Isolated Galaxies and Isolated Satellite Systems

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Content

- Isolated galactic satellite systems, from the SDSS Dr4plus sample (Ann, Park & Choi (2008).

- Isolated galaxies in the local universe, on going project using SDSS DR7. I will present a preliminary results only, with an emphasis on the strategy to find out isolated galaxies.

Search for isolated satellite systems

- Galactic satellite systems are good places to inspect the environmental dependence of galaxy morphology and to study the galaxy formation process since they are abundant and very localized systems with a size of less than 1 Mpc. However, there are only a few satellite systems of which their faint members are observed.

- Thanks to the galaxy redshift survey such as SDSS and 2DFGRS, it is now possible to undertake a statistical approach to understand the galactic satellite systems.

Data

- Primary sample of data is a subset of DR4plus which is a large scale structure sample extracted from the spectroscopic Main galaxy Sample of the SDSS DR5 (Adelman-McCarthy et al. 2007).
- We added 5503 galaxies brighter than r_{pet}=14.5 from various catalogs including NED. The total number of galaxies used here is 370,789 with known redshift and photometry.
- We used a flat ΛCDM cosmology with density parameters Ω_m=0.27, Ω_Λ =0.73.

Two steps to find out Isolated satellite systems

1) look for isolated galaxies brighter than $M_r = -19$ in the volume limited sample defined by redshift range ($0.02<z<0.0472$) and the limiting survey magnitude ($Mr < -18$) .

The target galaxy is isolated if r_p to its nearest neighbor is greater than $r_{virtar} + r_{virnei}$.
Here, neighbor is the galaxies with $M_{r,nei} < M_{r,tar}+1$ with velocity difference $\Delta V_{tar-nei} < 1000 kms^{-1}$

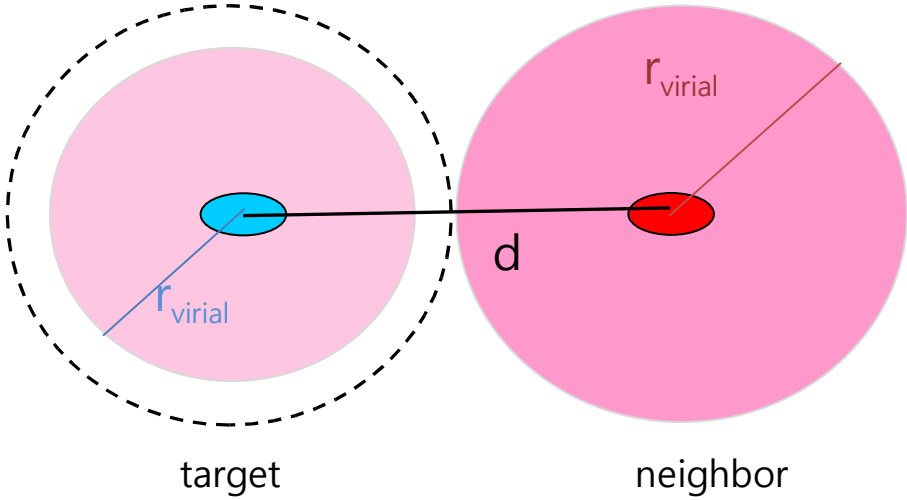
→ 8883 Isolated galaxies

•We defined virial radius of a galaxy as the projected radius (r_p) where the mean mass density within the sphere of a radius r_p is 200 times the critical density (ρ_c).

$$r_{vir} = (3\gamma L/4\pi 200\rho_c)^{1/3}$$

γ =2 for E/S0

=1 for Sp/Irrr



r_{vir} : 300 h^{-1}kpc, 240 h^{-1}kpc for early and late types with M_r =−20

2) Once the bright isolated galaxies were found, we searched for satellites associated with them among galaxies brighter than $M_r=-18$, by using two selection criteria:

(1) projected seperation (r_p) is less than the smaller of $1\ h^{-1}\mathrm{Mpc}$ and $d - r_{vir,nei}$, where d is the projected distance of the neighbor.

(2) magnitude difference between host and satellite is greater than 1 mag.

-> 2254 hosts and 4,986 satellites

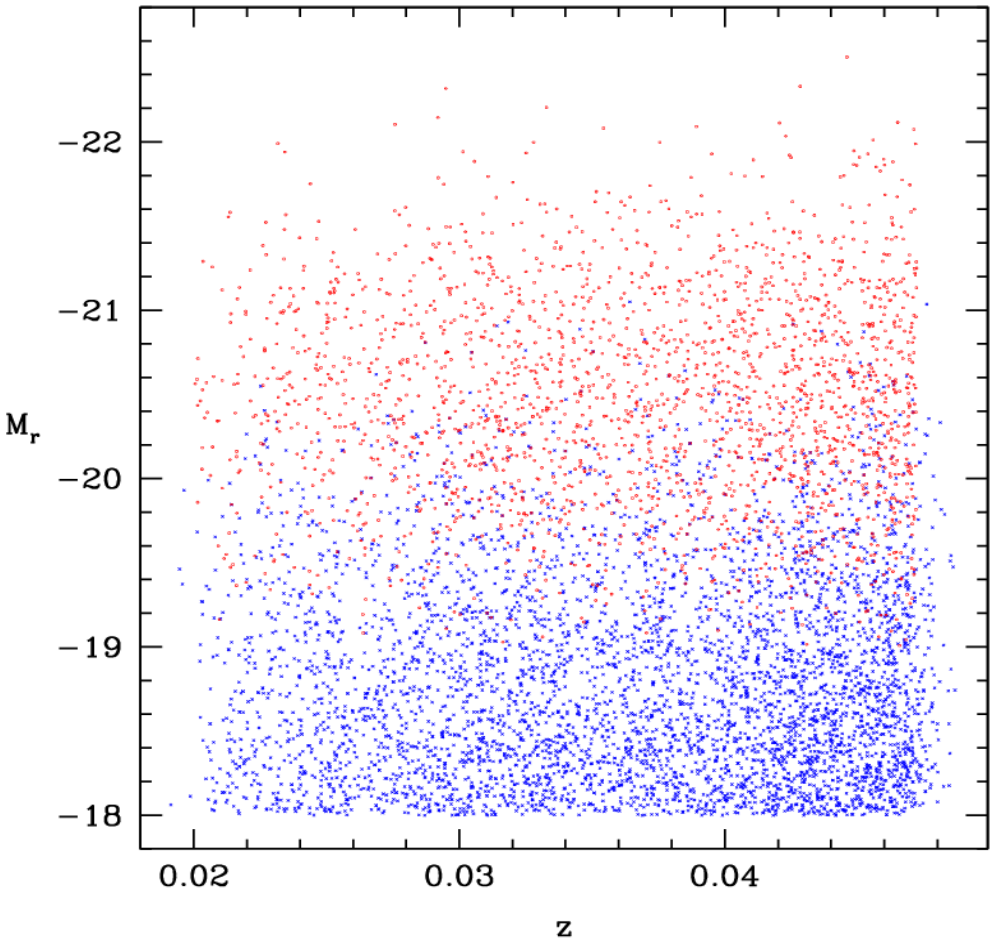
Isolated hosts and their satellites

Mean host luminosity:

M_r=−20.47

Mean satellite luminosity:

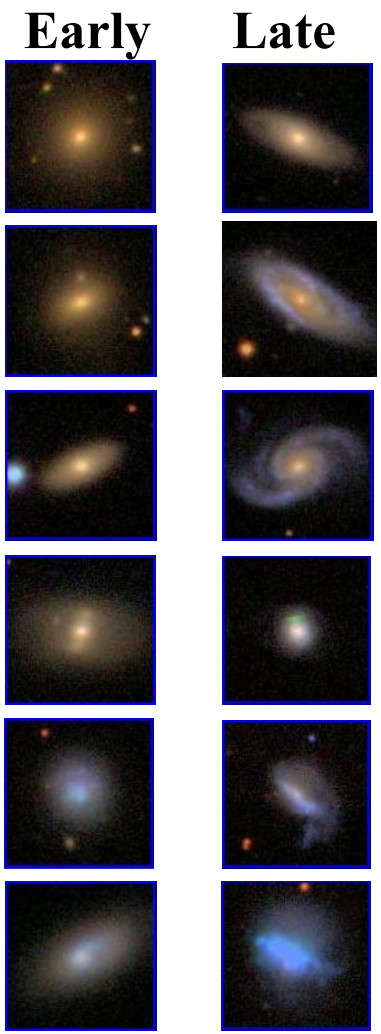
M_r=−18.67

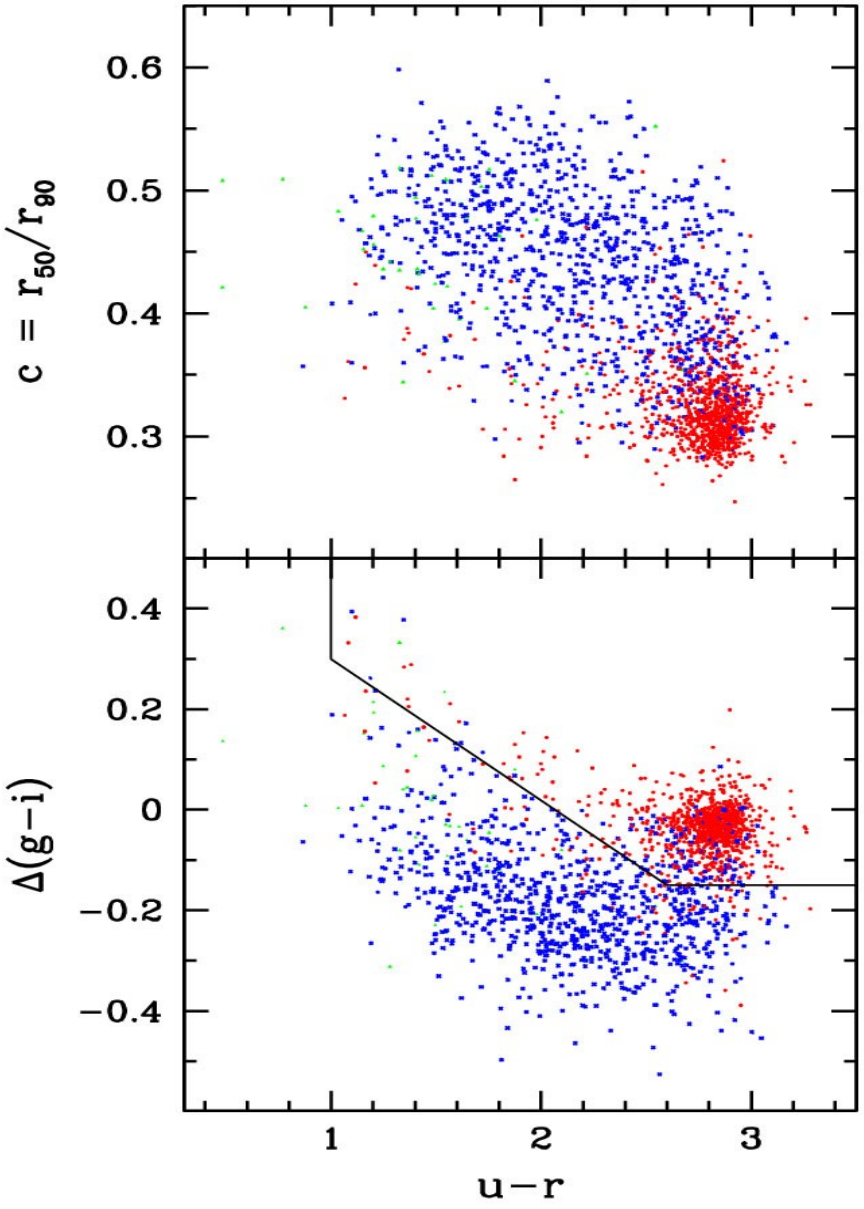


Morphology classification

- We classify the morphology of host galaxies by the visual inspection because visual classification is accurate for bright galaxies.
- However, we mainly employed the automated classifier of Park & Choi (2005) for satellites. The visual classification is used as a complementary one, especially for bright satellites or those suffering from close interactions or mergers.

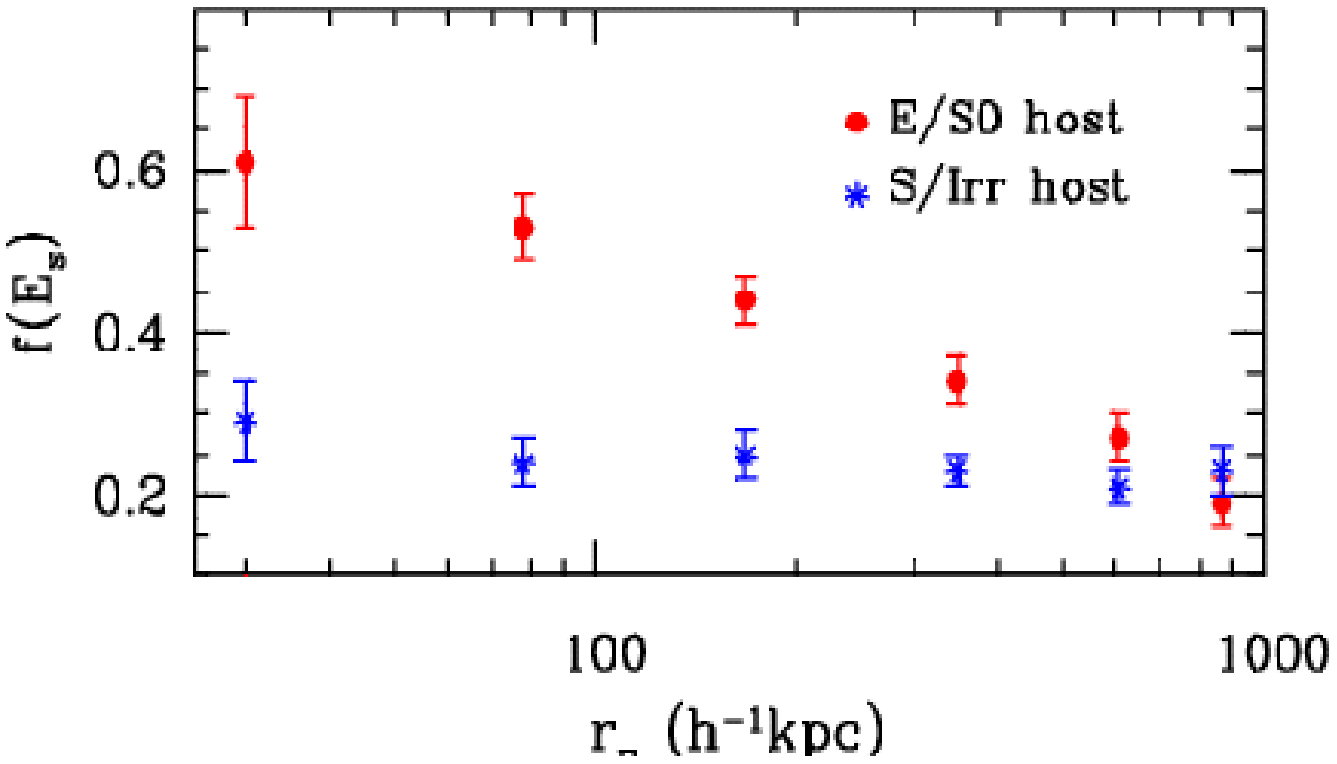
Morphology classification





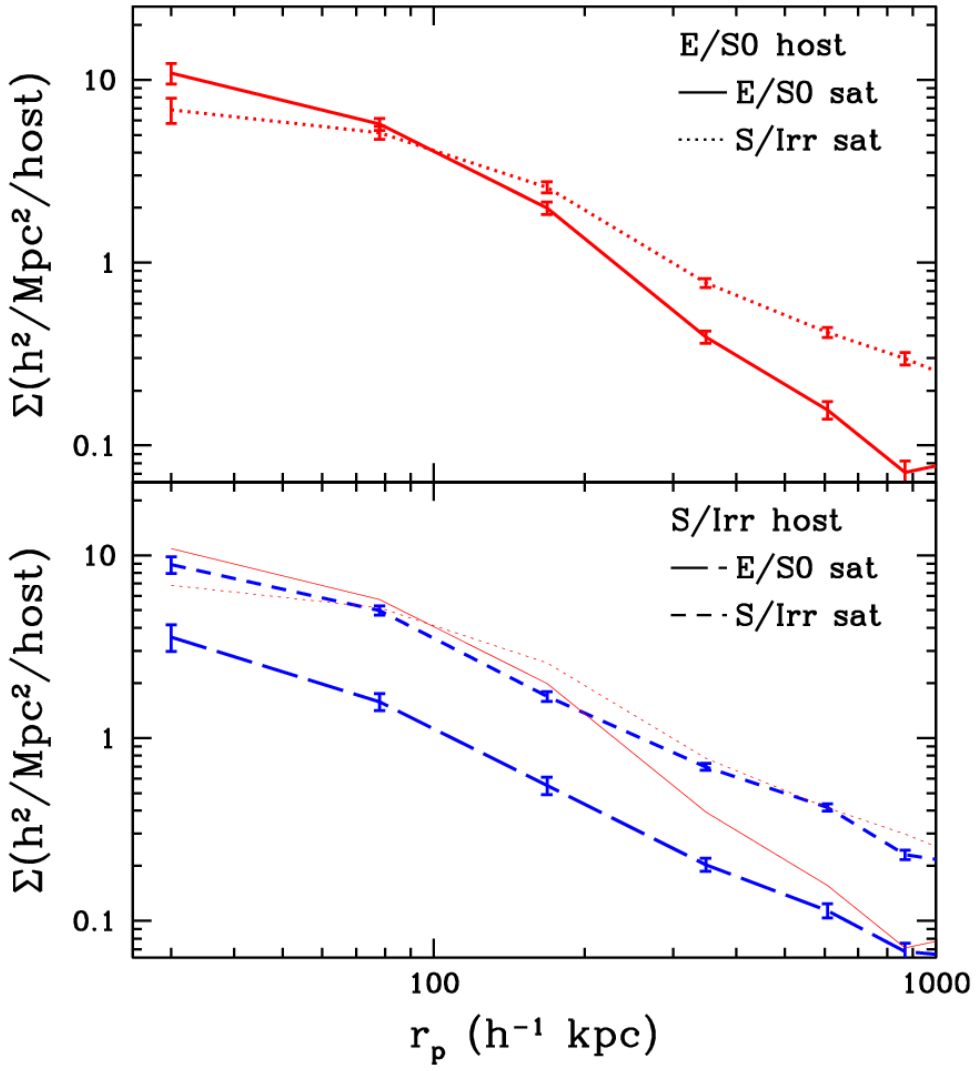
Park & Choi 2005

Morphology & Radial distribution



• Early type fractions of satellites hosted by early type galaxies are higher than those for late type hosts at least out to 350 h^{-1}kpc, which is roughly the virial radius of early type hosts.

Surface density of satellites

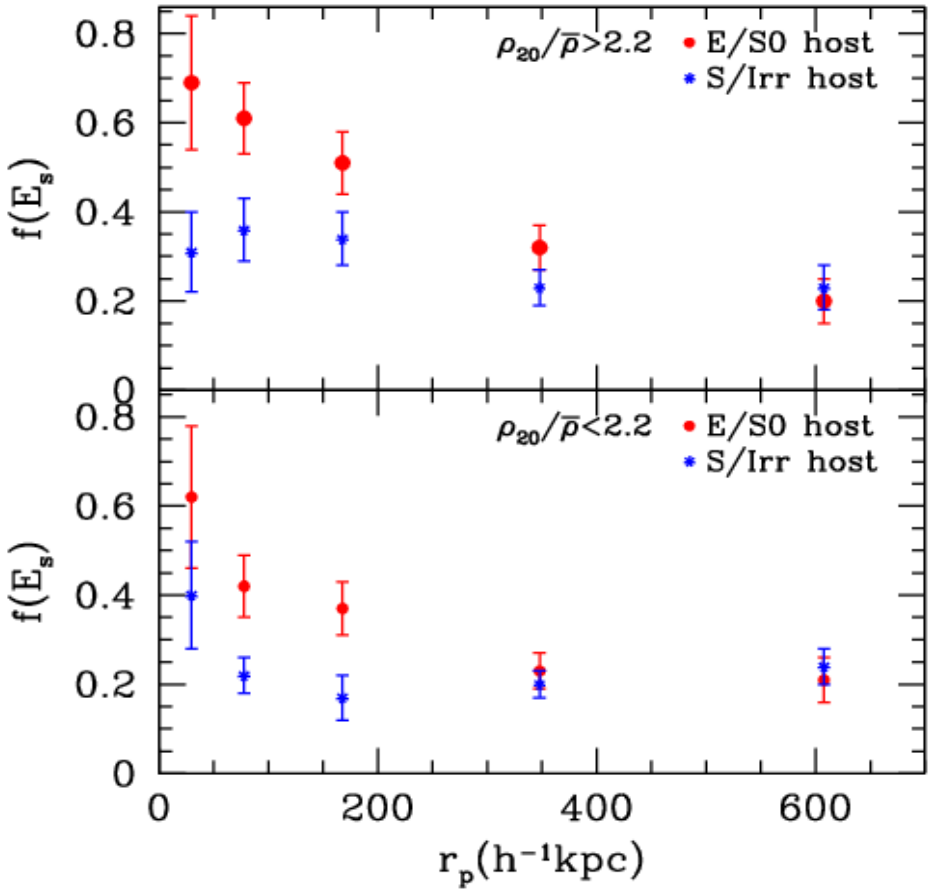


- Surface density of early type satellites associated with early type hosts decreases very rapidly. This is the reason for the more rapid decrease of early type satellite fraction in early type hosts than those in the late type hosts.

Background density dependence

$$\rho_{20}(\mathbf{x})/\bar{\rho} = \sum_{i=1}^{20} \gamma_i L_i W_i(|\mathbf{x}_i - \mathbf{x}|)/\bar{\rho}$$

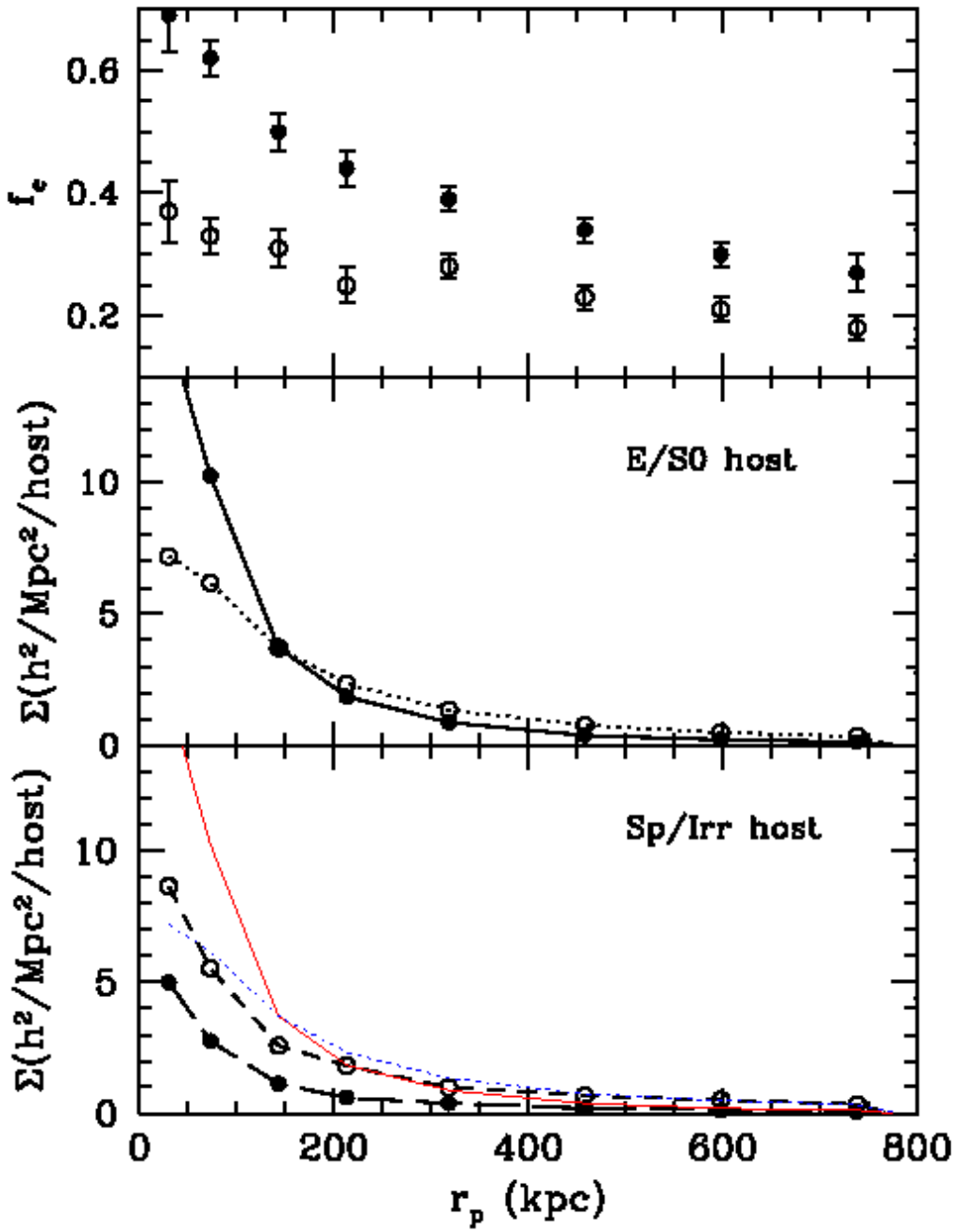
$$\bar{\rho} = \sum_{\text{all}} \gamma_i L_i / V$$



The background density plays a role in determining the moprhology of satellites. However, host morphology and r_p play a decisive role, suggesting hydrodynamic interactions at $r_p < r_{vir,host}$

- The galactic conformity found above is not much affected by the choice of Δm (1,1.5, 2, 2.5), ΔV and limiting r_p .
- We obtained qualitatively the same results with fixed survey radius

  eg, r_p=800kpc h^{-1} .



8353 satellites in 3472 systems:

$\Delta m=2$,
$\Delta v=500$km/s
$r_p=800$kpc h^{-1}

Isolated galaxies

What do isolated galaxies mean?

They are thought to be as

1) passively evolving galaxies formed in isolation via gravitational collapse of a primordial protogalactic cloud (Marcumet al. 2004).

and commonly defined as the galaxies with

no companions brighter than a magnitude difference (Δm) within a projected distance (r_p) and a radial velocity difference (ΔV).

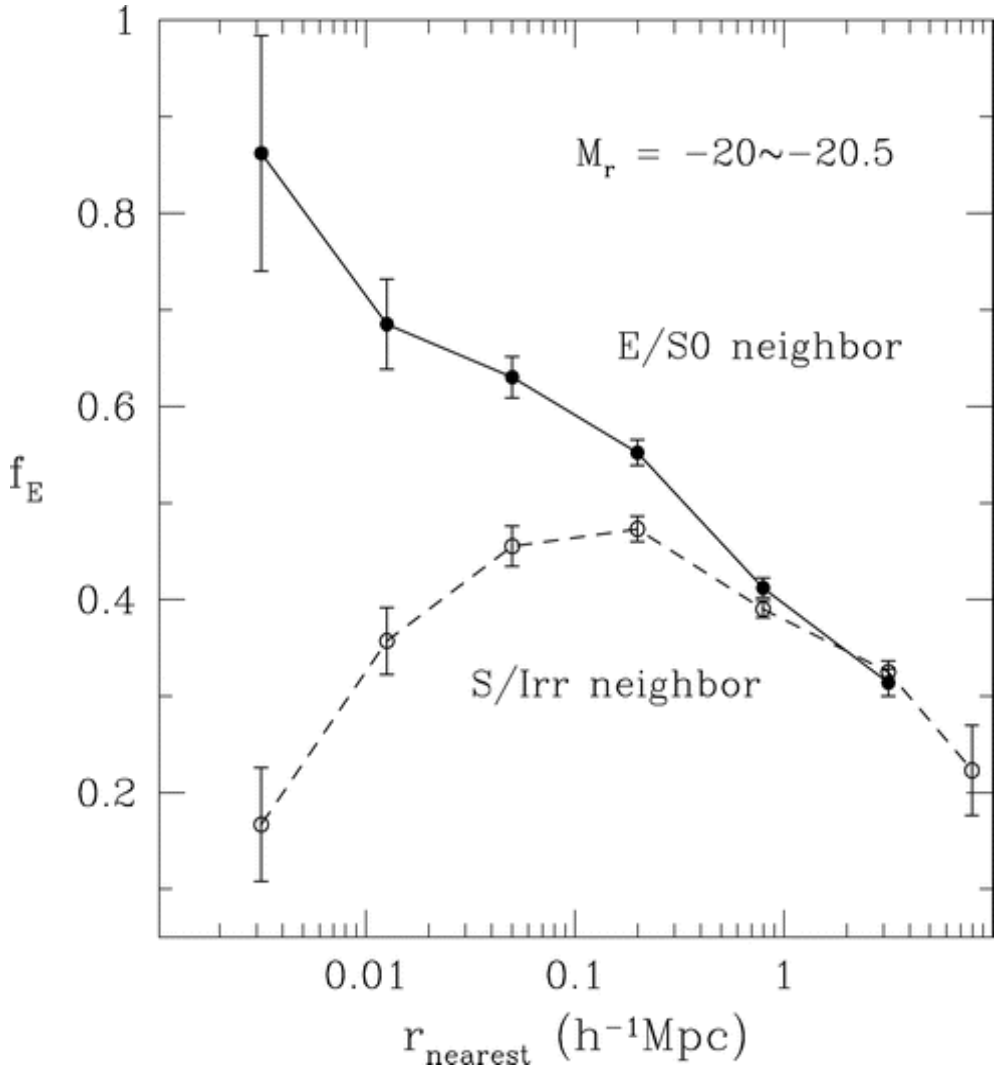
eg, $\Delta m=1$, $r_p = 1\ h^{-1}$Mpc, $\Delta V=1000$km/s

- However, we employed the projected distance to the nearest neighbor normalized by the virial radius of the nearest neighbor, $r_p/r_{vir,nei}$ as a measure of isolation along with the background density, since galactic conformity in satellite systems is most pronounced for the satellite galaxies at $r_p/r_{vir,host} < 1$, and the morphology and distance to the nearest neighbor play a decisive role in determining the morphology of a target galaxy (Park, Gott & Choi 2008, Park & Choi 2009),

Effect of neighbor

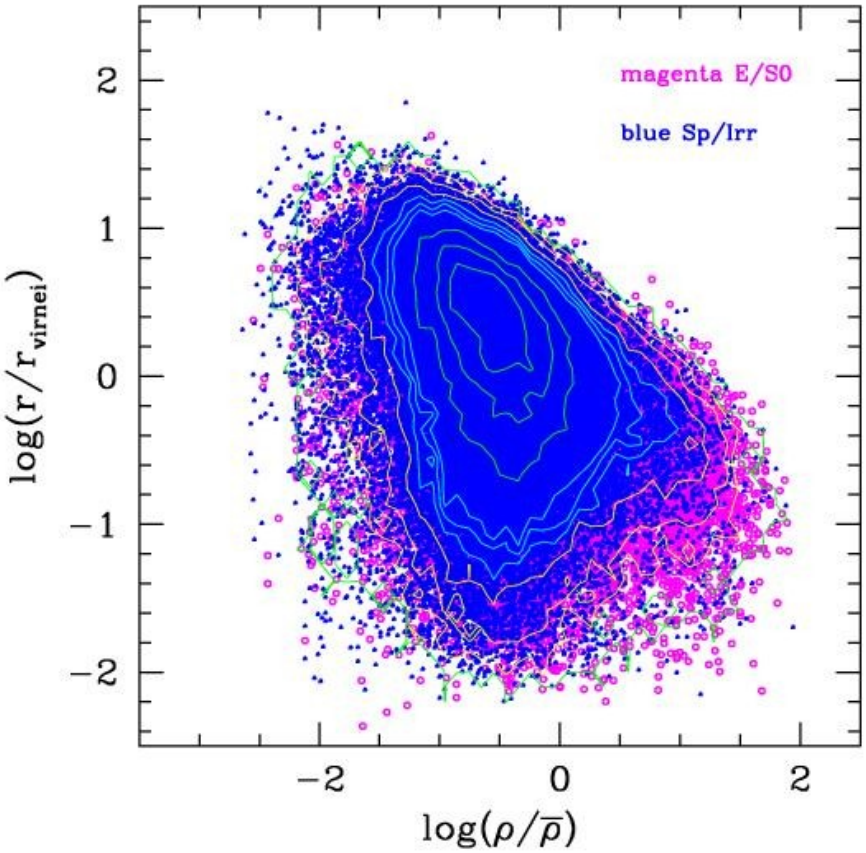
- Morpholoy of a galaxy depends on the distance to the neighbor galaxy.

- At $r < 0.5h^{-1}$Mpc, morphology of a galaxy strongly depends on the morphology of the neighbor.

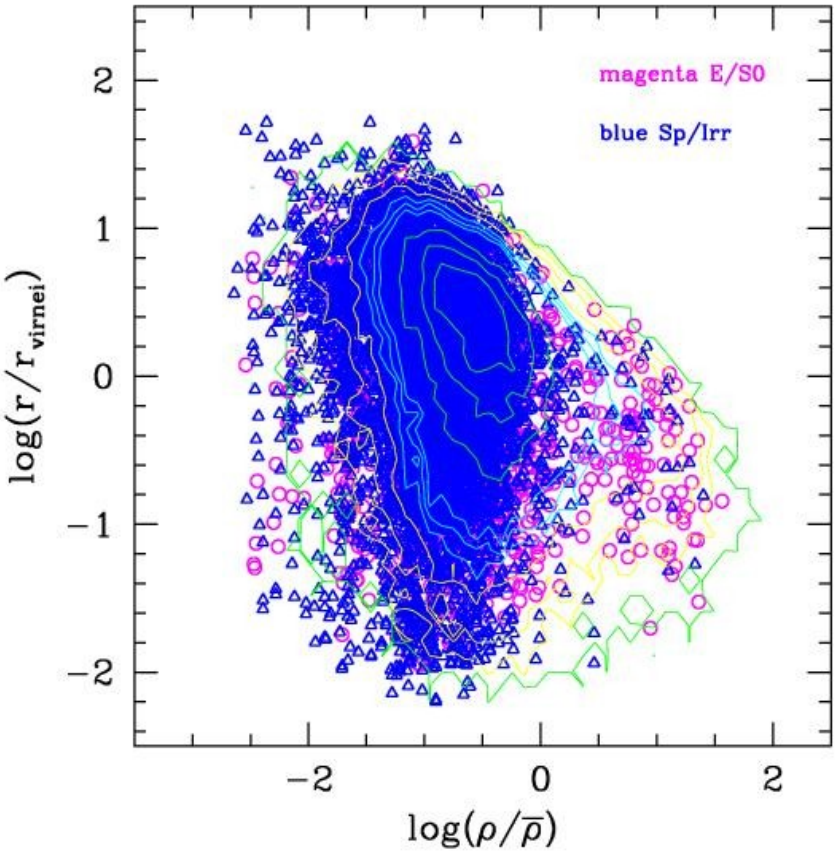


Park, Gott, & Choi (2008)

SDSS DR7 galaxies (n≈10^5)

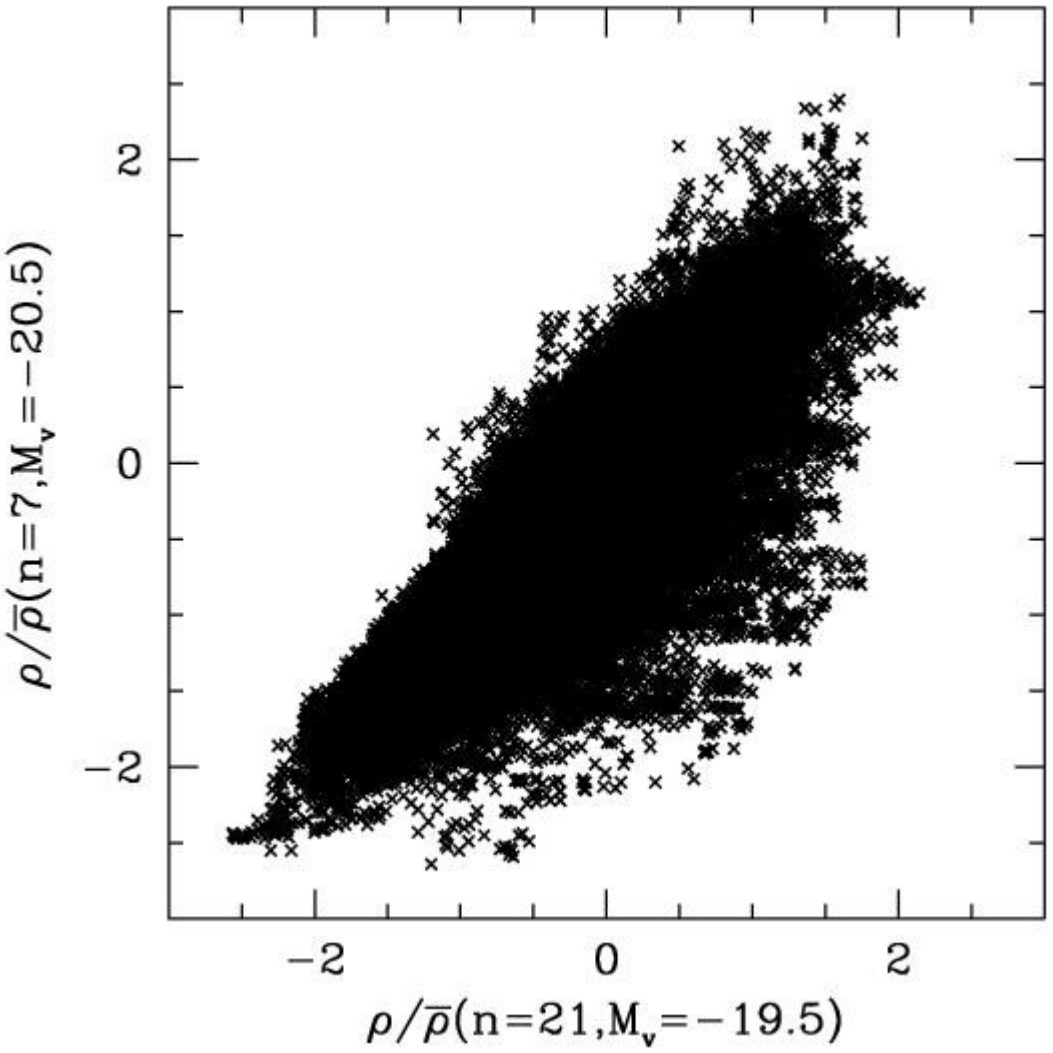


0.02 < z <0.04724



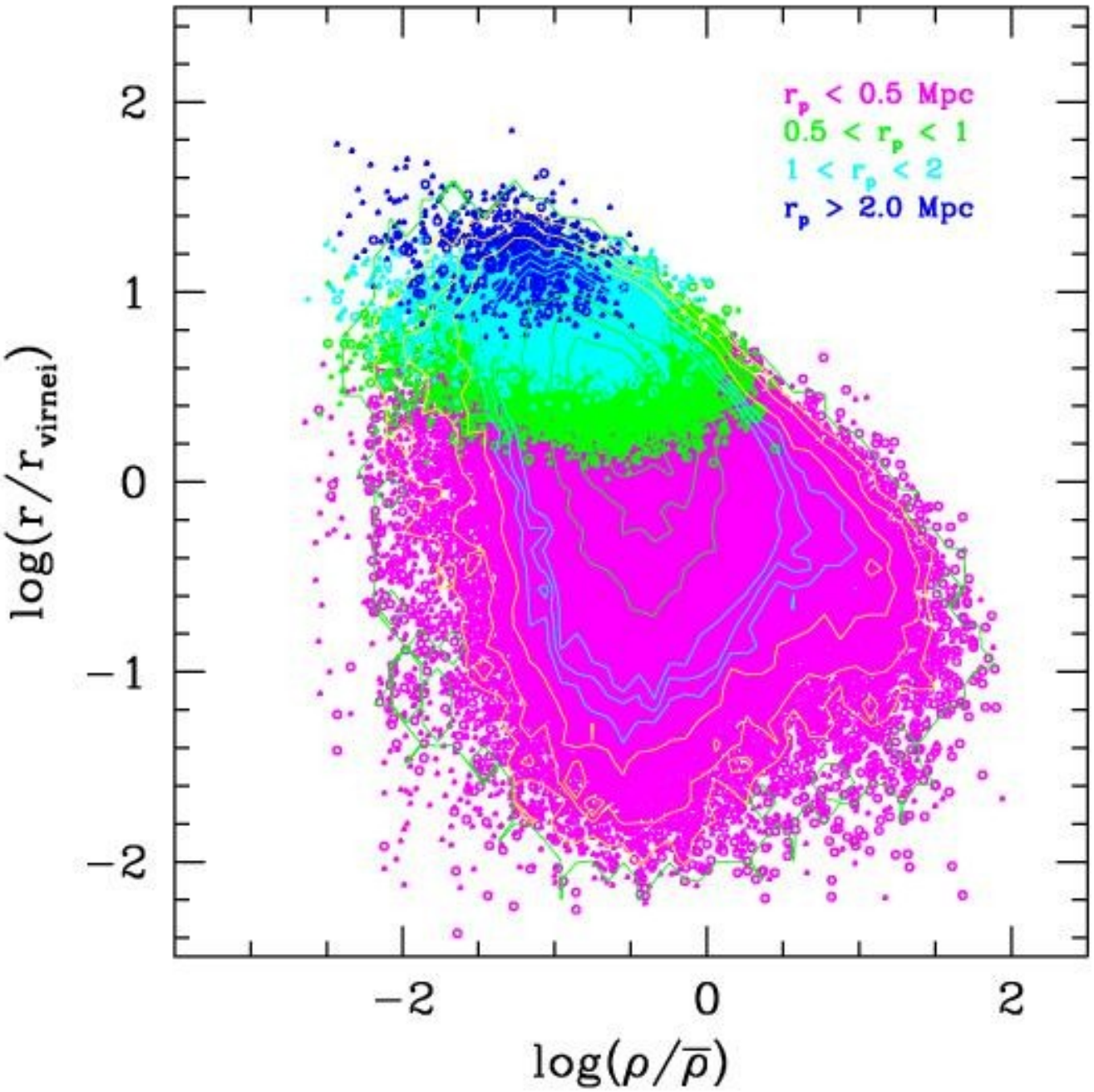
0.01 < Z < 0.02

Local background density

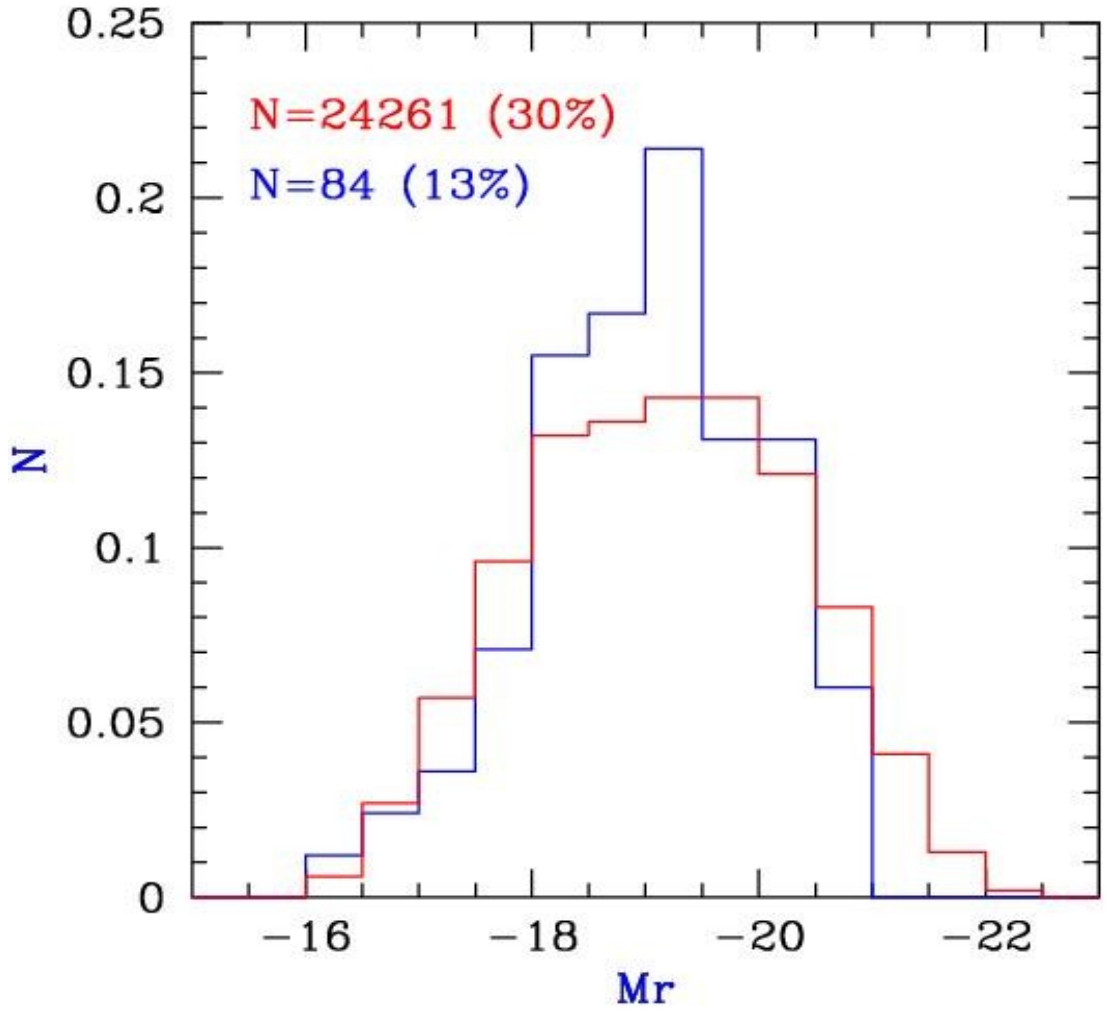


$\rho = n/4\pi r_p^2$ where n is the number of galaxies brighter than M_r^* within r_p

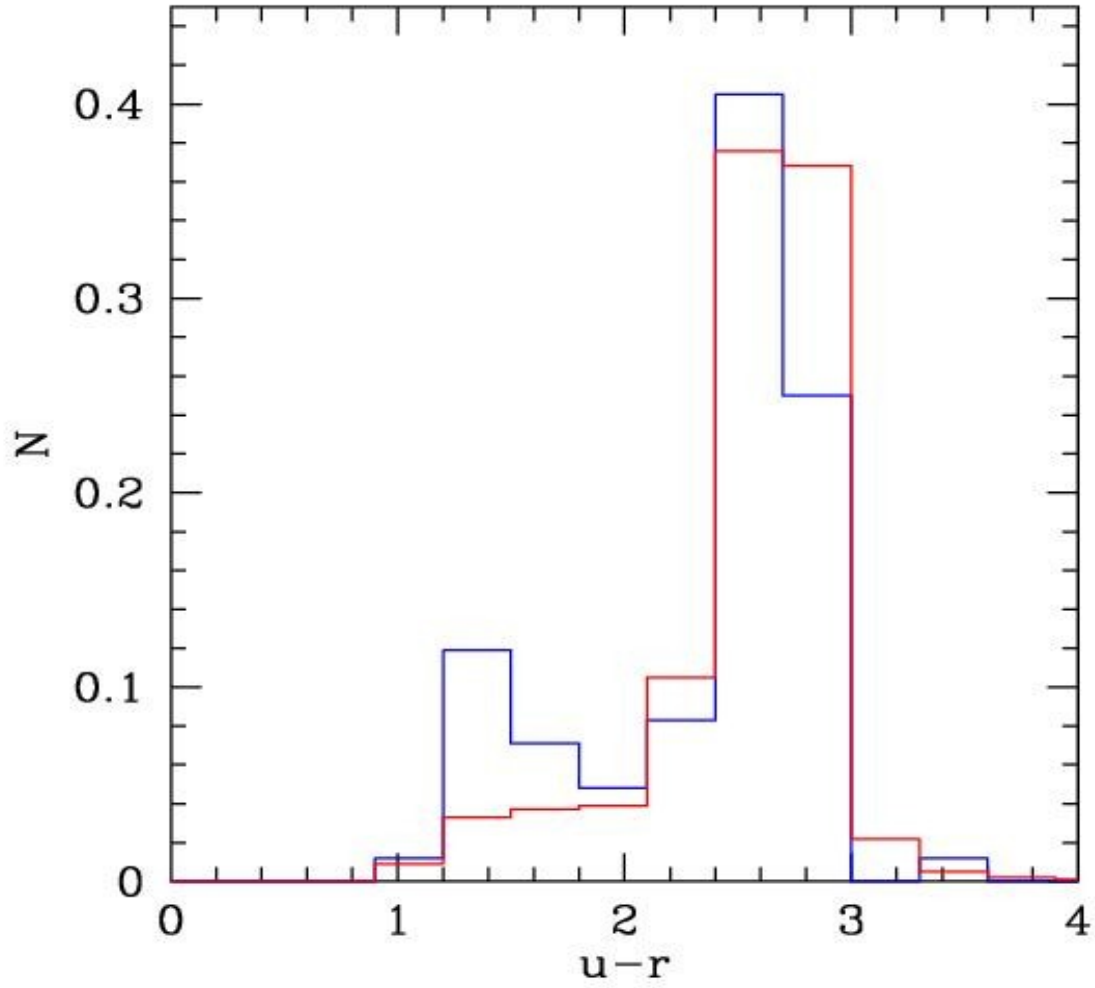
Normalized by the mean density of the volume limited sample ($0.02 < z < 0.05$)


r_p < 0.5 Mpc
0.5 < r_p < 1
1 < r_p < 2
r_p > 2.0 Mpc
$\log(r/r_{virnei})$
$\log(\rho/\bar{\rho})$
2
1
0
−1
−2
−2
0
2

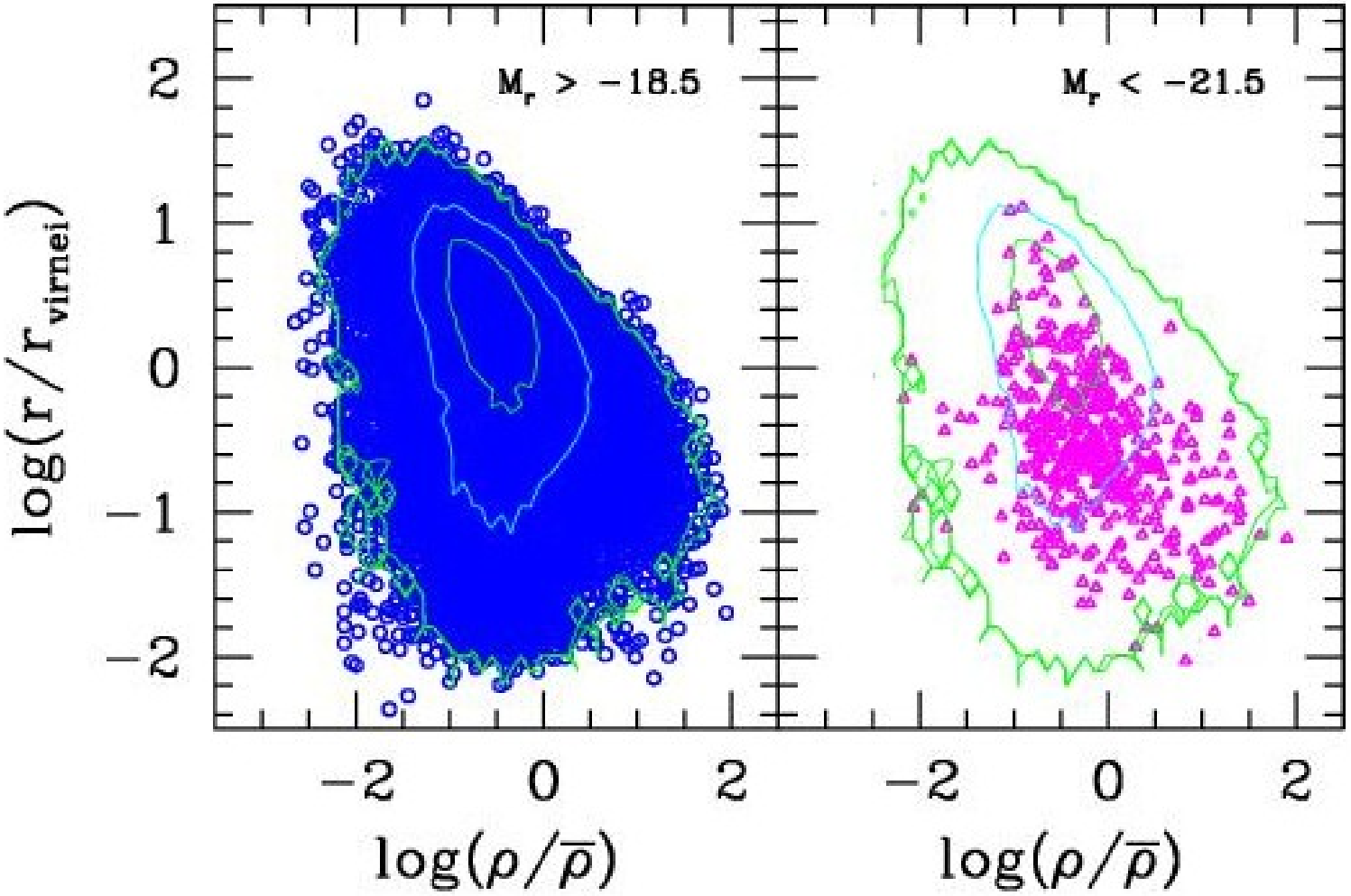
Luminosity of mostly isolated E/S0 galaxies



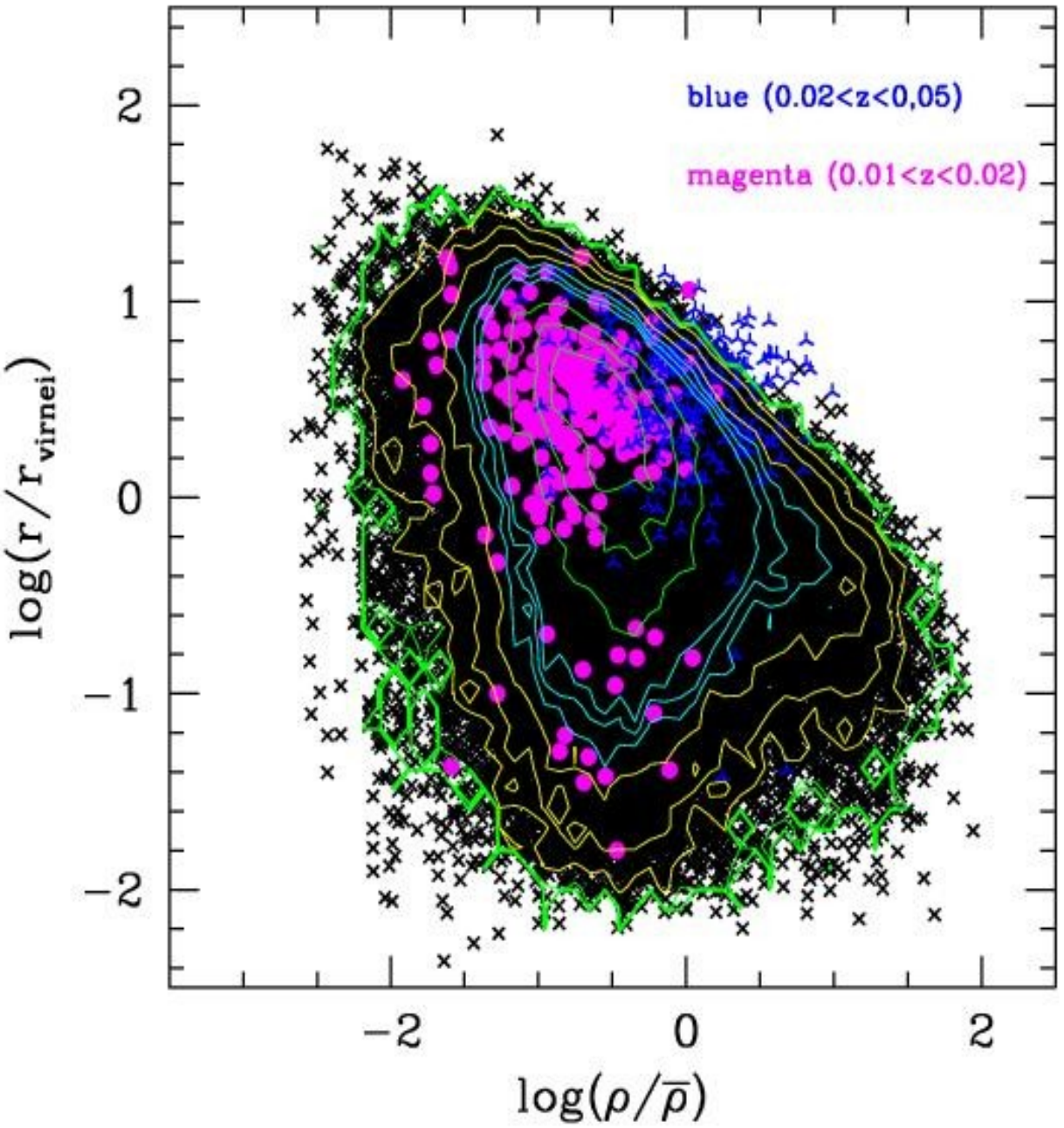
u-r colors of mostly isolated E/S0 galaxies



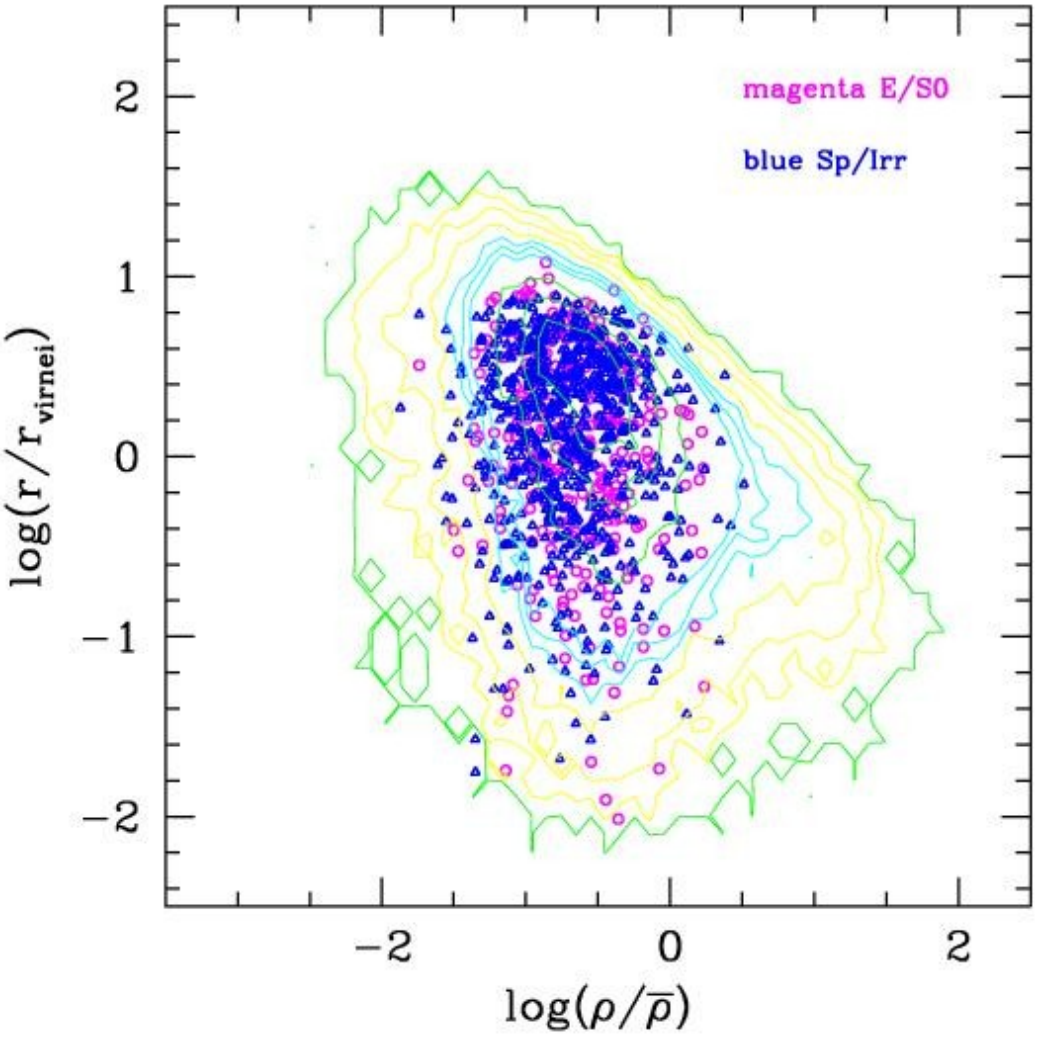
Luminosity distribution of galaxies in 0.02<z<0.05



CIG



Isolated satellite systems



Conclusions

- Morphology conformity prevails in the galactic satellite systems of which typical size is less than 1Mpc.
- Morphology conformity holds for both high and low density environment.
- The origin of the conformity in morphology is thought to be mainly hydrodynamic effects.
- The projected distance to the nearest neighbor normalized by the virial radius of the nearest neighbor along with the background density provide a useful diagnostics for the selection of isolated galaxies.


Thank you!