Formation and Evolution of Galaxy Bulges
Proceedings IAU Symposium No. 245, 2007
M. Bureau, E. Athanassoula & B. Barbuy, eds.

doi:10.1017/S174392130801778X

Central black hole mass determination for blazars

J. H. Fan, Y. H. Yuan, Y. Huang, Y. Gao, T. X. Hua and Y. Liu

[1]Center for Astrophysics, Guangzhou University, Guangzhou 510006, China

Abstract. In this paper, we used the method to determine the central black mass (M), and the boosting factor (δ), the propagation angle (Φ), and the distance along the axis to the site of the γ-ray production (d) as well for 32 γ-ray loud blazars with available variability timescales. If we take the intrinsic γ-ray luminosity to be λ times the Eddington luminosity, i.e. $L_\gamma^{in} = \lambda L_{Edd}$, then we have following results: the masses of the black hole are in the range of $(0.9 \sim 101) \times 10^7 M_\odot (\lambda = 1.0)$ or $(1.30 \sim 153) \times 10^7 M_\odot (\lambda = 0.1)$.

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1. Introduction

It is generally believed that the emission of high energy γ-rays from AGNs depends on $\gamma - \gamma$ pair production process because there are lots of soft photons around the central black hole. In 1995, Becker & Kafatos, based on the X-ray field of an accretion disk, calculated the γ-rays optical depth, and found that the γ-rays should escape preferentially along the symmetric axis of the disk, due to the strong angular dependence of the pair production cross section. The phenomenon of $\gamma - \gamma$ 'focusing' is related to the main issue of $\gamma - \gamma$ transparency, which represents a minimum distance between the central black hole and the site of γ-ray production (Fan 2005, Cheng *et al.* 1999). Therefore, the γ-rays are focused in a solid angle, $\Omega = 2\pi(1 - cos\Phi)$, so the apparent observed luminosity can be expressed as: $L_\gamma = \Omega D^2 F_\gamma (1+z)^{\alpha_\gamma - 1}$, here F_γ is the observed γ-ray energy flux, D the luminosity distance, z the redshift, α_γ the γ-rays spectral index. Because the observed γ-rays from blazars demand that the jet is almost pointing to us, so the optical depth τ is not greater than unity. The γ-rays come from a solid angle, Ω, instead of being isotropic. So, both the beaming and absorption effects must be considered when the properties of a γ-rays blazars are discussed. The optical variability supplies us with some information about the γ-ray emission region. All these considerations give us a method to estimate the basic parameters of γ-rays loud blazars, including the central black hole mass (M), the boosting factor (δ), the propagation angle (Φ) and the distance along the axis to the site of the γ-ray production (d).

2. Method

In this part, from our previous papers by Cheng, Fan, Zhang (1999) and Fan (2005) who obtained the optical depth expression based on the work by Becker & Kafatos (1995), we have four equations for the four parameters:

$$\frac{d}{R_g} = 1.73 \times 10^3 \frac{\triangle T_D}{1+z} \delta M_7^{-1}$$

$$L_{iso}^{45} = \frac{2.52 \lambda \delta^{\alpha_\gamma + 4}}{(1 - cos\Phi)(1+z)^{\alpha_\gamma - 1}} M_7$$

Table 1. Central Black Hole Masses for Blazars

Name	$\log(\frac{M}{M_\odot})$ $\lambda = 0.1$	$\log(\frac{M}{M_\odot})$ $\lambda = 1.0$	Name	$\log(\frac{M}{M_\odot})$ $\lambda = 0.1$	$\log(\frac{M}{M_\odot})$ $\lambda = 1.0$	Name	$\log(\frac{M}{M_\odot})$ $\lambda = 0.1$	$\log(\frac{M}{M_\odot})$ $\lambda = 1.0$
0202+149	7.9	8.08	0827+243	6.94	7.12	1604+159	8.4	8.58
0208-512	9.01	9.19	0836+710	7.8	7.97	1606+106	8.32	8.48
0219+428	8.47	8.65	OJ287	7.12	7.31	1611+343	8.2	8.37
0235+164	8.67	8.86	0906+430	8.25	8.42	1622-297	7.9	8.07
0234+285	8.24	8.41	0917+449	7.87	8.06	1633+382	8.36	8.54
0336-019	7.55	7.73	0954+556	8.39	8.56	Mrk501	8.02	8.22
0420-014	8.41	8.58	0954+658	8.6	8.77	NRAO 530	8.35	8.52
NRAO190	7.53	7.7	1011+496	8.35	8.53	1739+522	8.24	8.41
B0454-234	8.24	8.4	1055+567	8.37	8.54	B1741-038	8.21	8.38
J0454-463	8.27	8.43	Mrk 421	7.28	7.49	1830-210	8.32	8.49
B0458-020	8.82	8.99	B1127-145	7.77	7.94	1933-400	8.32	8.48
J0506-612?	8.24	8.41	1156+295	8.2	8.38	2005-489	8.2	8.34
0528+134	8.35	8.52	1219+285	7.17	7.37	2032+107	8.3	8.44
B0521-365	8.67	8.83	1222+216	8.38	8.55	2052-474	8.19	8.38
B0537-286	7.79	7.97	3C273	8.13	8.3	2155-304	7.55	7.71
0537-441	8.33	8.5	B1229-021	8.24	8.4	BL Lac	8.02	8.17
0716+714	7.51	7.68	3C279	8.65	8.83	CTA 102	8.4	8.57
0735+178	8.35	8.51	1331+170	8.16	8.33	3C 454.3	7.21	7.4
0804+499	8.04	8.22	B1334-127	8.2	8.36	2356+196	8.25	8.42
0829+046	8.55	8.71	B1510-089	8.56	8.73			

$$9 \times \Phi^{2.5} \left(\frac{d}{R_g}\right)^{-\frac{2\alpha_X+3}{2}} + kM_7^{-1} \left(\frac{d}{R_g}\right)^{-2\alpha_x-3} = 1$$

$$22.5\Phi^{1.5}(1-cos\Phi)-9\times\frac{2\alpha_X+3}{2\alpha_\gamma+8}\Phi^{2.5}sin\Phi-\frac{2\alpha_X+3}{\alpha_\gamma+4}kM_7^{-1}A^{-\frac{2\alpha_X+3}{2}}(1-cos\Phi)^{-\frac{\alpha_X+3}{2\alpha_\gamma+8}}sin\Phi=0$$

For a source with available X-ray, γ-ray data, and with data on short time scales, M_7, δ, d, and Φ, can be derived from the upper four equation, here $R_{ms} = 6R_g$, $R_0 = 30R_g$, $\omega = 3$ (a two-temperature disk) and $E_\gamma = 1GeV$ have been used. The results are shown in Table 1. The results are also compared with those by Barth *et al.* (2003); Rieger & Mannheim (2003); Shen *et al.* (2006); Wang *et al.* (1996); Woo & Urry (2003). Refer to our full paper for the detail consideration (Fan *et al.* 2007 in preparation).

Acknowledgements

This work is supported by NSFC(10573005,10633010) and the 973 project (2007-CB815405). We also thank the financial support from the Guangzhou Education Bureau and Guangzhou Science and Technology Bureau.

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