Do Eddington Ratio and Black Hole Mass Related to the Variability Properties for Low-redshift Quasars?

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Abstract: We examine the relation between both Eddington Ratio and black hole mass and optical variability by studying a sample of 76 low-redshift quasars selected from SDSS DR3. Combining the observations taken by SDSS, the variabilities in three different time intervals (5-years, year and month) are obtained by several observation runs taken with TNT 80cm telescope at Xinglong Observatory. No correlation is found between the variability amplitudes and Eddington Ratio or black hole mass for all the three timescales, which implies that the disk instability is not related with Eddington Ratio or black hole mass in the disk-instability model. In addition, we confirm the results that quasars become bluer when they turn brighter in all the three timescales.

1. Introduction

(1) The variability study plays an important role in understanding the physics of the central region

(2) People have searched for correlations between the variability and observational parameters (e.g. luminosity, redshift, rest-wavelength, time scales…) (Pica & Smith 1983; Cristiani et al. 1990; Hook et al. 1994; Cristiani et al. 1997; Giveon et al. 1999; Vanden Berk et al. 2004)

2. Motivation

In these previous studies, the above observational parameters (luminosity, redshift, rest-wavelength, timescales and so on) are not the essential parameters of quasars. Boroson & Green (1992) discovered two well-known Eigenvectors, and Boroson (2002) suggested that the Eigenvector 1 space is dominantly driven by Eddington ratio, and Eigenvector 2 by M_{BH}. So it is natural for us to expect that the variability might be related with some basic physical parameters, such as M_{BH} or Eddington Ratio.

3. Sample selection

We select a sample of 76 quasars from SDSS Data Release 3 by following criteria:

(1) Their redshift is smaller than 0.5

(2) Their magnitude of g band is smaller than 18 mag

(3) Their right ascensions are between 0 hour and 10 hours

(4) There should be enough (8-10) reference stars within 5 arcmin of the target quasars with comparable brightness

4. Photometrical observation and data reduction

(1) The standard Johnson B and R bands were used on 80cm TNT in Xinglong Observatory. Typical exposure time: B: 8-10min, R: 10-12min

(2) We do our observation in two periods of time: 2004.12—2005.4; 2005.10—2006.3, and get three different intervals of variability: 5 years, yearly, monthly

(3) We do multi-components modeling procedure with Gaussian components to fit the emission lines of every spectra of quasars.

(4) M_{BH} and Eddington ratio are derived from the flux of Hβ and the continuum.

5. Results

5.1 General sample properties: Principal component analysis

We find that the Eigenvector 1 is dominated by RFe, which has a projection of 0.8730 on E1. We test the well-known relationship between RFe and FWHM($H\beta$)$_b$ (Fig.1b) and between RFe and [OIII]/$H\beta_n$ (Fig. 1c). We also find an anti-correlation between RFe and the luminosity of [OIII] (Fig. 1a) and velocity shift of [OIII] component (Fig.1d).

5.2 Variability and M_{BH}, variability and Eddington ratio

We find no significant correlations between 5-years' variability and M_{BH}, (Fig. 2a), neither does variability and Eddington ratio (Fig. 2b). The year's and month's variability are shown in fig. 2c-2f.

5.3 Variability and color

We plot the relation between the color change and the amplitude of variability in Figure 3. We can conclude that quasars get bluer when they turn brighter. Furthermore, the three slopes are similar to each other, which indicates that the behavior of the variability in different timescale might be the same.

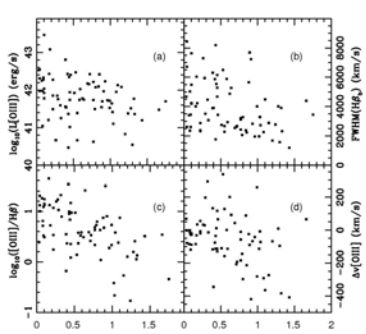

Fig1. (a)Plot of RFe vs. luminosity of [OIII] (b) RFe plotted against the FWHM of the broad component of Hβ (c) RFe plotted against line ratio of [OIII]/Hβ (d) Plot of RFe vs. velocity shift of [OIII] emission line. The reproductions of the correlations and PCA results in current study strongly indicates that the current quasar sample is typical and is a good laboratory for present study.

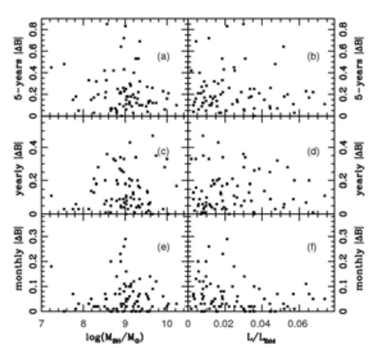

Fig. 2. (a) 5 years' variability plotted against the M_{BH}. (Rs = -0.112, Ps= 0.3318) (b) 5 years' variability plotted against L/L_{EDD}. (Rs = -0.012, Ps = 0.9149) (c) years' variability plotted against the M_{BH}. (d) years' variability plotted against L/L_{EDD} (e) month's variability plotted against the M_{BH} (f) month's variability plotted against L/L_{EDD}. No correlations are found between variability and M_{BH} or L/L_{EDD} in all three time scales.

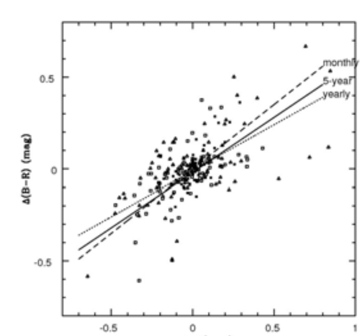

Fig. 3. Deviations from the light curve means of the B-R colors versus deviation of the B magnitudes for three variabilities with different intervals, the open triangles display 5-years' variability; the open squares represent year's variability, and the solid squares month's variability. The best-fitting slope for the three different internal of variability are specified. The slope for 5-years' variability (Rs = 0.603, Ps < 10^{-4}): 0.59±0.08; for year's variability Rs = 0.648, Ps < 10^{-4}): 0.48±0.08; for month's variability (Rs = 0.579, Ps < 10^{-4}): 0.70±0.09.

6. Discussion

(1) Wold et al. (2007) found M_{BH} correlates with the variability amplitude by separating into several small bins. However, they do not detect such relation in their PG quasar sample. We find no correlations between M_{BH} and variability. Larger samples with more complete time sampling may be more reliable.

(2) The variability in different timescales are corresponding to instability in different physical processes. By the calculations in Collier & Peterson (2001), we can estimate the ADAF accretion timescale will be ~1 month, the gas orbital timescale will be ~1 year, and the accretion disk thermal characteristic timescales will be ~5 years.

(3) To explain the mechanisms of variability in quasars, several theoretic models have been proposed in recent years, such as disk-instability (Kawaguchi et al. 1998), gravitational microlensing (Hawkings 1996), and starburst (Terlevich et al. 1992). However, it is difficult to explore the physical models linking variability and M_{BH} or L/L_{EDD} in more details at this stage. Our results directly indicates that the parameters which dominate the variability amplitudes might have no relation with L/L_{EDD} and M_{BH}

(4) Our results confirm the relation that quasar tend to be bluer in their brighten phase (Giveon et al. 1999).

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