AGN and Galaxy Clustering at z = 0.3 ~ 3.0 using the Japanese Virtual Observatory

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0. Abstract

Japanese Virtual Observatory (JVO) is an integrated database system developed by Astronomy Data Center of NAOJ. By accessing the JVO, one can retrieve reduced Subaru Suprime-Cam images, and also can access seamlessly to any Virtual Observatory compliant data services of the world. This poster describes an early result from the JVO: study of the clustering of galaxies around an AGN. Using the data obtained through the JVO, we measured correlation length between AGN and galaxy in ten times higher statistics than ever achieved at intermediate redshifts (z=1~2). We find an indication of enhanced clustering at distance less than 1Mpc from a bright AGN sample (M_b < -25)

1. Introduction

According to the hierarchical galaxy formation model, it is assumed that a large galaxy has been formed through the collisions and mergers of smaller galaxies. During the galaxy evolution, a massive BH is formed at the center of the galaxy, and accretion of matters into the BH radiates large amount of energy, which is observed as an AGN. It is, therefore, expected that the AGN is located at higher density region where probability of the galaxy collision is high.

Using the SDSS data, the clustering property of AGN and galaxy has been measured upto z~0.6. To extend this measurement to higher redshifts AGN, deep imaging observations are necessary. Using the data archive of Subaru Suprime-Cam, it is possible to measure the distribution of galaxies around an AGN at the intermediate redshift (z=1~2), which is difficult to be carried out with a smaller telescope. At this redshift range the formation rate of the AGN reaches a maximum, so it is interesting to see the relation AGN activity and its environment, which may reveal a fundamental clue for the mechanism of AGN evolution.

2. Dataset

We used the following dataset:

- AGN Catalog by Veron et al (2006)
- QSO Catalog (SDSS DR-5)
- Subaru Suprime-Cam reduced image
- UKIDSS DR2

We searched the Suprime-Cam images and UKIDSS IR data around the AGNs listed in the Veron et al and SDSS AGN catalog, .

We analyzed for 744 AGN samples.

The celestial distribution of the AGNs are shown in Figure 1.

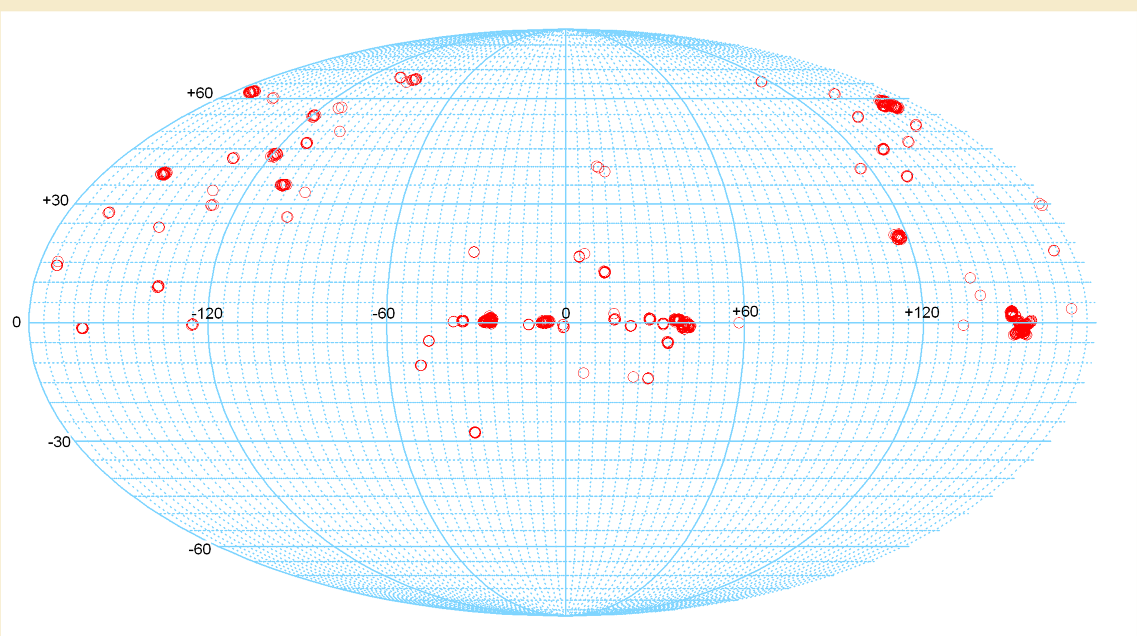

Figure 1 : The celestial distribution of the AGN analyzed in this work.(in equatorial coordinate)

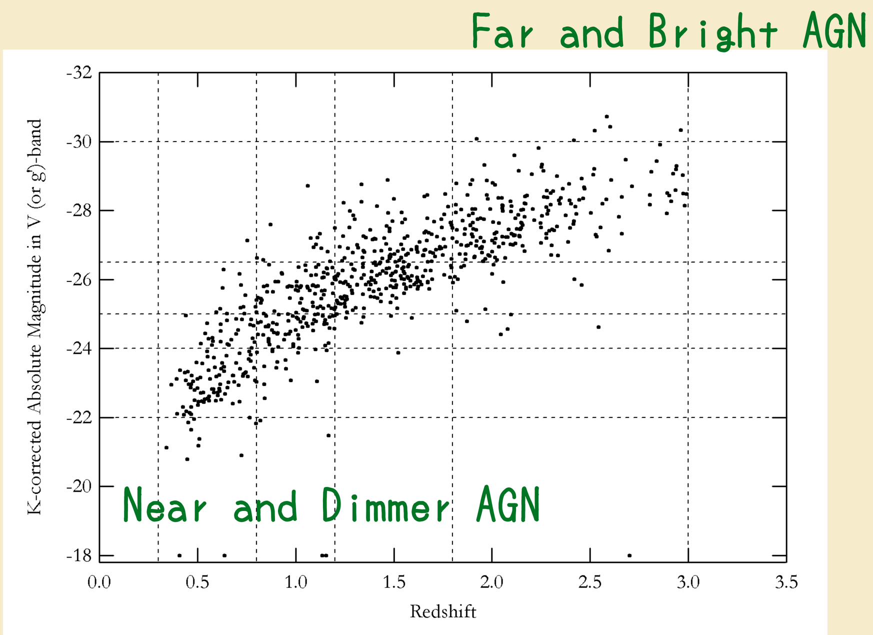

Figure 2: Absolute magnitude-redshift distribution of the analyzed AGNs.

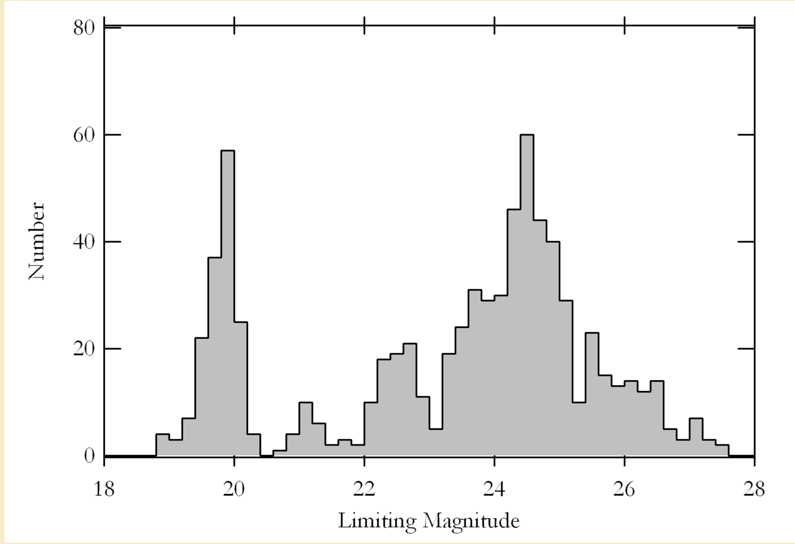

Figure 3: Limiting magnitude of observations for all the AGN samples. The peak around mag~20 corresponds to UKIDSS data, the peak around m~24 corresponds to the SuprimeCam data.

3. Analysis method

1. Create a catalog from Suprime-Cam image using the Sextractor. Create a multi-band catalog which consists of data in nine bands (B, V, R, I, i', z', J, H, K) at maximum.
2. Create a number density histogram of galaxy as a function of distance from the AGN. Unobserved area due to bad pixel, bright object, no data is corrected.
3. Remove samples which is strongly affected by the unassociated cluster of galaxies and/or inhomogeneity of the observations by applying 3 sigma deviation cut and χ^2 cut to the histogram.
4. For each subset of AGN samples grouped by its redshift and brightness, the averaged number density histogram is calculated. Assuming the number density profile of the form of Eq (1), we derive correction length r_0 for a fixed value of γ = 0.8.

$$\xi(r) = \rho(r)/\rho_0 - 1 = (r_0/r)^\gamma \quad (1)$$

$$\omega(r_p) = r_p \left(\frac{r_0}{r_p}\right)^\gamma \frac{\Gamma(1/2)\Gamma((\gamma-1)/2)}{\Gamma(\gamma/2)}, \quad (2)$$

$$= \frac{\sum N_i(r_p)/\sum S_i(r_p) - n_{bg}}{\sum \rho_{i,0}} \quad (3)$$

ρ_0 : average number density of galaxy at AGN's redshift
$\rho(r)$: observed number density as a function of distance from the AGN.
r_p : perpendicular distance from the AGN
Γ: The Gamma function
$N_i(r_p)$: projected number count of galaxies at distance r_p from i-th AGN.
$S_i(r_p)$: effective area corresponding to the number of $Ni(r_p)$
$\rho_{i,0}$: ρ_0 for the i-th AGN
n_{bg} : Back and foreground galaxy number density

The average number density is derived from Luminocity Function obtained by Gabasch et al.(2004, 2007)、Cirasuolo et al (2007).

4. Result

- We detected a clustering signal for dataset with redsfhit < 1.8 (Figure 5).
- We obtained a consistent result with the existing measurements for low redshift sample (z<1.2) (Figure 4, 5). No significant redshift dependence was measured. (Figure 7).
- Bright (and inevitably higher redshift) AGNs have a tendency showing higher clustering property within 1 Mpc.

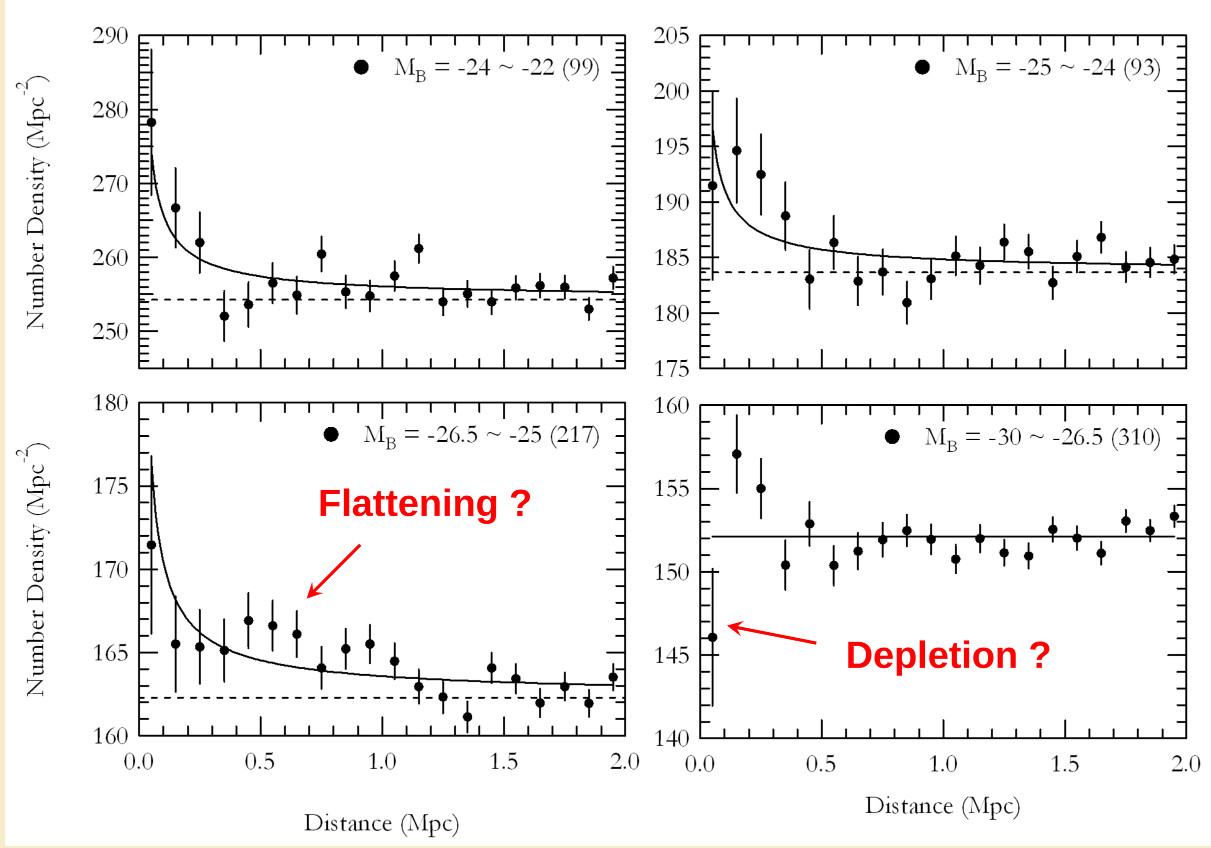

Figure 4: The distribution of Galaxy number density for each absolute magnitude range of AGN.

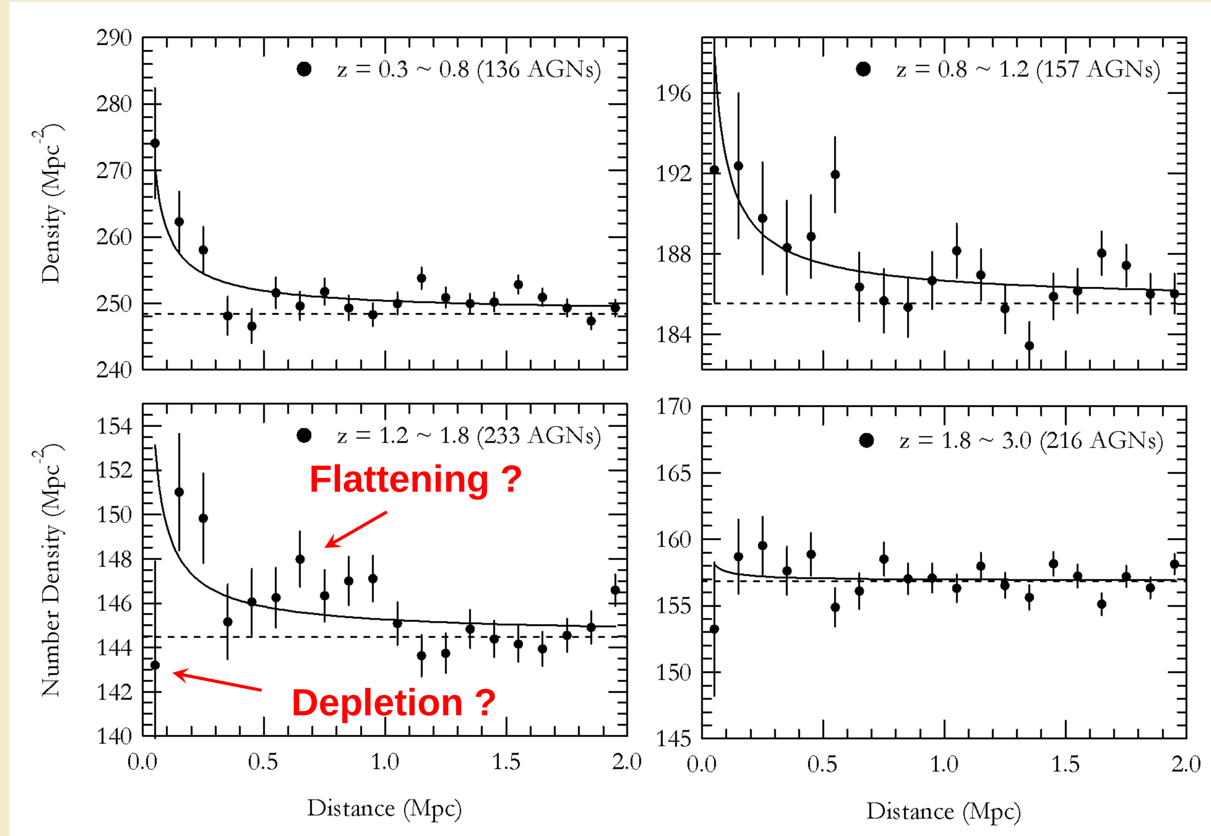

Figure 5: The distribution of galaxy number density for each redshift range of AGN.

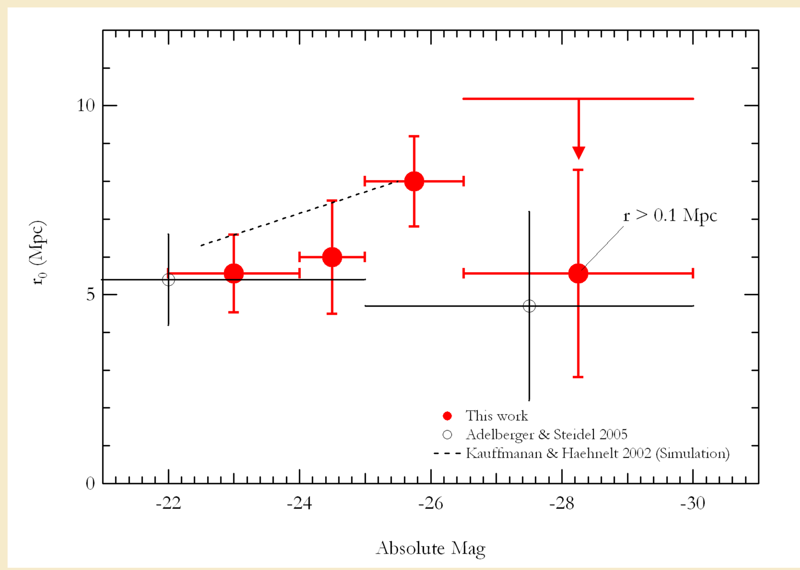

Figure 6: Dependence of the correlation length r_0 on the absolute magnitude of AGNs.

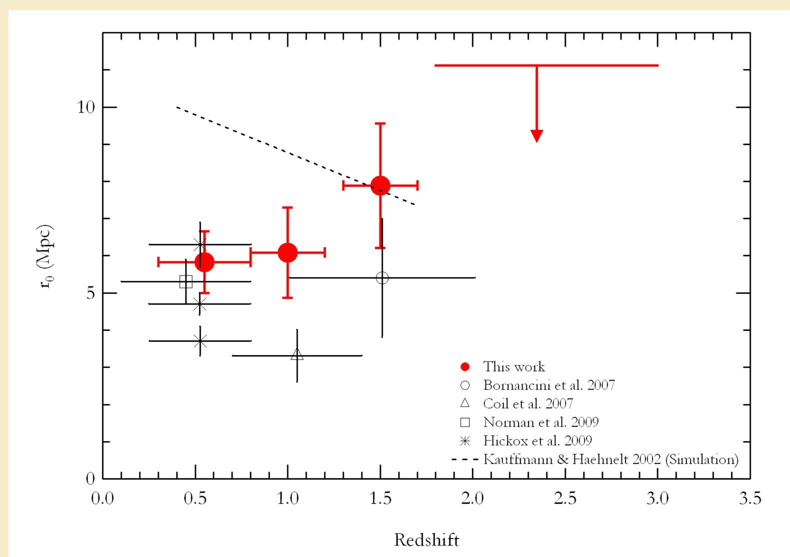

Figure 7: Dependence of the correction length r0 on the redshift of AGNs

5. Summary

We successfully measured the properties of AGN and galaxy clustering for wider redsfhit and absolute magnitude spaces in higher statistics than the other observations have made. The near and dimmer AGN have an environment similar to that of a typical galaxy, so the scenario that the galaxy merger trigger the AGN activity is unlikely for these AGNs. In the case of far and brighter AGN, overdensity is slightly measured at less 1Mpc from the AGN and the distribution is nearly flat at this distance range, which indicates these AGN is not necessarily located at the center of the galxy distribution.

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