

# ENVIRONMENTAL DEPENDENCE OF PROPERTIES OF GALAXIES IN THE SLOAN DIGITAL SKY SURVEY

Changbom Park, et al. 2007, ApJ, 658, 898

# OUTLINE

- I. Introduction
- II. Observational Data
- III. Analysis
- IV. Results
- V. Dependence on Analysis
- VI. Summary and Discussion

# I. INTRODUCTION

- ◉ From 1930s, environmental dependence of galaxy properties have been recognized, and from 1970s, many authors have tried to explain these dependence.
- ◉ Environmental dependence may be caused by physical process of galaxy formation and evolution.
- ◉ In this paper, they use volume-limited samples from SDSS to study relation between physical properties of galaxies and environment.

## II. OBSERVATIONAL DATA

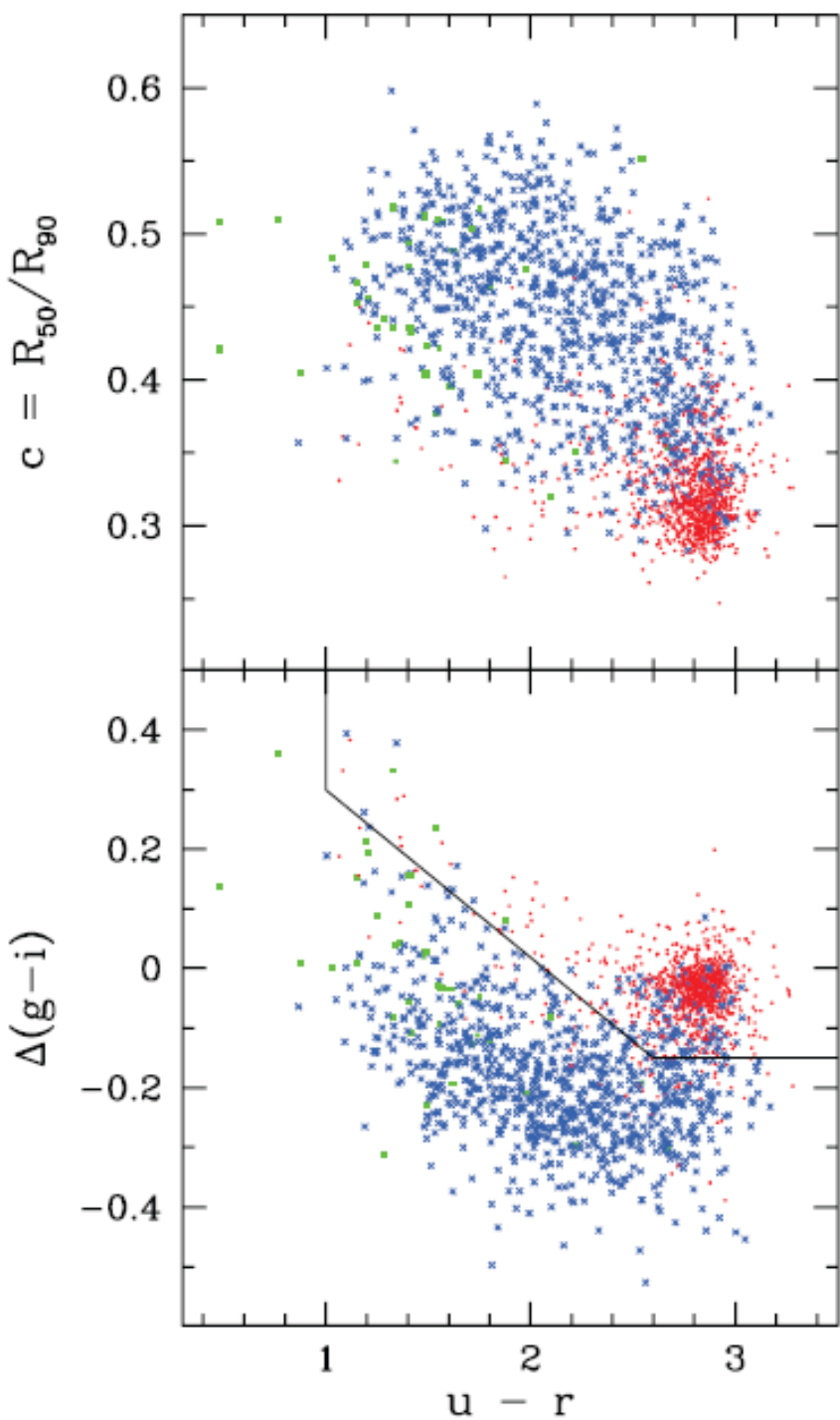
- ⊙ Using SDSS-DR4 samples and a part of SDSS-DR5 samples.
- ⊙ 317,533 galaxies
- ⊙ Magnitude :  $14.5 < r < 17.6$   
( $\rightarrow -22 < M_r < -19$ )
- ⊙ Redshift :  $0.001 < z < 0.5$
- ✓ The spectral redshift of 6% of the samples are not known, so they assign the redshift of the nearest neighbor.

## II. OBSERVATIONAL DATA

- The magnitude and color of galaxies are corrected.
- Correction for dust extinction by MW
  - Schlegel, et al. 1998
- K-correction
  - Blanton, et al. 2003b
- E-correction
  - Tegmark, et al. 2004
- ✓ To avoid dust extinction effect of galaxy itself, they exclude samples whose isophotal axis ratio are less than 0.6.

## II. OBSERVATIONAL DATA

- Definition of color gradient, concentration and morphology.
- Color gradient ;  
g-i color difference between  $R < 0.5 R_{\text{pet}}$  and  $0.5 R_{\text{pet}} < R < R_{\text{pet}}$  (negative means outside bluer)
- Concentration ;  
 $C_{\text{in}} = R_{50} / R_{90}$
- Morphology ;  
Divide galaxies into early and late types using color-color gradient space and color-concentration space.(next figure)



Morphology definition;

Red dots : early-type galaxy

Blue dots : late-type galaxy

### III. ANALYSIS

- How to estimate the local density of galaxies.
  - They adopt the spline kernel with adaptive smoothing scale to include a fixed number of galaxies.
  - In other words, they estimate the area which includes a fixed number of galaxies at fixed luminosity, and estimate the number density of galaxies.

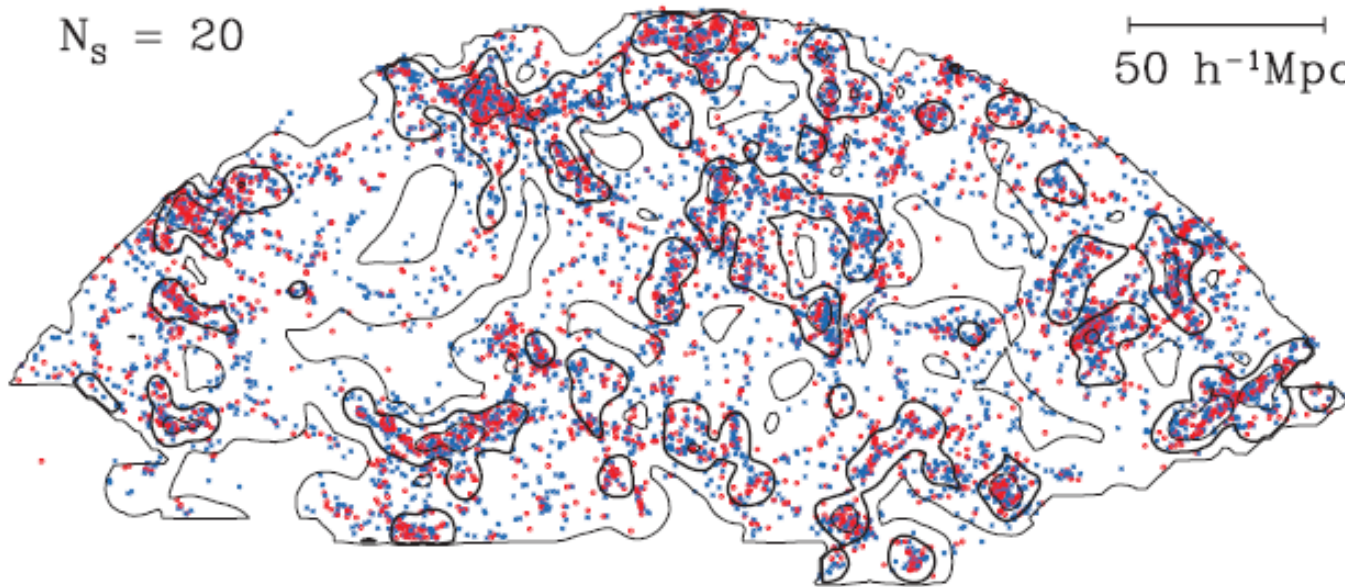


## IV. RESULTS -MORPHOLOGY-

- ◉ Late-type galaxies distribute uniformly, but early-type galaxies favorite dense region.
- ◉ Fraction of early-type galaxies increase monotonically with local density in all luminosity bins.
- ◉ In fixed density bins, fraction of early-type galaxies fainter than  $M_r = -21.2$  increases gradually with luminosity, but brighter ones have fractions larger than tendency.
- ◉ This may imply that bright early-types have different origin from faint ones.

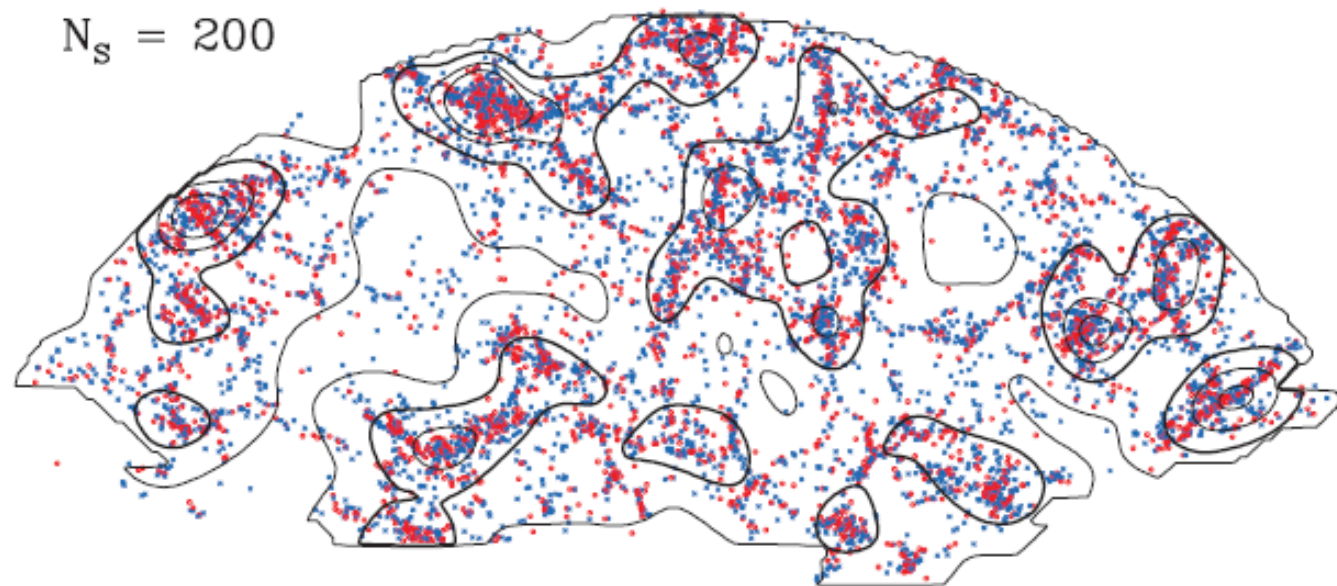
$N_s = 20$

50  $h^{-1}\text{Mpc}$

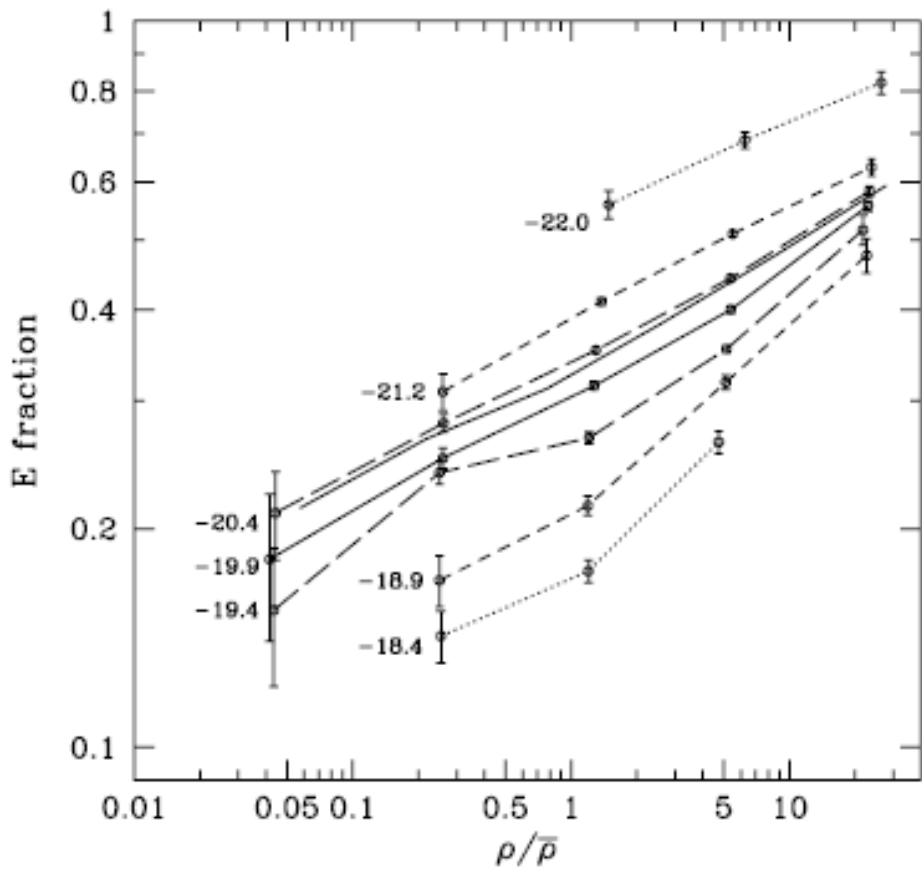


—  $\rho/\bar{\rho} = 0.1, 5$  —  $\rho/\bar{\rho} = 1$

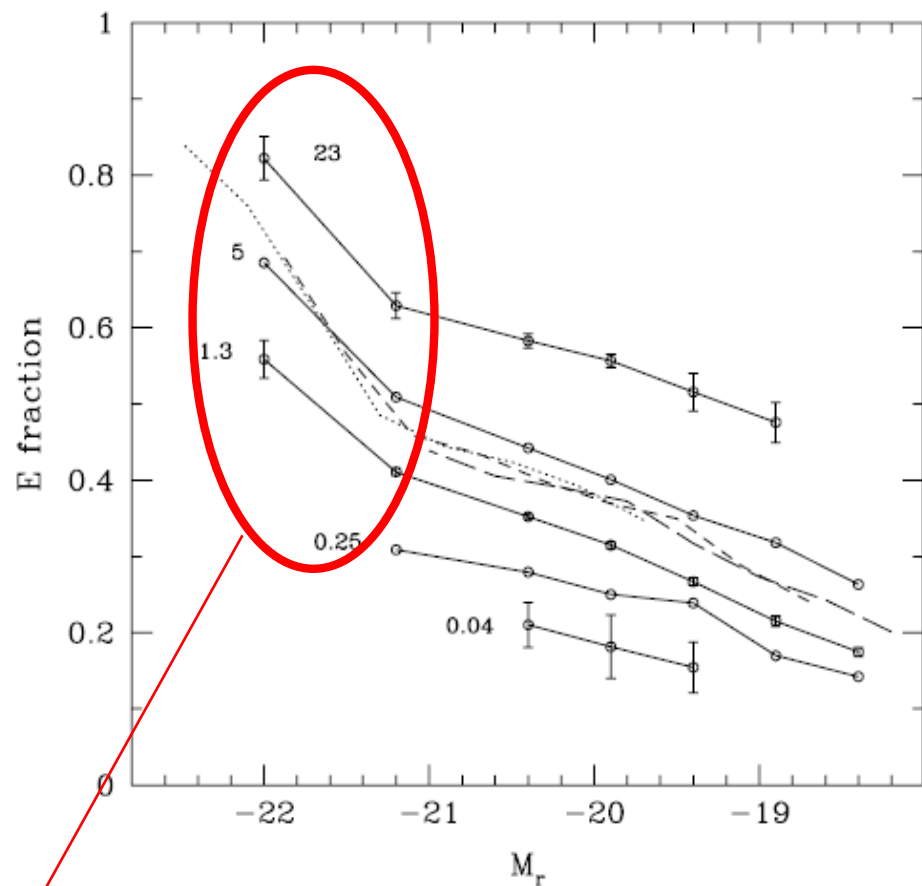
$N_s = 200$



—  $\rho/\bar{\rho} = 0.3, 2, 3$  —  $\rho/\bar{\rho} = 1$



morphology-density relation  
(at fixed luminosity)

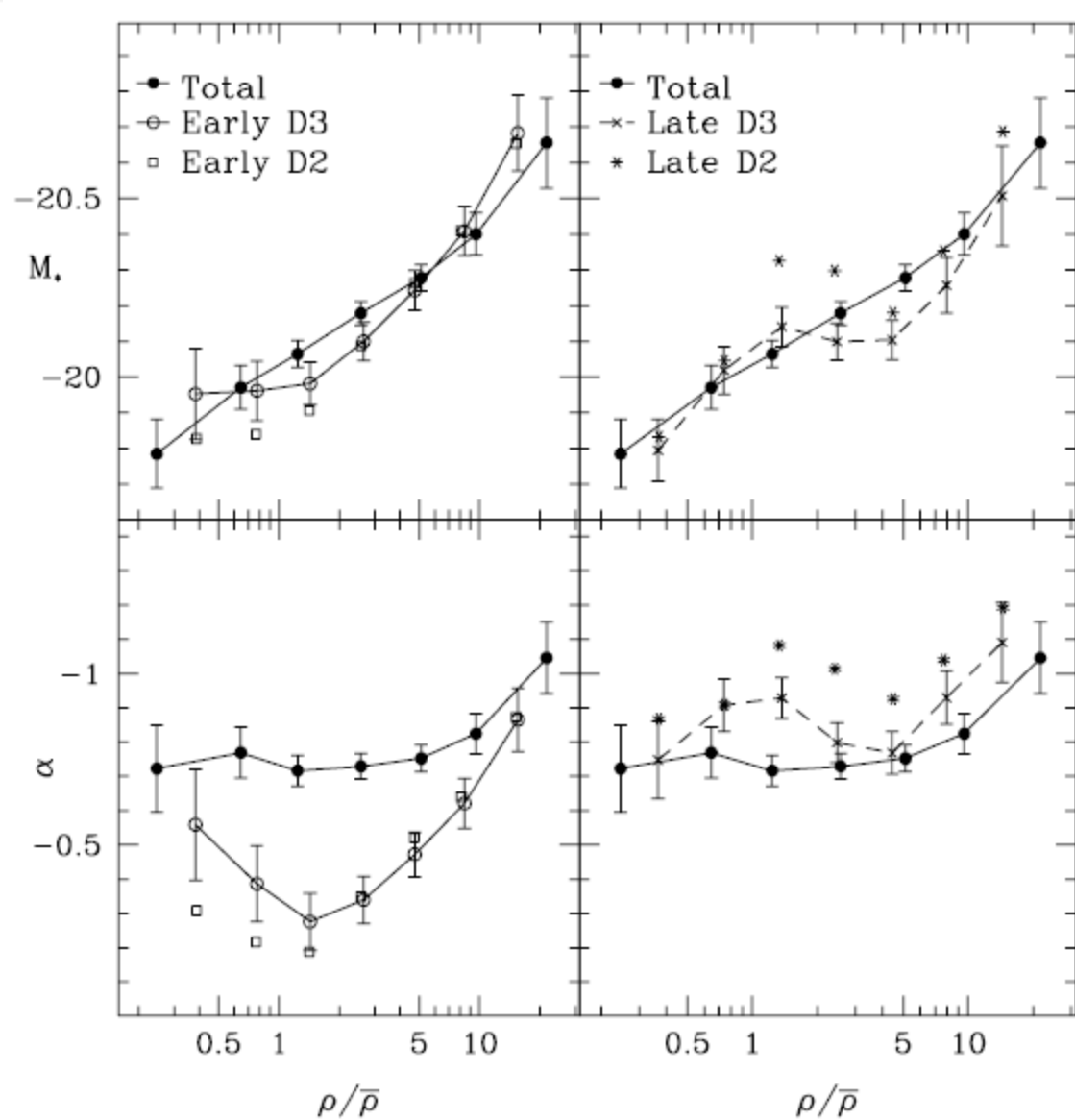
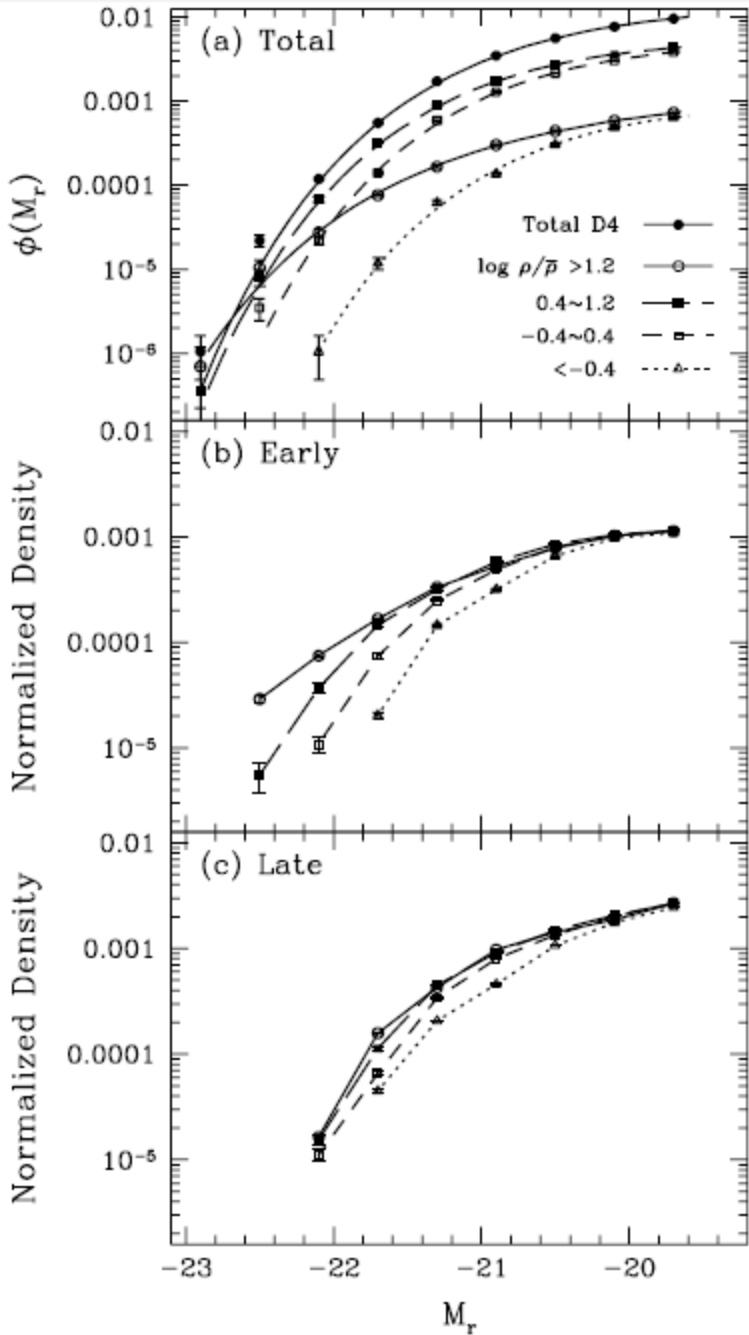


morphology-luminosity relation  
(at fixed density)

slightly higher fraction at luminous end

## IV. RESULTS -LUMINOSITY-

- ⊙ Luminous early-type galaxies exist denser region than luminous late-type ones do.
  - ✓ But they exclude late-type samples whose axis ratio are less than 0.6, so above view is not certain.
- ⊙ The faint-end slope of luminosity function,  $\alpha$ , has large value in dense region for both early-types and late-types.
- ⊙ This means that faint galaxies are more exist in dense region.
  - ✓ But the samples are brighter than -18.5 mag which are 1 mag fainter than  $M^*$ , so above view is not certain.



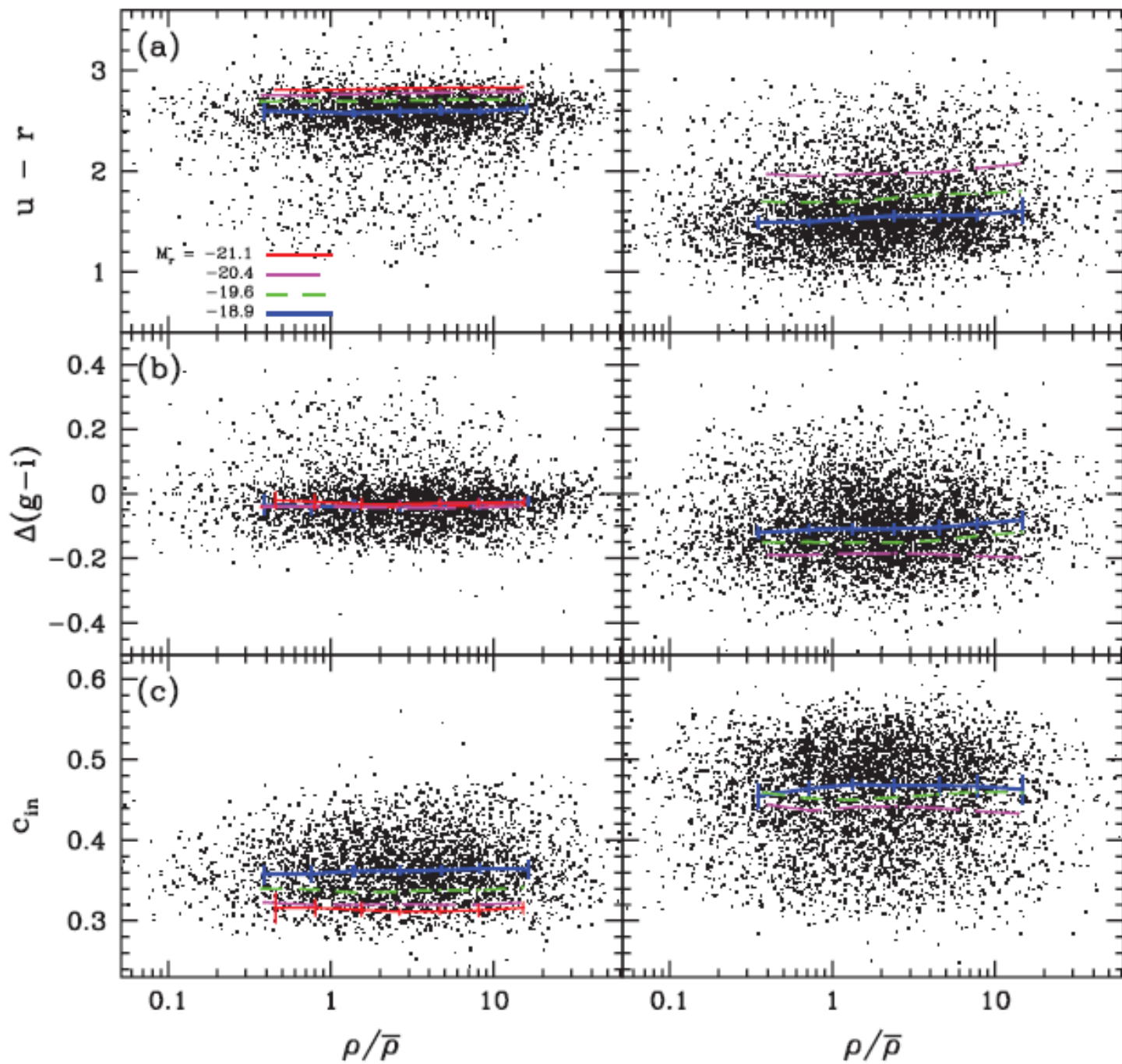
Left). Luminosity function  
 Up). The parameters of Shecher function

## IV. RESULTS -OTHER PROPERTIES-

- ◉ Color ;  
→ no environmental dependence
- ◉ Color gradient ;  
→ no environmental dependence
- ◉ Concentration ;  
→ no environmental dependence

E/S0

S/Irr



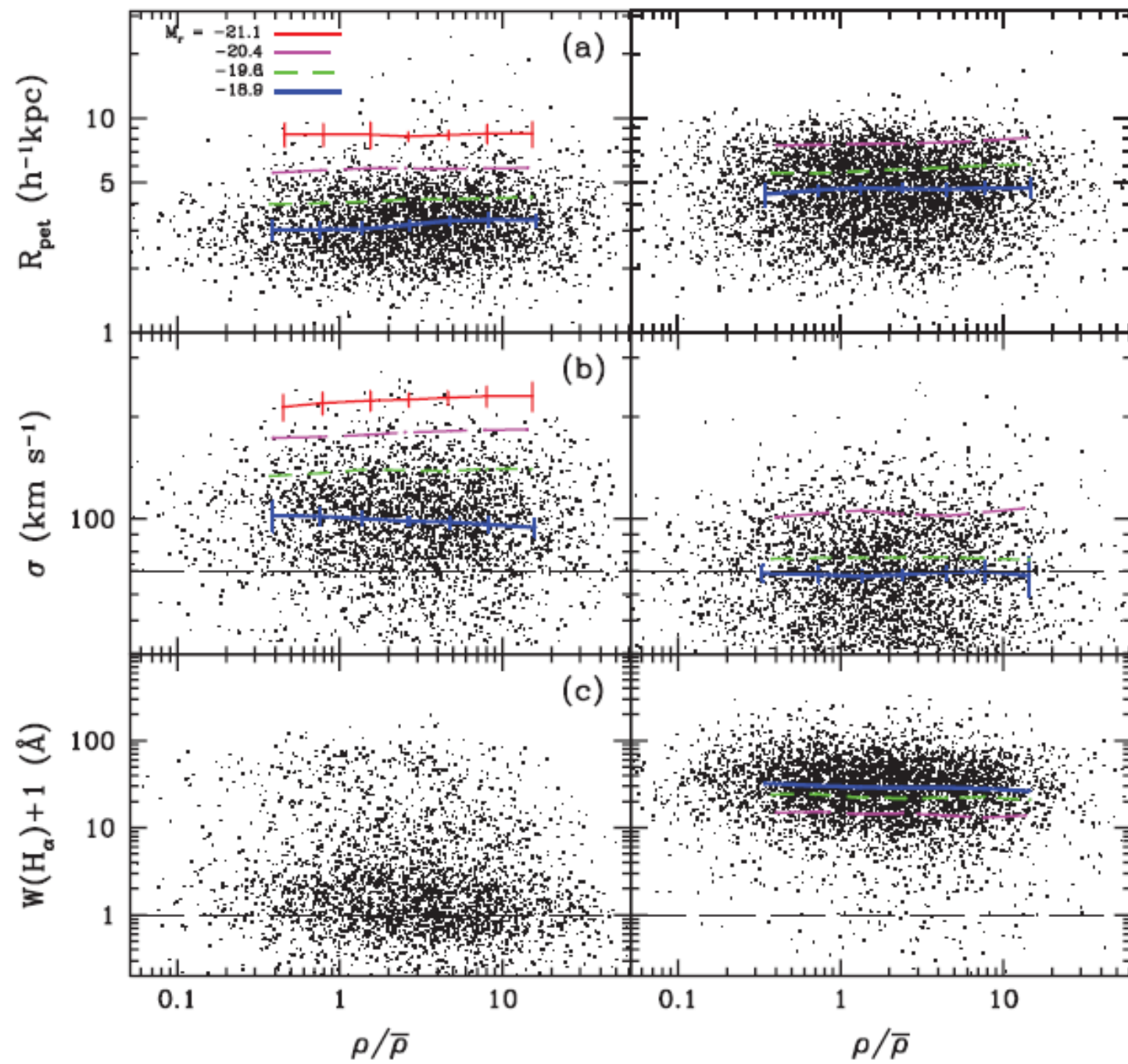
## IV. RESULTS -OTHER PROPERTIES-

- ◉ Size ;
  - slightly larger in dense region, but not clear
- ◉ Velocity dispersion of early-types ;
  - faint early-types have slightly small value in dense region
- ◉ Star formation rate ;
  - faint late-types have slightly low value in dense region
- ◉ Axis ratio of early-types ;
  - no environmental dependence



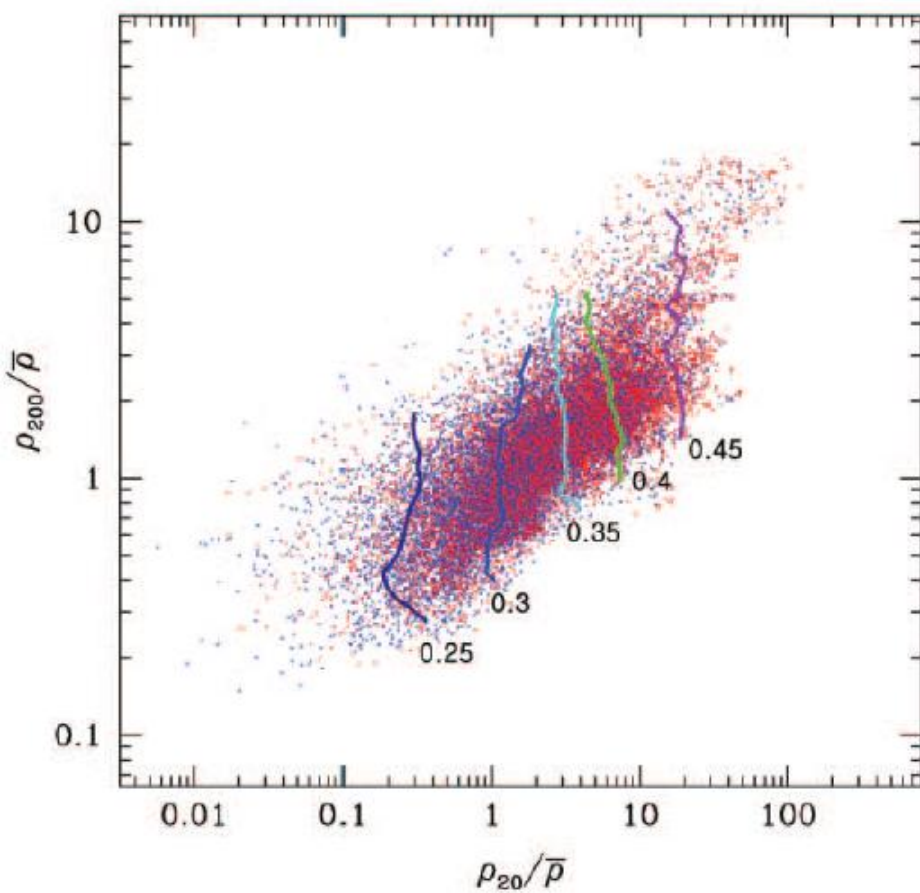
E/S0

S/Irr

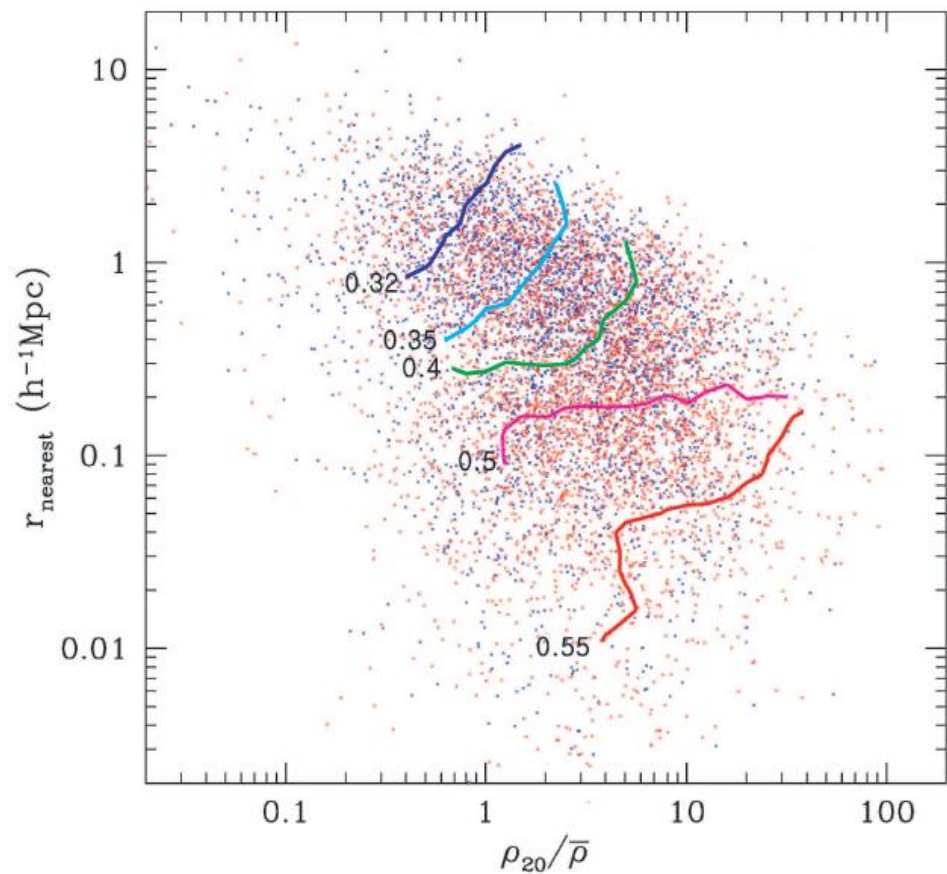


# V. DEPENDENCE ON SMOOTHING SCALE

- ◉ From the results, physical parameters without morphology and luminosity have no or slight environmental dependence.
- ◉ Above discussions are done with smoothing scale,  $N_s$ , is 20. To investigate environmental dependence clearly, change the scale from 20 to 200.
- ◉ But results are not changed.
- ◉ Moreover, environment described by the smoothing scale  $N_s=200$ , roughly consistent 12Mpc, does not affect galaxies' morphology.



small-scale vs large-scale environment

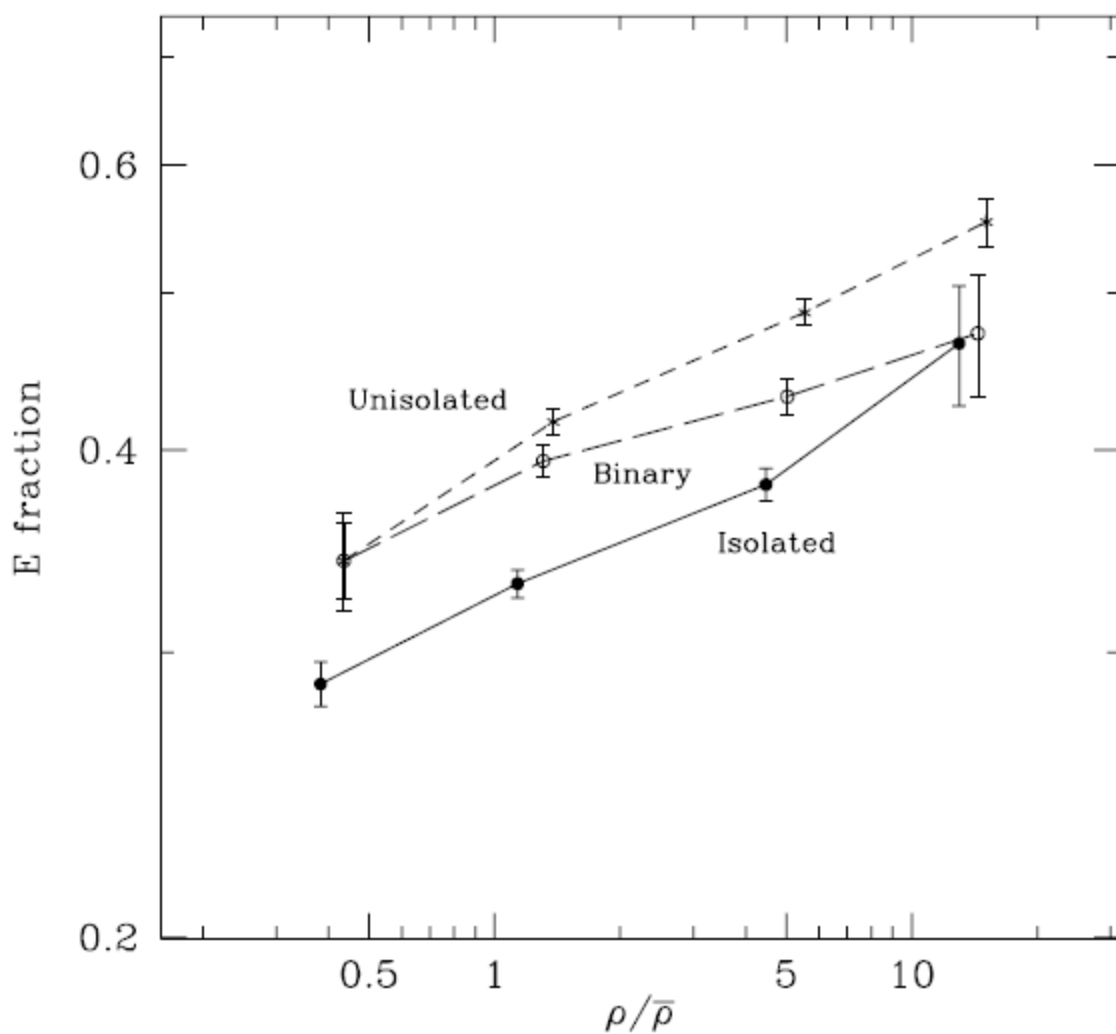


small-scale environment  
vs  
distance to nearest neighbor

Contour is the number of early-type fraction

# V. DEPENDENCE ON SMOOTHING SCALE

- ◉ Next, to study origins of environmental dependence of morphology and luminosity, dividing samples whether a galaxy has neighbors or not.
- ◉ Isolated galaxies have lower fraction of early-type galaxy than unisolated galaxies do.
- ◉ If a galaxy has a neighbor whose mass is larger than 25% of target's, their gravity affect their morphology each other.



Early-type fraction increases with density, but isolated galaxies have lower value of fraction.

# VI. SUMMARY AND DISCUSSION

- ⦿ Differences from previous studies ;
  1. They use the spline kernel to define environment.
  2. They define morphology using only samples' color. The reliability may be exceed 93%.
  3. The data used in this study are volume-limited samples.
  4. They exclude late-type galaxies whose axis ratio are less than 0.6.

# VI. SUMMARY AND DISCUSSION

## ◎ Results ;

1. The fraction of early-types increase with luminosity and local density. But it is still uncertain that galaxies' morphology are affected by whether local density or neighbors' gravity.
2. Physical parameters without morphology and luminosity are not dependent with environment. Their dependence, suggested in previous studies, caused by morphology or luminosity dependence.
3. The environment whose scale is 12Mpc do not affect galaxies' morphology. And the morphology of a galaxy having comparable neighbors in 200kpc is affected strongly by their gravity.

## VI. SUMMARY AND DISCUSSION

- How is the galaxy morphology determined ?
  - The currently popular scenario of galaxy formation and evolution is galaxies grow through merger and gravitational interaction.
  - But this scenario is explanation for dense region, and it cannot explain the origin of continuous morphology-luminosity-environment relation from low to three orders higher density region.
  - Moreover, their results show that a galaxy morphology is affected by exist of comparative neighbors in 200kpc without direct physical interaction.