Properties of Galaxies around AGNs in the HSC Wide Survey

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The ubiquity of super massive black holes (SMBHs) at the centers of galaxies has been recognized from the observation of nearby galaxies. The mechanism of the evolution of SMBHs is however still an open question. Accretion in a secular mode caused by gravitational instability inside a galaxy is one of the mechanism to deliver the gas content into the SMBH. The bright quasi-stellar objects (QSOs) is thought to be maintained by the accretion induced by external processes such as galaxy interactions and/or mergers. Different accretion modes can be the source of feeding SMBH.

We examined the environment of active galactic nuclei (AGNs) to investigate the relevance of the external process to the evolution of SMBHs with masses larger than $10^8\,M_\odot$ [1]. We used the data of the Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP, S15b) for deriving galaxy samples, and the SDSS QSO catalog from which mass of the SMBHs was obtained using the empirical formula relating the emission line width and continuum luminosity to the black hole (BH) mass. The total number of AGN samples used here is 5,345, and those samples cover the redshift range of 0.6–3.0 and the BH mass range of 10^8–$10^{10}\,M_\odot$. This is the first opportunity to investigate the environment of AGNs up to 3.0, which covers the era of the peak of star formation and mass accretion rate for SMBHs, in unprecedented statistics.

Figure 1 shows the distribution of over density of galaxies with a given absolute magnitude at projected distances of 0.2–2.0 Mpc from AGNs relative to those at 7.0–9.8 Mpc. The measured distributions (markers and dashed lines) indicate over density at a bright end against the expectations calculated from the luminosity function obtained in literature (solid lines). It is known that more luminous galaxies tend to be more clustered than less luminous galaxies. According to the SDSS survey and the Subaru deep survey, the auto-correlation length of luminous ($< M_*$: break point of the luminosity function) galaxies is at most $10\,h^{-1}$ Mpc. The auto-correlation length estimated from the over density measured in this work amount to $40\,h^{-1}$ Mpc if we assume that there is no correlation between the distribution of AGNs and the luminous galaxies observed around the AGNs. To resolve the discrepancy from the previous results, we need to think of the association between the AGNs and the luminous galaxies. This indicates that there is an activity which induces star formation and feeding SMBHs beyond $> 10^8\,M_\odot$ in multiple galaxies concurrently at several Mpc scale. We also obtained the indication that the environment of AGNs with larger BH mass has tendency to have larger red galaxy fraction. Those result indicate that the mechanism to evolve the SMBH beyond $10^8\,M_\odot$ is related with the large scale phenomena such as a collision between clusters and/or groups of galaxies.

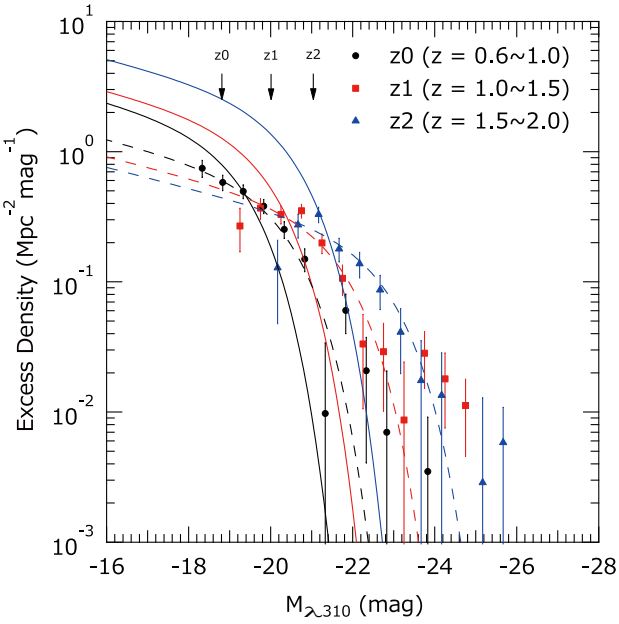

Figure 1: Absolute magnitude distributions of galaxies measured by subtracting the distribution at projected distance from AGNs r_p = 7.0–9.8 Mpc from that at 0.2–2.0 Mpc (markers). Detection efficiency (completeness) of galaxies was corrected. Solid lines represents the distribution expected from the luminosity function measured in literature. Dashed lines are the Schechter function fitted to the observation. The arrows indicate 90 % detection limit.

Reference

[1] Shirasaki, Y., et al.: 2018, *PASJ*, **70**, S30.