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BLACK HOLE MASS MEASUREMENTS WITH REST-FRAME OPTICAL QUASAR SPECTRA AT 3<z<6

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ABSTRACT

We summarize the progress on the rest-frame optical spectroscopy of quasars at 3<z<6, from the AKARI QSONG program. QSONG (Quasar Spectroscopic Observations with NIR Grism) is an AKARI space telescope mission program which utilizes the unique spectroscopic capability in the wavelength range of 2.5-5 μm. This spectral window has been utilized for detecting redshifted Hα emission lines of our high redshift subsample of quasars. From the calculated emission line widths and luminosities we measured supermassive black hole masses using well calibrated optical mass estimators. Science topics regarding optical based black hole masses at high-z are discussed.

Key words: galaxies: active; infrared: telescope; conferences: proceedings

1. INTRODUCTION

The recent discovery of 10^{10} $M_\odot$ supermassive black holes (hereafter BHs, McConnell et al., 2011) further constrained the massive limit of BHs, pushing the previous 10^9 $M_\odot$ order limit to heavier regimes. The $M_{BH} - \sigma_*$ relation, connecting the mass of the BH and that of its host galaxy bulge, hints that extremely massive BHs are likely to be the most massive systems out of BH-host galaxy co-evolution. This study on the growth of massive BHs however becomes interesting as we still find 10^9 $M_\odot$ BHs in distant active galaxies, even up to z=7 (Mortlock et al., 2011). For BHs to grow into such masses at high redshifts, it would have required rapid mass growth rate in the early universe (Volonteri & Rees, 2005), thus providing constraints on the BH evolutionary scenario.

In understanding the nature of distant, growing BHs, reliable mass estimation is necessary. However, BH masses in active galaxies are from single-epoch mass estimators calibrated with rest-frame optical spectra, having few factors of uncertainty (Onken et al., 2004). In addition to this uncertainty rest-frame UV emission lines have been used to weigh BHs at high-z, where BH mass from some of UV lines have significant discrepancy with that from Hβ (Shen et al., 2012).

Therefore we introduce a near-infrared grism study of high-z quasars, covering the 2.5-5 μm window suitable to observe the redshifted rest-frame optical spectra. The AKARI mission Program QSONG (**Q**uasar **S**pectroscopic **O**bservations with **N**IR **G**rism) has the feasibility to measure rest-frame optical (Hα or Hβ) based BH masses at z>3, which would be difficult from the ground due to atmospheric absorption and high sky background.

2. SURVEY DESCRIPTION AND CURRENT STATUS

Our high-z QSONG sample are ∼150 luminous quasars at 3<z<6, out of SDSS (Schneider et al., 2007) and APM-UKST (Storrie-Lombardi et al., 1996, 2001) surveys. The targets are optically selected, spectroscopically confirmed type-I AGN, while flux-limited to z-band AB magnitudes of ∼ 18.5 and 19 in bright and faint subsamples, with more pointings of exposure time assigned to fainter targets for clear line detection. All targets were observed in near-infrared grism (NG)

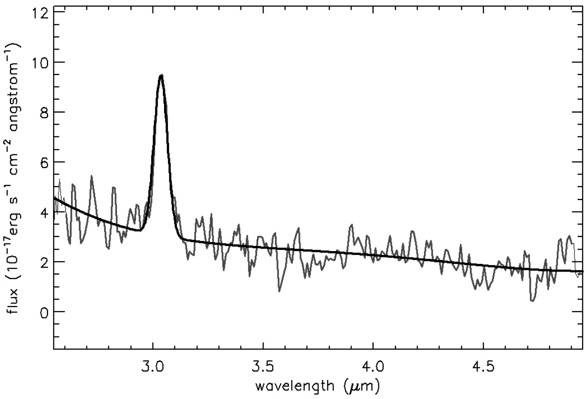

Fig. 1. An example of fitting a z=3.6 AKARI QSONG quasar spectrum, with continuum and emission line model components overplotted.

mode with spectral resolution of R = 120, while a limited number of additional prism (R = 20) observations were performed to better investigate continuum properties.

Until the final observations in January 2010, the QSONG survey covered 762 pointings of quasars during its 1st and 2nd year of warm phase (phase 3) observations, where $\sim$ 60% of the data are targeted for high-z quasars. Due to the relatively strong background noise in phase 3, careful data reduction was applied to obtain a cleaner set of spectra. After running the spectroscopic pipeline (IRC_SPEC_TOOLKIT_P3 version 20090211) we subtracted remaining hot pixels using L.A.Cosmic (van Dokkum, 2001), and stacked multiply observed pointings with sigma clipping applied over wavelength matched spectra. We checked the use of the treatment above, and found the Hα emission feature to stay in its shape while the continuum got cleaner. Selecting objects that meet meaningful S/N for emission line analysis (>5 within the vicinity of the Hα emission line), we measured BH masses using the Hα based mass estimator (Greene & Ho, 2005) after fitting the spectra around the emission line (Fig 1).

3. SCIENCE TOPICS

Having obtained a set of rest-frame optical BH mass estimates in high-z, we summarize ongoing research topics.

- Comparison of Hα and CIV based BH masses: this expands previous studies on the usefulness of UV based BH masses to higher redshift.
- Mass distribution of luminous high-z quasars: depending on the results from the topic above, we are to better understand the growth of BHs in the early universe (z>5) with more reliable BH masses out of rest-frame optical and/or UV emission lines.

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