Bivariate Luminosity Function of Galaxy Pairs

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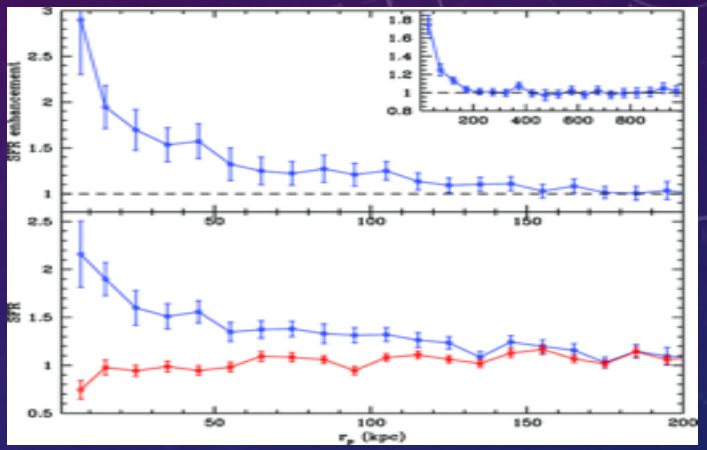
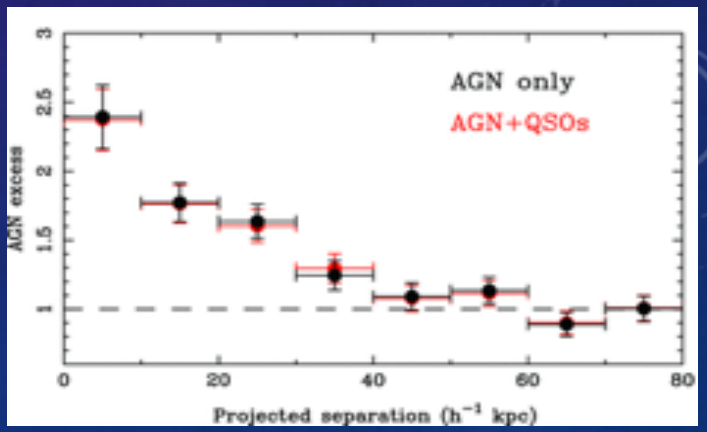
Galaxy Pairs and Interaction

- Galaxy pair is a good probe to study galaxy-galaxy interaction.

- d<50kpc
  - strong interaction ==> different physical properties (SFR, AGN fraction, morphology)
- d>50kpc
  - weak interaction ==> no obvious evidence
- How to quantify weak interaction?



Ellison et al. 2011



Patton et al. 2013

Luminosity Function of Galaxy Pairs

- Luminosity function of two-galaxy system:

$$\Phi(M_A, M_B) = \Phi(M_A)\Phi(M_B)X(M_A, M_B)$$

  - If A and B have no strong interaction, e.g. two field galaxies
    - X(A,B)=1
  - If A and B have strong interaction, e.g. two paired galaxies
    - X(A,B)=f(A,B)?

- Motivation :
  - Bivariate luminosity function of galaxy pairs
  - X(A,B,d)
  - Physical process for X(A,B)=f(A,B)

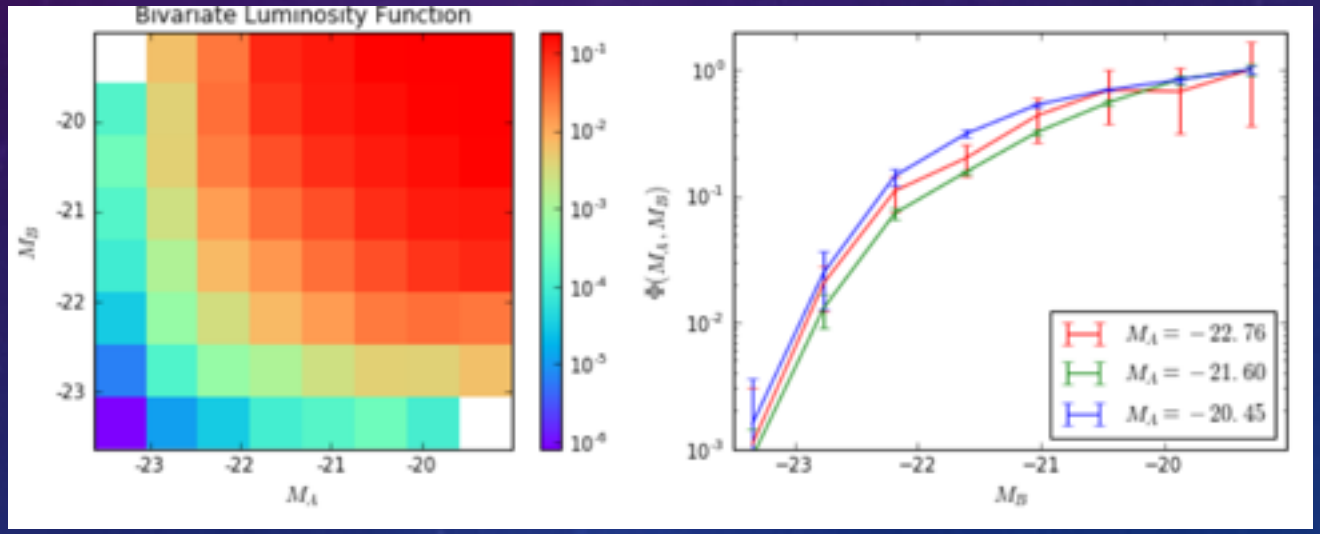
Galaxy Pair Sample

- Parent Sample: SDSS VAGC-NYU (Main Galaxy Sample)
  - r<17.77 after extinction corrected
  - Redshift range: 0.005<z<0.2
  - Spectral redshift: DR7 686542 + DR13 12698 + LAMOST DR4 3753
- Pair Sample
  - Projected separation: 10kpc ~ 300kpc
  - Radial velocity difference: |dv|<500km/s
  - Absolute magnitude in r-band: Mr<-19
  - 44702 galaxy pairs

Bivariate Luminosity Function

- Method: Stepwise Maximum Likelihood 2D (Ball et al. 2005)

$$\psi_{jk} = \frac{\sum_{i=1}^{N_g} W_{ijk}}{\sum_{i=1}^{N_g} \left(H_{ijk} / \sum_{l=1}^{N_M} \sum_{m=1}^{N_X} \psi_{lm} H_{ilm} \right)},$$



- BLF for different projected separation bin

Parameterization

Schechter Function

$$\Phi_{schechter}(M) = \phi_* 10^{0.4(\alpha+1)(M-M_*)} \exp\left[-10^{0.4(M-M_*)}\right]$$

- ϕ^* → Normalization density
- α → Power law slope at faint end
- M_* → Characteristic magnitude

$$\Phi(M_A, M_B) = \Phi_{Schechter}(M_A) \cdot \Phi_{Schechter}(M_B) \cdot e^{\beta(M_A - M_B)^2}$$

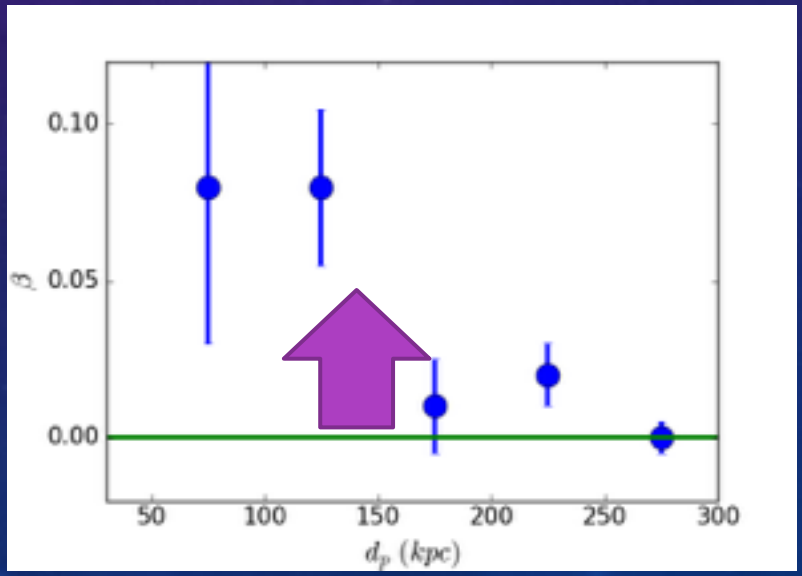
Correlation parameter ß

- ß < 0 → More pairs with small mass ratio.
- ß = 0 → A and B are independent.
- ß > 0 → More pairs with large mass ratio.

Result 1: Characteristic Separation

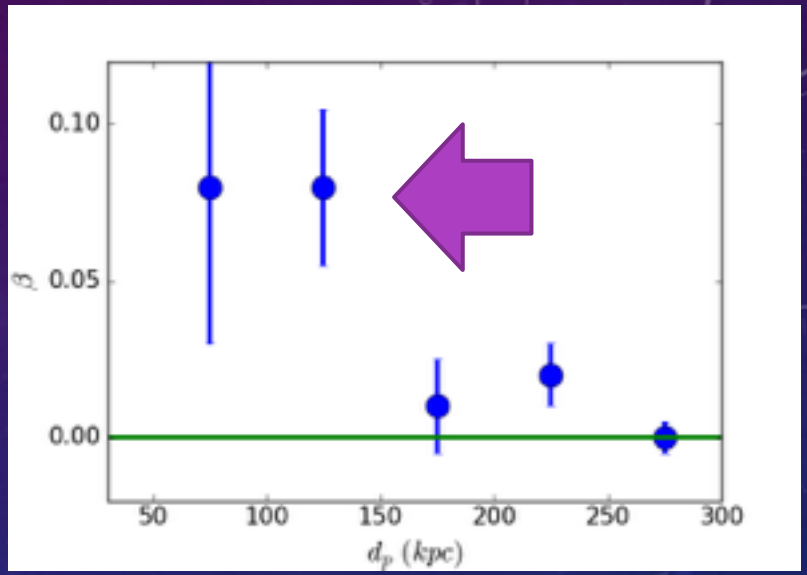
- When d > 150kpc, ß=0
  - Luminosity of pair members are independent.
- When 50kpc<d<150kpc, ß≠0
  - Luminosity of pair members are correlated.

- Characteristic separation: d* ≈ 150kpc



Result 2: Effect of Dynamic Friction

- ß > 0 for 50kpc < d < 150kpc
- Larger fraction of high mass-ratio pairs



- Time scale of dynamic friction

$$\tau_{DF} \sim \frac{M_{pri}/M_{sat}}{\ln(1 + M_{pri}/M_{sat})}$$

  - higher mass-ratio ==> larger merge time scale ==> longer lifetime ==> higher probability to be detect ==> higher fraction
  - observational effect

- Mock pair sample ß=0 + observational effect of dynamic friction
  - ==> pair sample ß=0.8

Future Work

- Pairs for d < 50kpc, parameter ß is no sufficient.
- Bivariate luminosity function for other band (e.g. SDSS g i z, WISE).
- Larger pair sample based on new LAMOST data, especially for close pairs.

Summary

- We make a new galaxy pair sample based on SDSS DR7 Main Galaxy Sample joint SDSS DR13 and LAMOST DR4, which has higher completeness.
- Bivariate luminosity function of galaxy pairs in r-band was calculated for different projected separation bin. We define correlation parameter ß to describe correlation of member magnitude.
- We find a characteristic projected separation d≈150kpc, below which interaction between member galaxies is strong enough to lead ß>0.
- ß>0 could interpret by observational effect caused by dynamic friction.