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

Y. Shirasaki, M. Tanaka, M. Ohishi, Y. Mizumoto, T. Takata (NAOJ)、N. Yasuda (University of Tokyo, ICRR)

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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 science result of 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 that the clustering is stronger at higher redshifts.

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 of AGN activity and its environment, which may reveal a fundamental clue for the mechanism of AGN evolution and also for the evolution of large scale structure of the universe.

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 750 AGN samples.

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

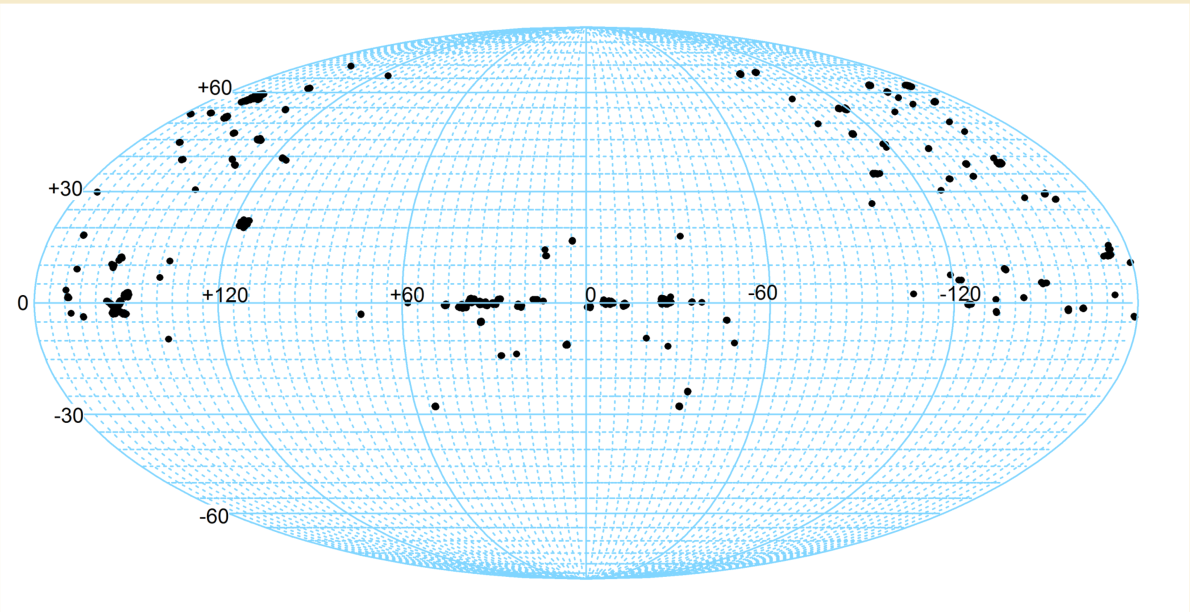

Figure 1 : The celestial distribution of the AGN analyzed in this work.(in equatorial coordinate)

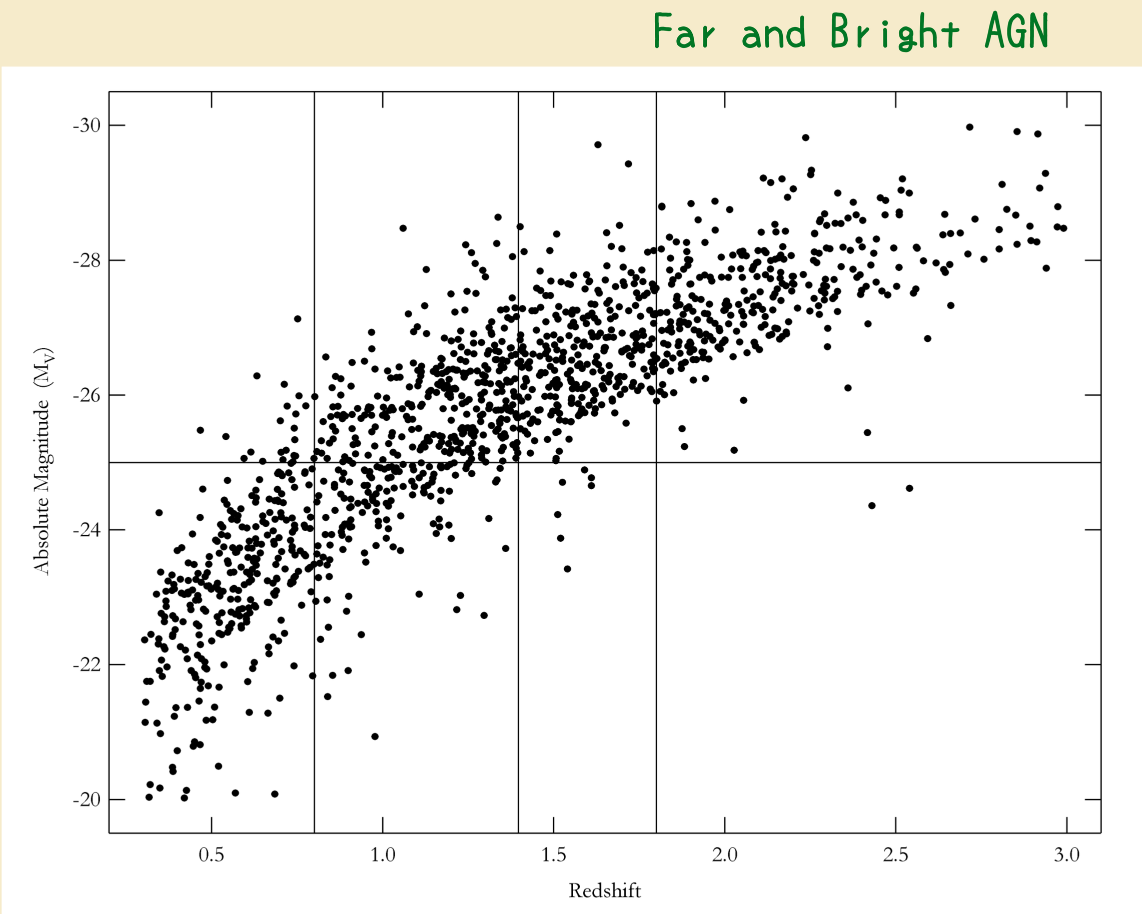

Figure 2 : K-corrected V or g' band absolute magnitude vs redshift of the AGNs used in this work.

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, unused data suffered by a bright object, and bad pixel fraction are 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

ρ_0 is derived from Luminocity Function obtained by Gabasch et al.(2004, 2007)、Cirasuolo et al (2007).

4. Result

- We detected a clustering signals for datasets with redsfhit 0.3 to 1.8 (Figure 3).
- When compared among the same brightness datasets, the clustering is stronger at higher redshift. Blue (Dark AGN) and red (Bright AGN) markers of Figure 4.
- The distribution of galaxies around bright high-z (z=1.5-1.8) AGNs is almost flat at < 1Mpc, which indicates that the AGNs are not necessarily located at the center of galaxy distribution.

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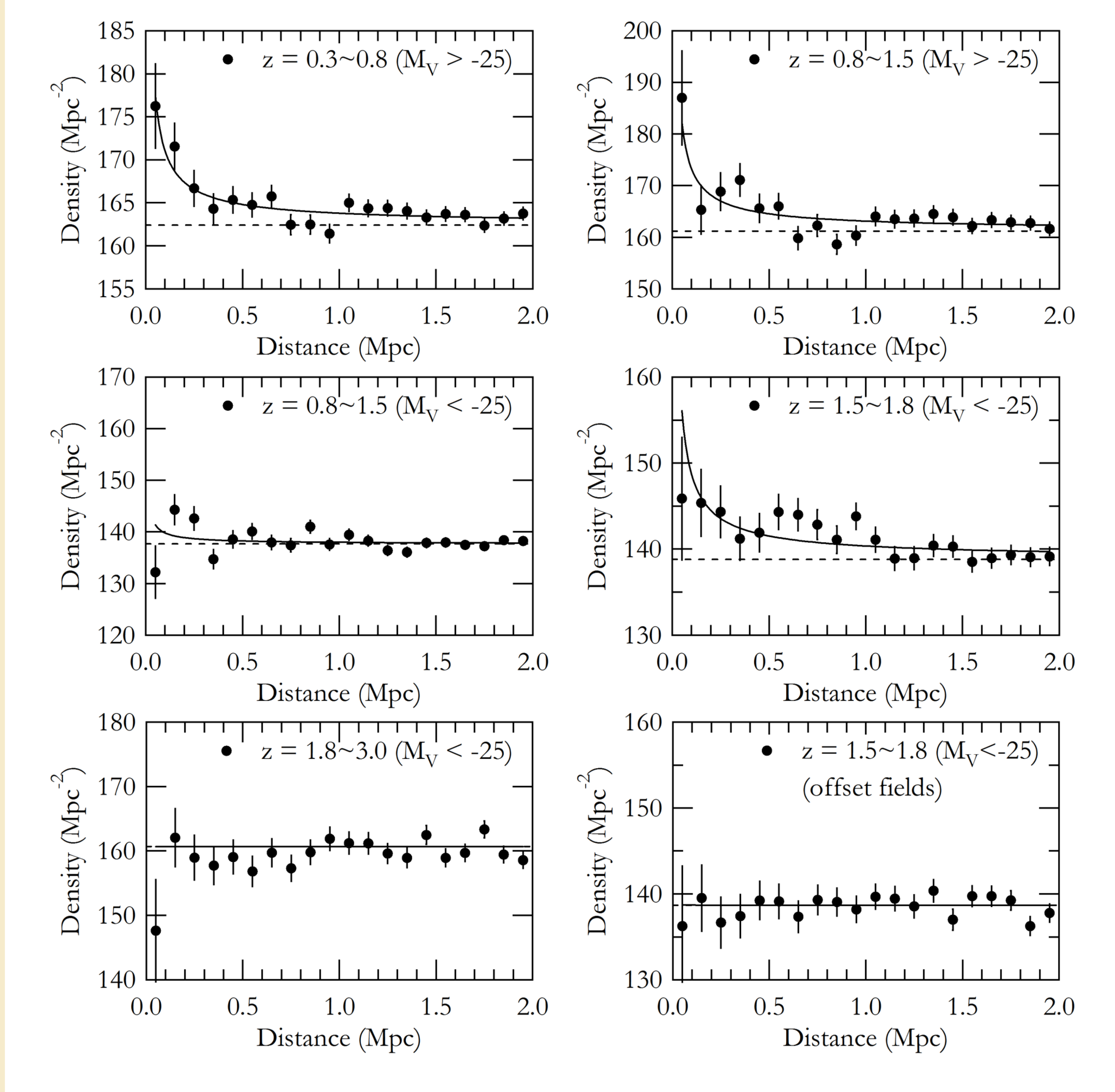

Figure 3: The average of Galaxy number density around AGNs of each absolute magnitude and redsfhit range.

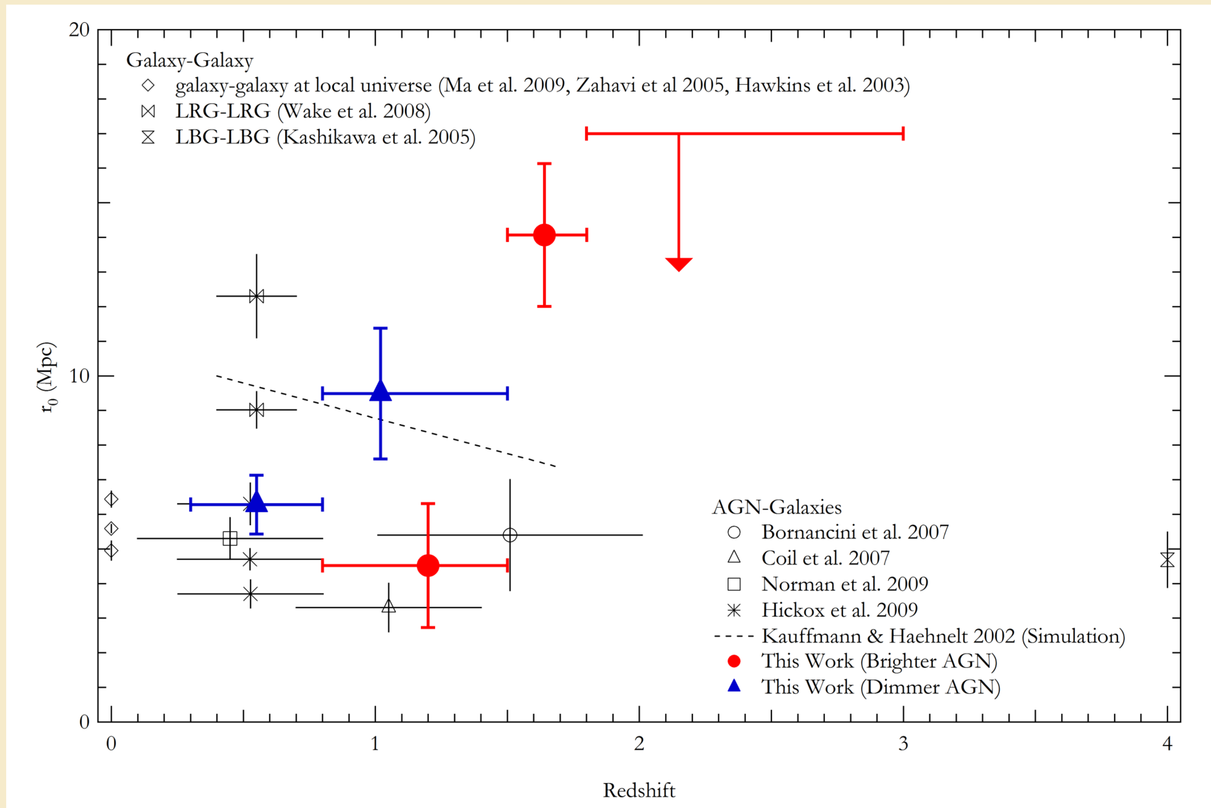

Figure 4: Measured correlation length r_0 as a function of redshift.

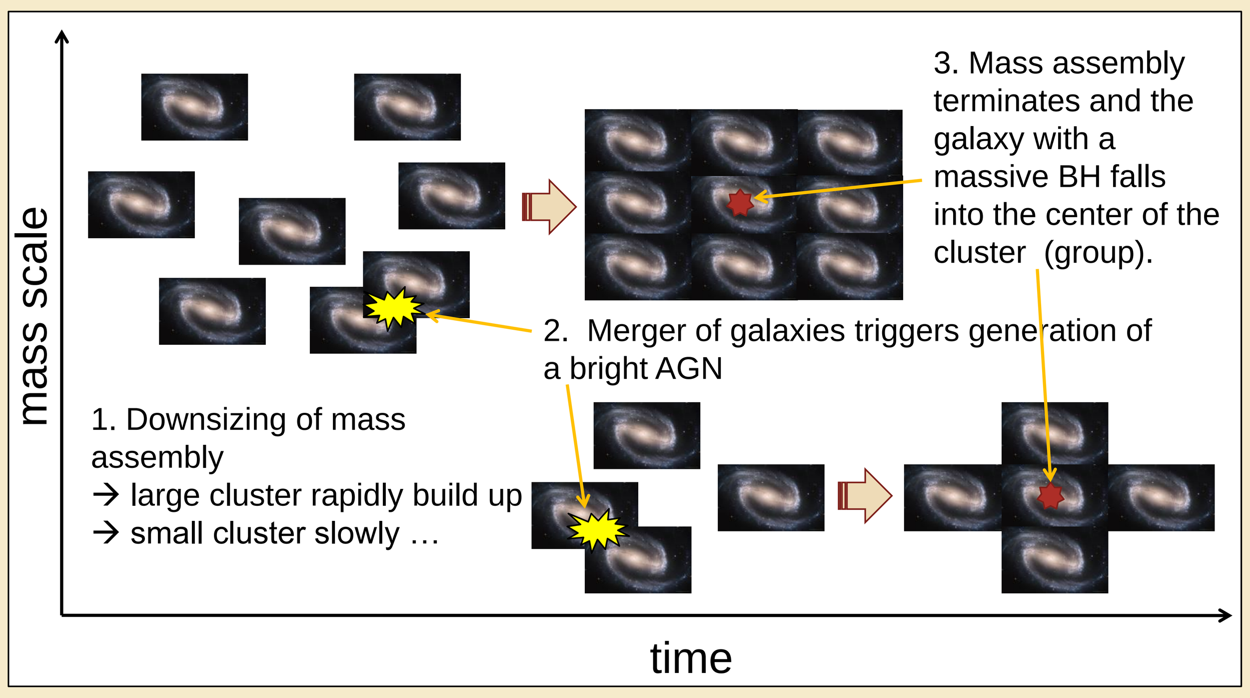

Figure 5: A picture of galaxy clustering and AGN evolution inferred from this observational result.

5. Discussion & Conclusions

This observation result is compatible with the major merger scenario which incorporates the downsizing of mass assembly (Figure 5).

At higher redshift, assembly of larger systems are dominant, so the AGN produced at this epoch has a denser environment. The assembly of the larger system terminates more rapidly than the smaller system, so the smaller scale assembly becomes dominant at lower redshift. The AGN produced during the low-mass assembly has a sparser environment.

AGNs may have similar brightness when they are produced, regardless of their environment. The bright phase of the AGN terminates when gas accreting to the BH is exhausted. The environment of a dimmer AGN reflect the environment where it was produced.

To be more confident about this scenario, more observational data should be obtained both qualitatively and quantitatively. The observations of huge number of AGN fields with the Hyper Suprime-Cam will give more definite observational evidence on the evolution of a massive BH.