Environment of supermassive black holes observed with Virtual Observatory

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It is believed from observational evidences that most galaxies have a supermassive black hole at their centers. A lot of theoretical models for the formation of the supermassive black holes have been proposed. According to the one of the most promising models, at first, a lot of massive stars are formed as a result of a galaxy merger, then intermediate-mass black holes are formed by the collisions of these massive stars. Then the intermediate-mass black holes move to the center of the galaxy, merge with the other intermediate-mass black holes, and then produce a supermassive black hole. Thus it is expected that supermassive black holes are mostly produced at environment of high galaxy density. The supermassive black hole accretes the surrounding matter and emit strong radiation, which can be observed as an active galactic nucleus (AGN). It is observationally found that the number density of AGN peaks at around redshift two, which corresponds to the universe of ten billions years ago, and is thought that the supermassive black holes were produced mostly at this epoch. Thus it is expected that the AGNs produced in this epoch are found in the environment of high galaxy density. Studies of AGN environment have been conducted by many authors by using data obtained from large surveys such as the SDSS, however, the redshift of observable galaxies is limited to 0.6. To extend the study toward higher redshift use of a large telescope is inevitable, however, it is difficult to obtain enough observation time for measuring the AGN environment with good enough statistics.

We decided to use archive data of the Suprime-Cam attached on the Subaru telescope to conduct the study of AGN environment at higher redshift. Japanese Virtual Observatory (JVO)[1] provides reduced Suprime- Cam data and enables correlation search among dataset provided at any VO of the world. We retrieved cutout images of the Suprime-Cam around AGNs, measured number of galaxies as a function projected distance from the AGNs, and derived cross correlation function between AGNs and galaxies[1]. We also used UKIDSS catalog, which is data obtained by the UKIRT infrared telescope. In this study, about two thousands of AGNs at redshift from 0.3 to 3.0 were analyzed (Figure 1). As a result, we found that the high redshift AGNs reside at environment of higher galaxy density, where it is expected that galaxy merger happened more frequently (Figure 2).

[1] http://jvo.nao.ac.jp

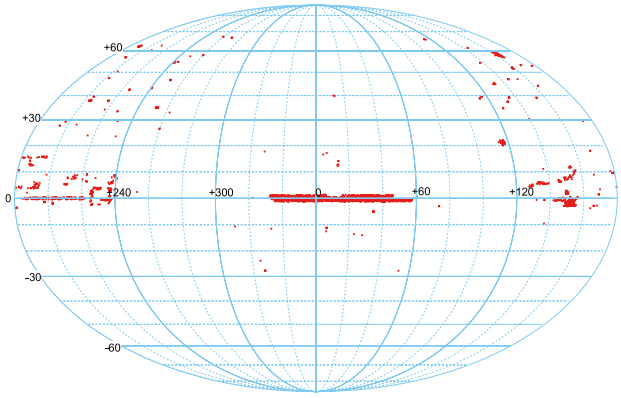

Figure 1: Sky distribution of AGNs analyzed in this work in equatorial coordinate.

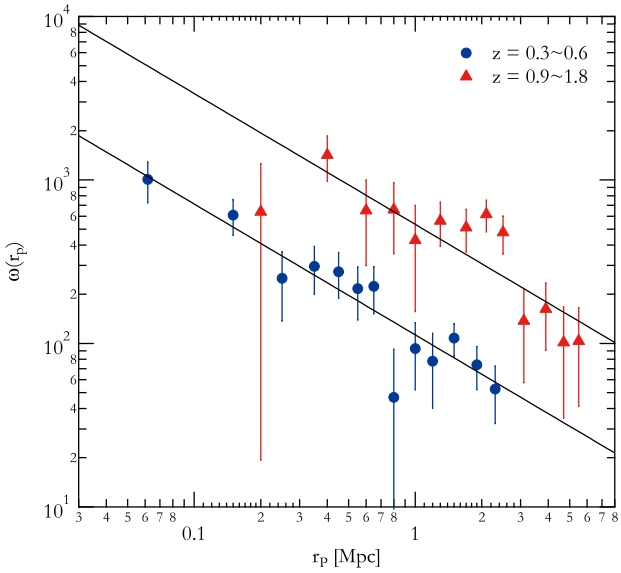

Figure 2: Projected cross correlation function between AGNs and galaxies.

Reference

[1] Shirasaki, Y., et al.: 2011, *PASJ*, **63**, S469.