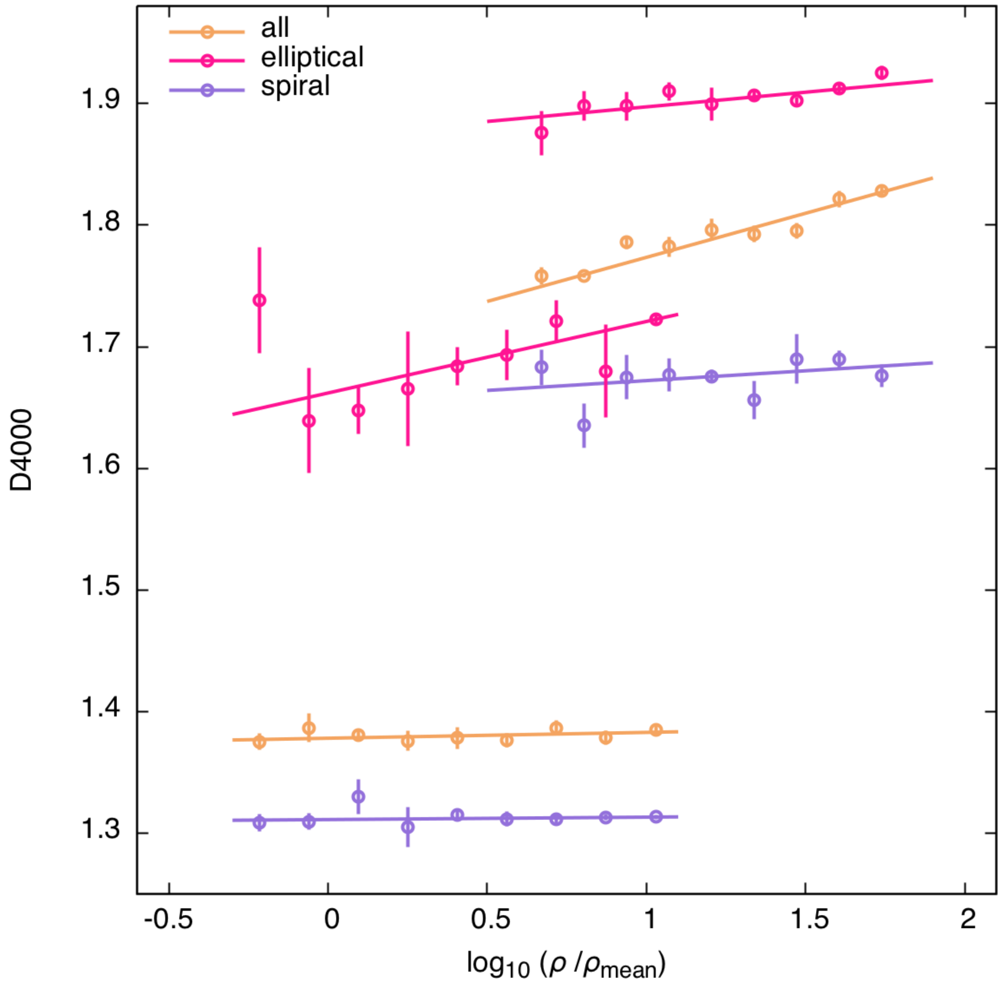
Star formation rate after weighting



Our analysis:

- SDSS
- Luminosity-function-corrected smoothed luminosity density
- Weighting by stellar mass & distance

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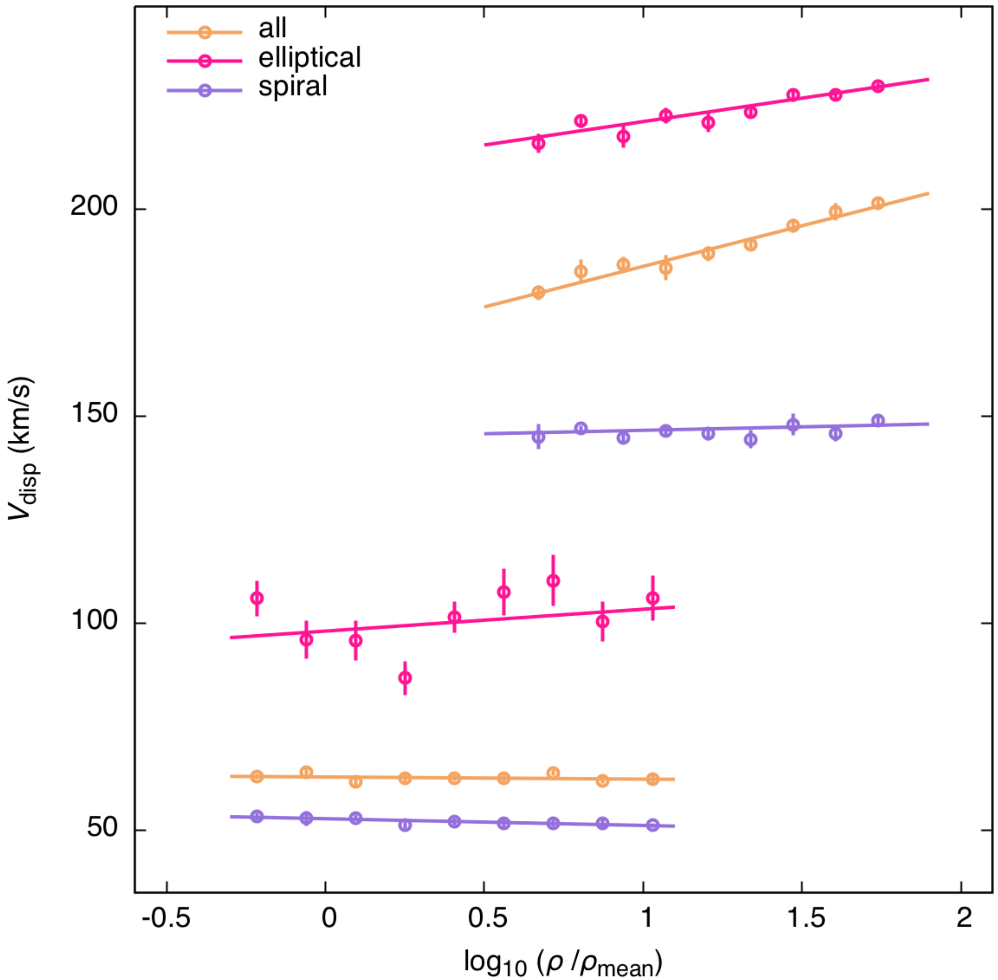
D4000 after weighting



Our analysis:

- SDSS
- Luminosity-function-corrected smoothed luminosity density
- Weighting by stellar mass & distance

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Stellar velocity dispersions after weighting

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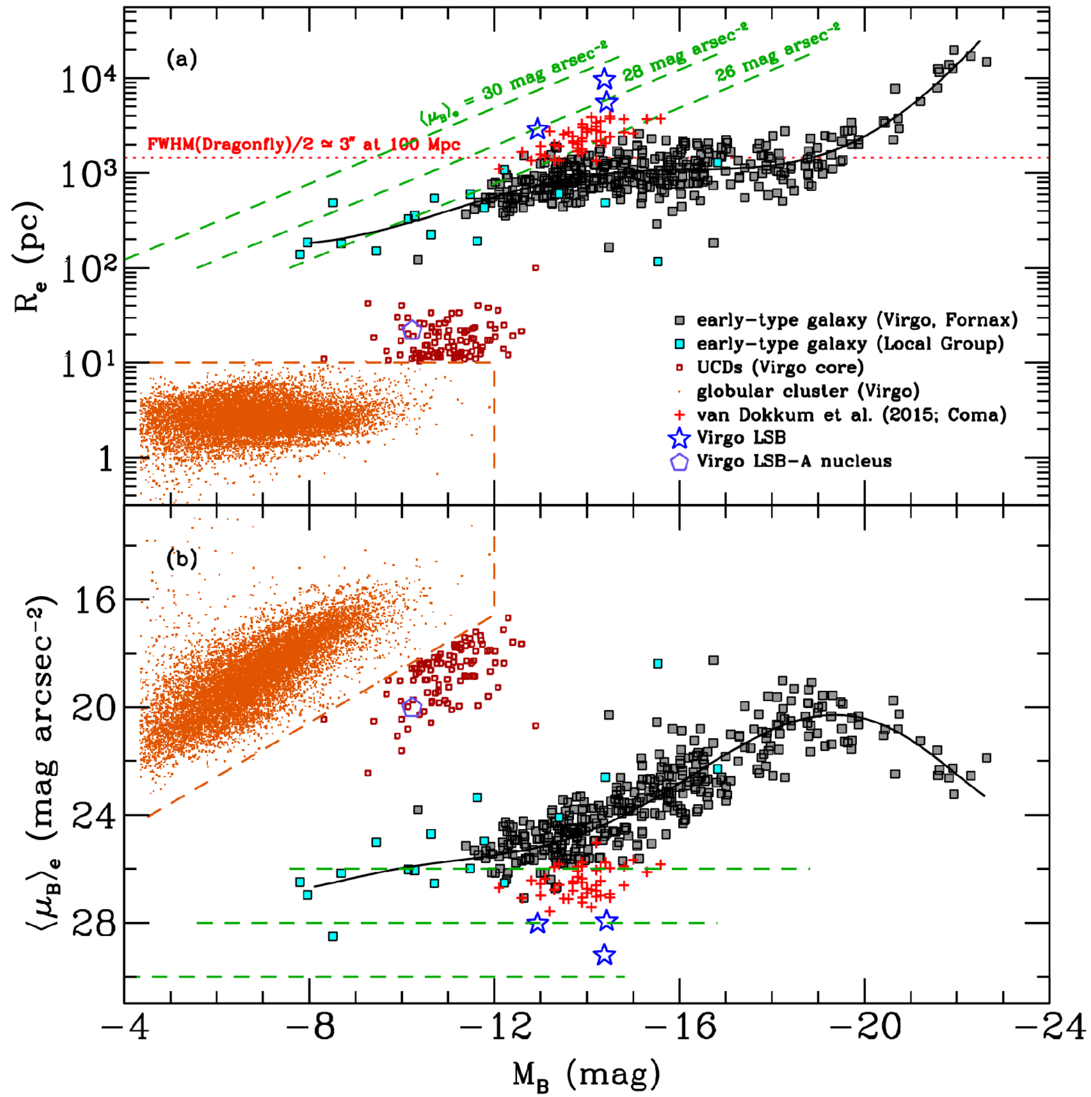
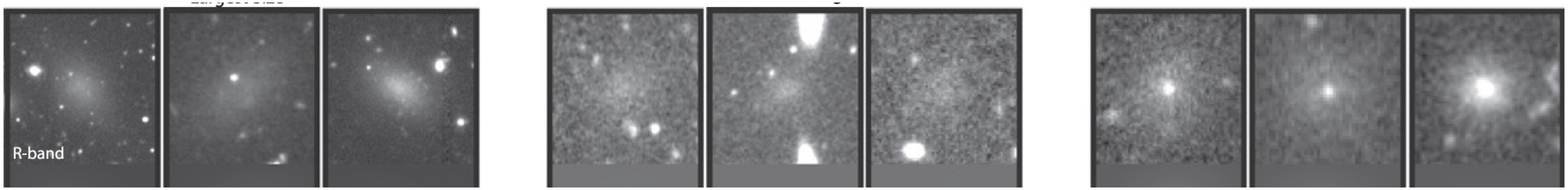
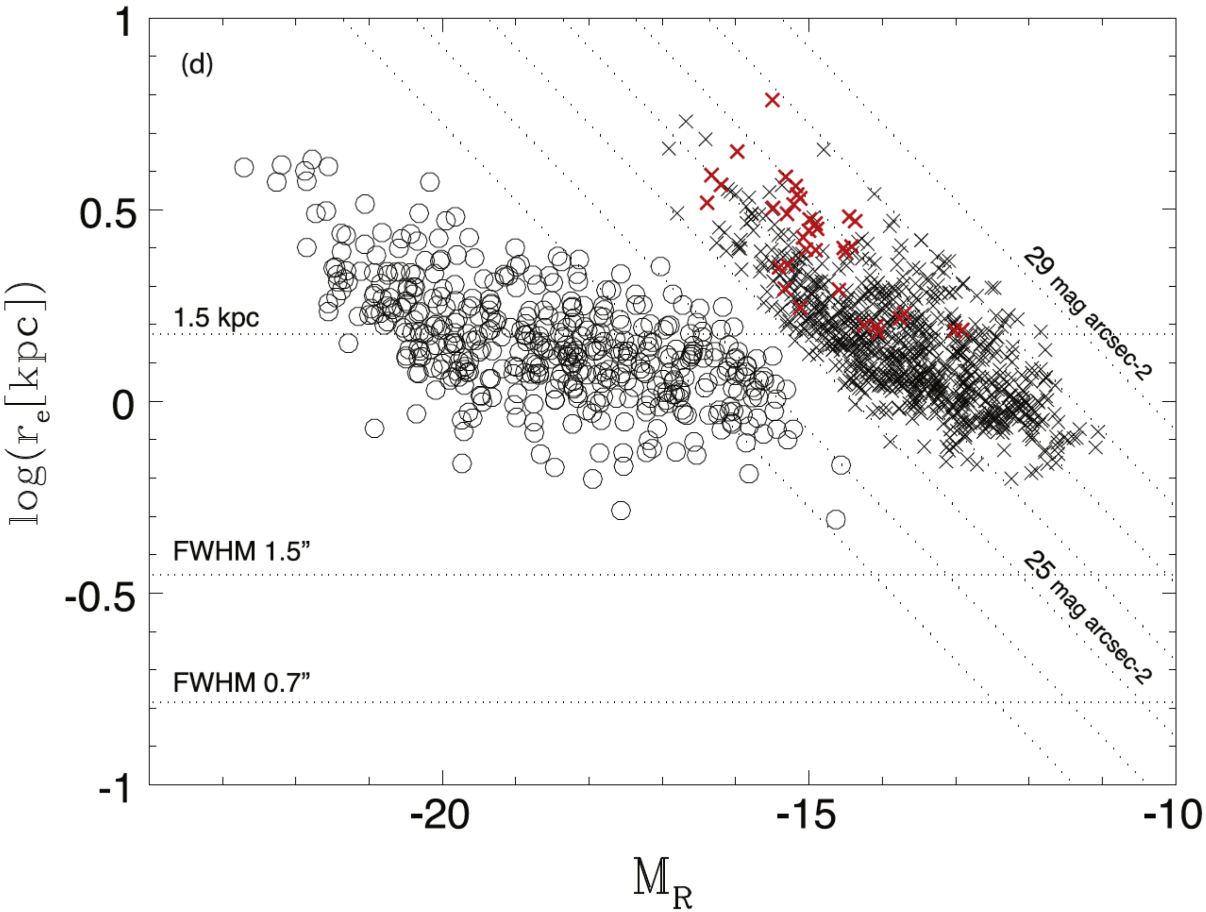
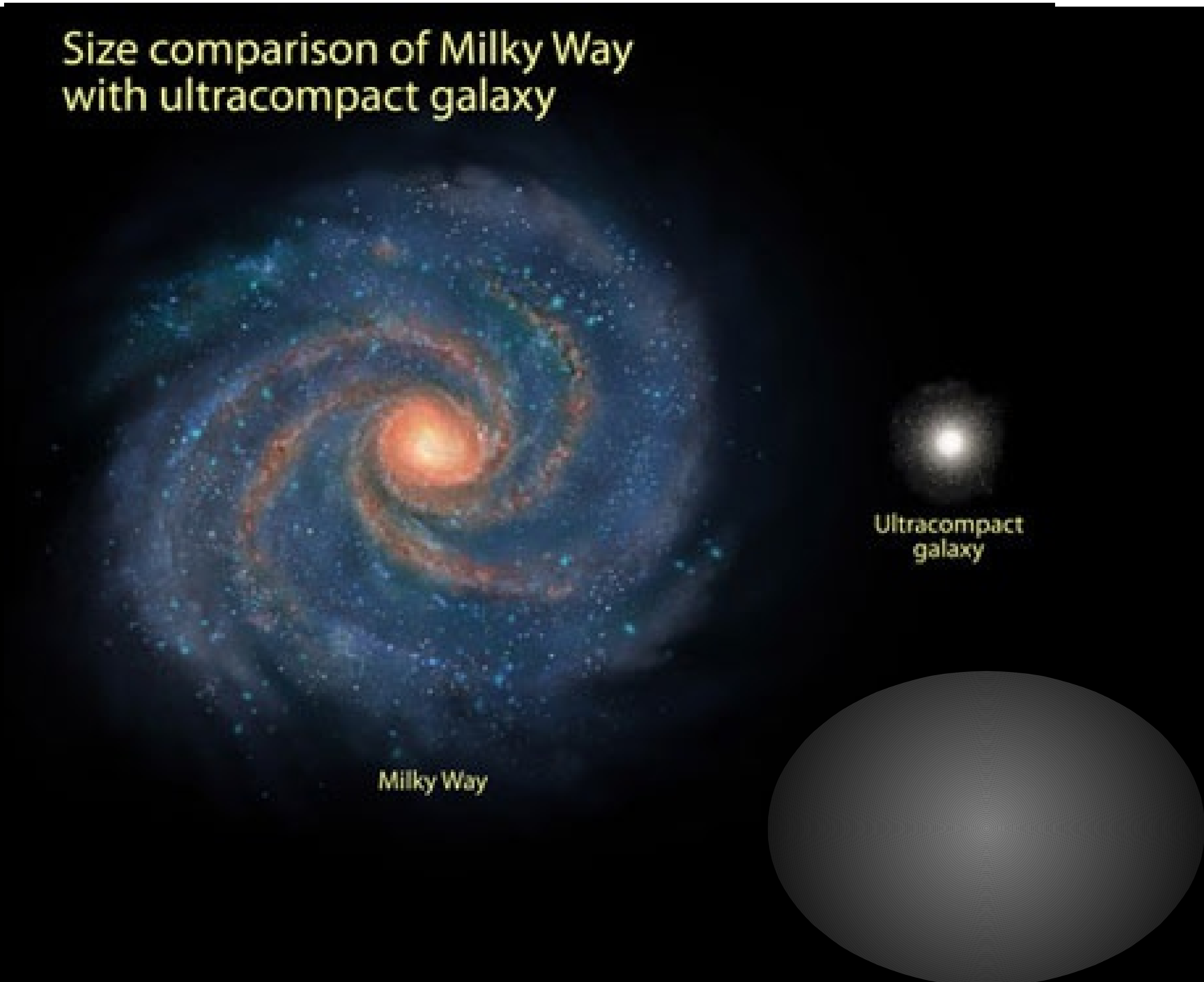


Figure 3. Structural properties of the Virgo LSBs compared with other stellar systems, including early-type galaxies in the Virgo and Fornax Clusters and in the Local Group, as well as GCs and UCDs in Virgo, and the extreme LSBs found in Coma. The dashed orange lines show the GC selection box, while lines of constant surface brightness are shown in green.

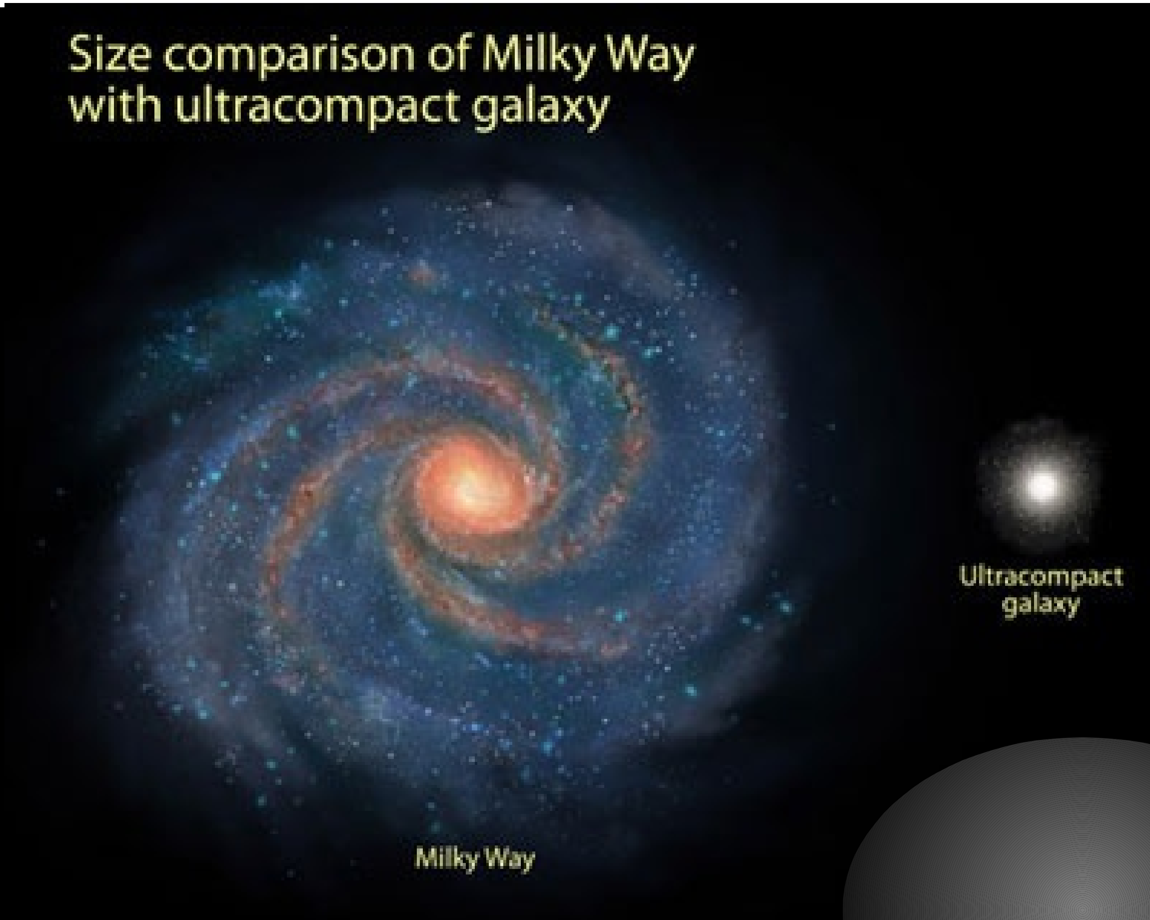


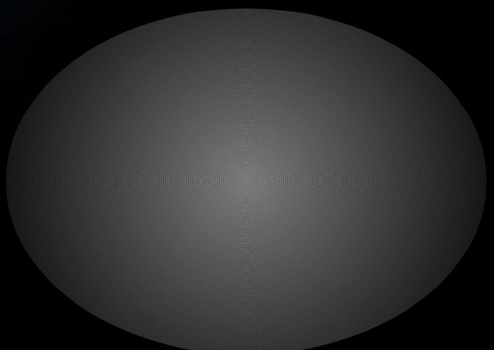


Koda et al. 2015



Ultradiffuse galaxy





Ultradiffuse galaxy

Different kinds of dark matter?

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Thanks!