From Far East to Far Infra-Red: galaxy clustering and Galactic extinction map







## Yasushi Suto

Department of Physics, University of Tokyo



**SDSS Collaboration Meeting 2006 Seoul** 



風

前

华

A

皆

唐

Seoul National University, September 22-24, 2006

Recent work related to SDSS at University of Tokyo: 鶏口牛後

- genus statistics and phase correlation of SDSS galaxies (Hikage et al. 2003, 2004,2005; Hikage, Matsubara, and Suto 2004; Park et al. 2005)
- 3pt correlation functions of SDSS galaxies (Kayo, Suto, Nichol et al. 2004)
- 2pt correlation functions of SDSS quasars and cosmological constant (Yahata et al. 2005)
- constraints on the deviation from Newton's law of gravity from SDSS galaxy power spectrum (Shirata, Shiromizu, Yoshida & Suto 2005; Yamamoto et al. 2006)
- testing the Galactic dust map against SDSS galaxy number counts (Yahata et al. 2006)
- Bispectrum and nonlinear biasing (Nishimichi et al. 2006)

## How galaxies trace mass? galaxy biasing

SDSS significantly advanced our knowledge of galaxy distribution on large scales

how to relate it to mass (dark matter) distribution ?

#### empirical perturbation expansion

$$\delta_{gal} = b_1 \delta_{mass} + \frac{b_2}{2} \delta_{mass}^2 + \cdots$$

often consider the linear term alone (for two-point statistics, or in linear regimes)
 higher-order terms ? ⇒ higher-order statistics

## **3pt correlation functions of SDSS galaxies** *in redshift space*



Clear luminosity, morphology and color dependences of (2pt) bias disappear in 3pt amplitude Kayo et al. PASJ 56(2004) 415

### nonlinearity of galaxy bias required

• if linear bias:

$$\delta_{gal} = b_1 \delta_{mass} \Rightarrow Q_{gal} = \frac{Q_{mass}}{b_1}$$

this is clearly inconsistent with SDSS data !even in nonlinear bias:

$$\left| \delta_{gal} = b_1 \delta_{mass} + \frac{b_2}{2} \delta_{mass}^2 + \dots \Rightarrow Q_{gal} = \frac{1}{b_1} \left[ Q_{mass} + \frac{b_2}{b_1} \right] \right|$$

still, dependence on  $b_1$  is expected  $Q = Q(X_1) \Rightarrow correlation between <math>b_1 \& b_2$ 

## b<sub>2</sub>/b<sub>1</sub> against b<sub>1</sub> for SDSS galaxies and halo-occupation-distribution model



both observations and HOD models suggest a clear trend of  $b_2/b_1$  vs.  $b_1$ fairly insensitive to bias models generic correlation in gravitational instability picture?

## Constraints on deviation from Newton's law of gravity at cosmological scales

Shirata, Yoshida, Shiromizu & Suto (2005, 2006)



#### Modified shape of power spectrum Shirata et al. (2005)





Modified gravity vs. Cosmological constant: from SDSS to WFMOS Yamamoto, Bassett, Nichol, Suto & Yahata PRD in press, astro-ph/0605278 modified Friedmann equation (spatially flat)  $H^{2} - \frac{H^{2/n}}{r_{c}^{2-2/n}} = \frac{8\pi G}{3}\rho$ ■ n=2: DGP model,  $n=\infty$  : cosmological constant  $\sim$  r<sub>c</sub>: key parameter ~1/H<sub>o</sub> r<r<sub>c</sub>: 4D space-time, r>r<sub>c</sub>: 5D space-time if spatially flat  $(H_0 r_c)^{2/n-2} = 1 - \Omega_m$ 

# The cosmological constant vs. the modified DGP model



ratios relative to the cosmological constant model (spatial flatness is assumed) Yamamoto et al. astro-ph/0605278

### **Predicted shifts of BAO peaks**



purely linear theory, observation in  $\Lambda$  CDM assumed Yamamoto et al. astro-ph/0605278

# Current constraints from the SDSS LRG sample



fit to linear theory for k<0.2hMpc<sup>-1</sup> observation in ∧ CDM assumed Yamamoto et al. astro-ph/0605278

# Expected constraints from future WFMOS z=1 sample



#### Yamamoto et al. astro-ph/0605278

## Galactic extinction map vs. galaxy number counts



Galactic extinction map by Schlegel, Finkbeiner & Davis (1998: SFD)  dust extinction estimated from <u>IR emission</u>

can be used for <u>absorption</u> <u>correction</u>???

 independent consistency check is needed

## DR4 survey area vs. A<sub>SFD</sub> SDSS DR4 Imaging ~10<sup>7</sup> galaxies, 6600 deg<sup>2</sup>



## Estimating Galactic extinction from galaxy number count



 divide the SDSS DR4 survey area into many small regions according to A<sub>SFD</sub>

 combine those un-contiguous regions into 69 bins with ~100 deg<sup>2</sup> each

compare the galaxy number density S<sub>gal</sub> for those bins

### Cumulative distribution function of $A_{r,SFD}$



68 % of the survey area has  $A_{r,SFD} < 0.1$ 30 % of the survey area has  $A_{r,SFD} < 0.05$ 

### galaxy surface density Sgal vs. SFD extinction AsFD *If A*SFD is perfect

smaller S<sub>gal</sub> at larger A<sub>SFD</sub> before correction
 constant S<sub>gal</sub> after correction



confirmed for A<sub>SFD</sub>
>0.1, but *quite the opposite for A<sub>SFD</sub> < 0.1*68% of the SDSS
survey area has A<sub>SFD</sub>
<0.1 !</li>

What's wrong ?

<u>*Yahata*</u>, Yonehara, Suto, Turner, Broadhurst & Finkbeiner (2006)

**Origin of the anomaly ?** A<sub>SFD</sub> is estimated assuming that the reddening is proportional to the Farinfrared emission flux (100  $\mu$  m) the anomaly indicates the positive correlation between galaxy surface density and the FIR flux at least where the real extinction is small

**100**  $\mu$  m flux = Galactic dust + galaxies

contamination by the FIR emission from galaxies ???

## comparison with A<sub>HI</sub> from HI map



 $A_{SFD} > A_{HI}$ at  $A_{SFD} < 0.1$ (unphysical binning effect at  $A_{SFD}$ < 0.02)

 stronger trend for larger S<sub>gal</sub> regions

Yahata et al. (2006) astro-ph/0607098

## simulations to test the hypothesis

- Gaussian distributed galaxies over the survey area
  - (a bit confusingly) assume that A<sub>SFD</sub> represents the true Galactic extinction
  - add galaxy FIR contribution according to



Tiny but systematic error in A<sub>SED</sub> a typical amplitude of the systematic error in A<sub>SFD</sub> is ~0.01mag c.f., mean flux of the background IR which was removed in making the SFD map is ~ 0.04 mag this is tiny, but systematic ■  $S_{gal}$  ↑ ⇒  $A_{dust}$  ↑ ⇒  $S_{gal}$  ↑ ↑ becomes even larger after correction for A<sub>dust</sub> systematically overestimates the contrast of real structure maybe important for precision measurements





statistically significant clustering of SDSS activities detected in the Far East this week
 hopefully not an artifact due to the Far Infrared contamination in the extinction map