Revisiting the Completeness and Luminosity Function in High-redshift Low-luminosity Quasar Surveys

NIIDA, Mana, NAGAO, Tohru (Ehime University)
IKEDA, Hiroyuki (NAOJ)
MATSUOKA, Kenta (University of Florence)
KOBAYASHI, Masakazu (NIT, Kure College)
TOBA, Yoshiki (ASIAA)
TANIGUCHI, Yoshiaki (Open University)

At the center of most galaxies, there is a supermassive blackhole (SMBH) whose mass is 10^6 – $10^9\,M_\odot$. It is now recognized that SMBHs already existed at $z\sim7$ [1]. However it is totally unclear how those SMBHs have formed and evolved. To investigate the evolution of SMBHs, quasars who release the huge radiative energy powered by the gravitational energy of SMBHs are useful. The luminosity of quasars correlates with the mass of SMBHs. Therefore, to examine the mass evolution of SMBHs, it is important to measure the evolution of the quasars number densities as a function of the redshift and luminosity (quasar luminosity functions; QLFs). However, the number densities of the low-luminosity quasars at the high redshift derived by the previous studies have large uncertainty [2,3]. This is due to the large systematic error in the quasar selection method based on the imaging data.

To derive the accurate number density of the low-luminosity quasars at the high redshift, we improve the method of the quasar selection. We specifically focus on the luminosity dependence of quasar spectra (the Baldwin effect [4]) whose effect on the quasar selection was ignored in the previous studies. We quantify this luminosity dependence using the Baryon Oscillation Spectroscopic Survey (BOSS) quasar catalog. Based on these obtained results and using the latest model of the inter-galactic medium (IGM) attenuation [5], we establish the new method for deriving the quasar number densities. By this method, we calculate the completeness of quasar survey at $z\sim4$–5, using the COSMOS deep images observed with Subaru/Suprime-Cam. Based on this result, we revisit the low-luminosity quasar number densities. In the results, the revisited number densities are ~24 % lower and ~43 % higher than that estimated by the conventional method at $z\sim4$ and 5, respectively (Fig. 1). Recent surveys of high-luminosity quasars have reported that the quasar number densities increase from the early univers to $z\sim2$ and then decrease to now. Furthermore the higher-luminosity quasars show the peak of their number densities at higher redshifts than lower-luminosity quasars. This indicates that more massive SMBHs grew earlier (i.e., down-sizing). The results of our study suggest that the low-luminosity quasar number density decrease from $z\sim2$ to $z\sim5$. This indicates that even at high-redshift the evolution of quasar number densities is consistent with the down-sizing evolutionary picture. See [6] for more details.

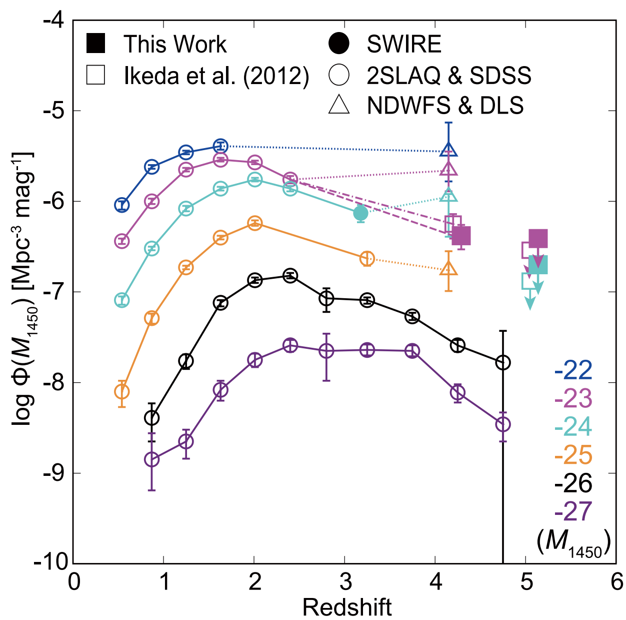

Figure 1: Redshift evolution of the quasar number density for each luminosity. Filled squares and open squares show the results of this study and those of conventional method, respectively. We also show the results of the previous studies for high-luminosity or low redshift quasars as each symbols. The filled squares at $z\sim4$ and 5 are slightly shifted to the right direction to avoid the overlap with other symbols. Our study makes it possible to measure the low-luminosity quasar number densities at $z\sim4$, 5 more accurately.

References

[1] Mortlock, D. J., et al.: 2011, *Nature*, **474**, 616.
[2] Ikeda, H., et al.: 2011, *ApJL*, **728**, L25.
[3] Ikeda, H., et al.: 2012, *ApJ*, **756**, 160.
[4] Baldwin, J. A.: 1977, *ApJ*, **214**, 679.
[5] Inoue, A., et al.: 2014, *MNRAS*, **442**, 1805.
[6] Niida, M., et al.: 2016, *ApJ*, **832**, 208.