An Optically Faint Quasar Survey at z~5 in the CFHTLS Wide Field: Estimates of the Black Hole Masses and Eddington Ratios

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In order to understand the evolution of supermassive black holes (SMBHs), many quasars have been discovered up to $z\sim7$ by the various quasar surveys (e.g., [1]). Utilizing these quasar sample, the black hole mass (M_{BH}) and Eddington ratio (L/L_{Edd}) of SMBHs have been measured with a wide range of redshift so far. As for the high redshift, M_{BH} of SMBHs have been measured from the single-epoch virial estimators [2] and then L/L_{Edd} of SMBHs also have been measured. Utilizing these physical parameters, a number of studies for the growth history of the SMBHs have been investigated so far [3]. However, previous studies have been limited mostly to luminous quasars which are likely to be high L/L_{Edd} objects and the mechanism of SMBH formation is still unclear, due to the lack of the faint quasars at high redshift. Some $z\sim5$ faint quasar surveys have been carried out and the faint side of the QLF at $z\sim5$ has been derived [4]. While a large sample of faint quasars at $z\sim5$ have been constructed, the achieved signal-to-noise (S/N) ratio of the spectra is not sufficient to derive M_{BH}. Therefore we focus on the public database of CFHT legacy survey (CFHTLS; [5]) to discover faint quasars with high S/N ratio of their spectra. Among the CFHTLS-Wide fields (~145 deg^2), we specifically focus on a ~6 deg^2 area that is covered also by the United Kingdom Infrared Telescope (UKIRT) Infrared Deep Sky Survey (UKIDSS; [6])-Deep Extragalactic Survey (DXS) to select faint quasars effectively. Utilizing these photometric data, we select nine photometric candidates and identify three $z\sim5$ faint quasars, one $z\sim4$ faint quasar, and a late-type star. Since two faint quasar spectra show C IV emission line without suffering from a heavy atmospheric absorption, we estimate M_{BH} and L/L_{Edd} of them. The inferred $\log M_{\mathrm{BH}}$ are 9.04 ± 0.14 and 8.53 ± 0.20, respectively. In addition, the inferred $\log L/L_{\mathrm{Edd}}$ are -1.00 ± 0.15 and -0.42 ± 0.22, respectively. If we adopt that L/L_{Edd} = constant or $\propto (1+z)^2$, the seed black hole masses (M_{seed}) of our $z\sim5$ faint quasars are expected to be $>10^5 M_\odot$ in most cases (Figure 1). We also compare the observational results with a mass accretion model where angular momentum is lost due to supernova explosions [7]. Accordingly, M_{BH} of the $z\sim5$ faint quasars in our sample can be explained even if M_{seed} is $\sim10^3 M_\odot$. Since $z\sim6$ luminous quasars and our $z\sim5$ faint quasars are not on the same evolutionary track, $z\sim6$ luminous quasars and our $z\sim5$ quasars are not the same populations but different populations, due to the difference of a period of the mass supply from host galaxies [8].

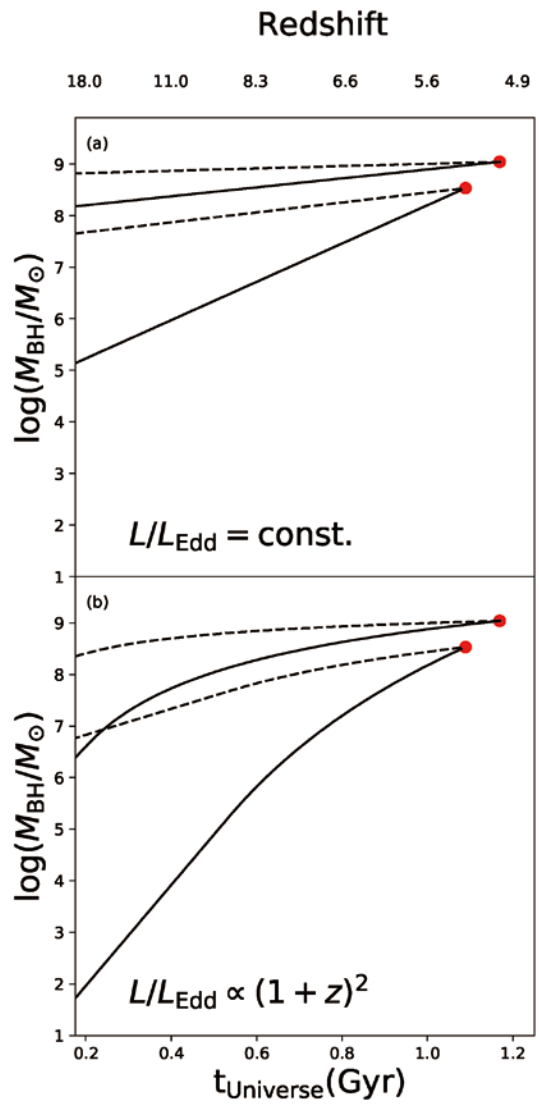

Figure 1: Evolutionary tracks of the SMBHs in our sample. Upper and lower panels show M_{BH} vs. t_{Universe}. Solid and dashed lines show the evolutionary tracks for η=0.1 and η=0.3, respectively.

References

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