J. Astrophys. Astr. (2011) **32,** 315–317

Measurement of Black Hole Mass Radio-Loud Quasars

Cheng-Yue Su[1], Z.-F. Chen[2], R.-L. He[1], C.-H. Zhang[1] & T.-T. Wang[1]
[1]*Guangdong University of Technology, Guangzhou 510006, People's Republic of China.*
[2]*Center for Astrophysics, Guangzhou University, Guangzhou 510006, People's Republic of China.*
e-mail: cysu@gdut.edu.cn

Abstract. In this work, we construct a sample of 1585 radio-loud quasars to measure their black hole masses using broad emission lines. We compare our black hole masses with the virial black hole masses measured by Shen *et al.* (2010). We find that there is a large deviation between them if our black hole mass is measured from the CIV broad emission line. Whereas, if our black hole mass is measured from broad emission line of Mg II or Hβ, both the values are consistent.

Key words. Black hole physics—methods: statistical—galaxies: active.

1. Introduction

Generally, the virial black hole mass is measured through the optical continuum luminosity and broad emission line width. For the radio-loud quasars, however, the jet emission contributes obviously to the optical continuum (Scarpa & Urry 2002). Therefore, the virial black hole mass measured by this method possibly exceeds its true value (Wu *et al.* 2004). In this work, we measure the black hole mass from broad emission line using the following empirical relations:

$$\mathrm{M_{BH}(H\beta)} = 4.68 \times 10^6 \left(\frac{\mathrm{L(H\beta)}}{10^{42}\ \mathrm{erg/s}}\right)^{0.63} \left(\frac{\mathrm{FWHM(H\beta)}}{1000\ \mathrm{km/s}}\right)^2 M_{\mathrm{sun}}$$

(Vestergaard & Peterson 2006)

$$\left.\begin{aligned}\mathrm{M_{BH}(MgII)} &= 2.9 \times 10^6 \left(\frac{\mathrm{L(MgII)}}{10^{42}\ \mathrm{erg/s}}\right)^{0.57} \left(\frac{\mathrm{FWHM(MgII)}}{1000\ \mathrm{km/s}}\right)^2 M_{\mathrm{sun}} \\ \mathrm{M_{BH}(CIV)} &= 4.6 \times 10^5 \left(\frac{\mathrm{L(CIV)}}{10^{42}\ \mathrm{erg/s}}\right)^{0.6} \left(\frac{\mathrm{FWHM(CIV)}}{1000\ \mathrm{km/s}}\right)^2 M_{\mathrm{sun}}\end{aligned}\right\}$$

(Kong *et al.* 2006)

where L(Hβ), L(MgII) and L(CIV) are the luminosities of broad emission lines and FWHM(Hβ), FWHM(MgII) and FWHM(CIV) are the FWHM of broad emission lines. Each emission line is modelled by two Gaussian with one for broad emission line and the other for narrow line.

2. Sample

This sample is based on the catalogue of quasar properties from SDSS DR7 (Shen *et al.* 2010) and the radio catalogue of the FIRST 20-cm survey (White *et al.* 1997) and the GB6 6 cm survey (Gregory *et al.* 1996). We explore a sample of radio quasars by cross-identifying the sample of Shen *et al.* (2010) and the FIRST and GB6 radio-detected sources. We then select radio-loud quasars by F(5 GHz)/F(2500 Å)>10 (Stocke *et al.* 1992), where F(5 GHz) is the flux density at 5 GHz and F(2500 Å) is the flux density at 2500 Å, and we obtain a sample of 1585 quasars. The radio flux at 5 GHz is derived from the radio flux at 20 cm and 6 cm and their spectral indices. The optical flux densities and the virial black hole masses are adopted from Shen *et al.* (2010) where it is assumed that the broad line region is virialized, the

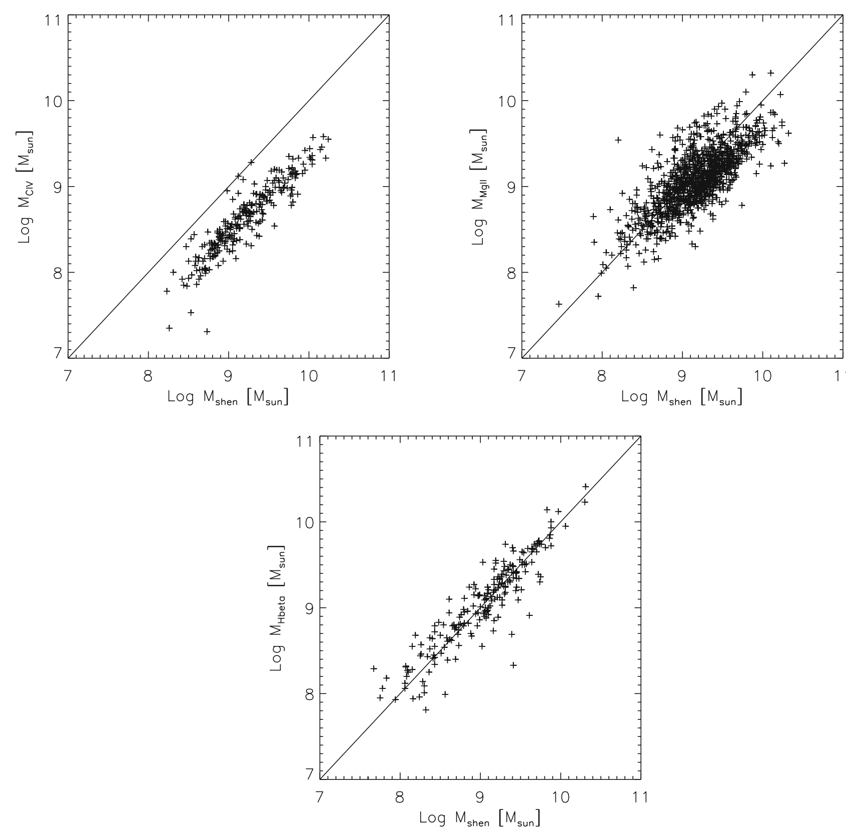

Figure 1. The X-axis stands for the virial black hole mass and the Y-axis represents the black hole mass measured from broad emission line in each panel. The left panel: the black hole mass is measured from CIV broad emission line. The right panel: the black hole mass is measured from Mg II broad emission line. The bottom panel: the black hole mass is measured from Hβ broad emission line.

continuum luminosity is considered as a proxy of the broad line region radius, and the broad line width is considered as a proxy of the virial velocity.

3. Result

As shown in Fig. 1, we directly compare the black hole masses measured from broad emission lines with the virial black hole masses. The figure shows that the virial black hole mass is overestimated when compared to the black hole mass measured from CIV broad emission line, as what has been already predicted by Wu *et al.* (2004). Whereas, they do not meet the expectation when measured from MgII or Hβ broad emission lines. Since the error in estimating the black hole mass by both methods through CIV broad emission line is large, we are not sure if the departure between them arises from the contribution of the jet emission.

References

Gregory, P. C., Scott, W. K., Douglas, K., Condon, J. J. 1996, *Astrophys. J. Suppl.*, **103**, 427.
Kong, M. Z., Wu, X. B., Wang, R., Han, J. L. 2006, *Chinese J. Astron. Astrophys.*, **6**, 396.
Shen, Y., Hall, P. B., Richards, G. T. *et al.* 2010, arXiv: 1006.5178.
Stocke, J. T., Morris, S. L., Weymann, R. J., Foltz, C. B. 1992, *Astrophys. J.*, **396**, 487.
Scarpa, R., Urry, C. M. 2002, *New Astron. Rev.*, **46**, 405.
Vestergaard, M., Peterson, B. M. 2006, *Astrophys. J.*, **641**, 689.
White, R. L., Becker, R. H., Helfand, D. J., Gregg, M. D. 1997, *Astrophys. J.*, **475**, 479.
Wu, X. B., Wang, R., Kong, M. Z., Liu, F. K., Han, J. L. 2004, *Astron. Astrophys.*, **424**, 793.