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Center Black Hole Mass Determinations for Fermi Blazars*

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Abstract. In this paper, we estimated the black hole mass for some blazars with available variability time scales by assuming that the γ-ray emissions are from a distance of 200R$_g$ from the center. The results show that the central black hole masses are in the range of log $(M/M_\odot)$ = 6.45 to 8.30.

Keywords. Galaxies:active-galaxies:BL Lac objects-galaxies:quasars-Fermi(LAT)

1. Introduction

Blazars are extreme subclass of active galactic nuclei (AGNs) showing special observation properties. The power for all types of AGNs is almost universally ascribed to accretion onto supermassive black holes with masses $M \sim 10^{6-9} M_\odot$ (Dermer & Gehrels, 1995). Blazars show variability in the γ-ray band on timescales from hours to months(Mukherjee, *et al.* 1997). Some authors claimed that the γ-rays are produced at a region of $\sim$100 R$_g$ (R$_g$= GM/c^2)(Hartman 1996) and a few 100 R$_g$ (Ghisellini & Gabriele, 1996) from the central black hole, it is also found to be 205 R$_g$ (Xie *et al.* 1996). The distance is useful for the determination of the central black hole mass. In this paper, we will use the Fermi observations data (Nolan *et al.* 2012) and the assumption of the γ-ray emission region, $R_\gamma \sim 200 R_g$ to estimate the central black hole mass. Here, we adopt $\mathrm{H_0 = 73 km\,s^{-1} Mpc^{-1}}$.

2. Method and Results

We now describe the method to estimate the central black hole mass for a blazar with variability time scale (Fan *et al.* 1999). If we take the variability timescale as the measurements of the emission size, R, then R obeys to the inequality, $R \leqslant \frac{c\Delta T \delta}{1+z}$, here c is the speed of light, δ is the Doppler factor, z the redshift, and ΔT the time scale. If $R = 200 R_g$, then we have $(\mathrm{M/M_\odot}) \leqslant 3.6 \cdot 10^6 (\frac{\Delta \mathrm{T}}{1\mathrm{hr}}) \frac{\delta}{1+\mathrm{z}}$. In a beaming frame, we have that the observed luminosity, $\mathrm{L^{ob}}$, is associated with the intrinsic luminosity, $\mathrm{L^{in}}$, $\mathrm{L^{ob}} = \delta^{4+\alpha} \mathrm{L^{in}}$ (here we take $L^{in} = \lambda L_{Edd.} = 1.26 \cdot 10^{45} \lambda M_7$), then we have, $\delta \geqslant [\frac{L^{ob}_{45}(1+z)}{0.454(\frac{\Delta T}{1hr})\lambda}]^{\frac{1}{5+\alpha}}$,

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Table 1. Black Hole Masses for Fermi Blazars

Name	Class	z	F(1-100GeV)	α_γ	ΔT	δ_γ	log $(M/M_\odot)$
1	2	3	4	5	6	7	8
0208-512	FSRQ	1.003	37.9	2.4	134	1.56	8.27
0219+428	BL	0.444	256	1.85	30	2.25	7.93
0235+164	BL	0.94	187	2.02	72	2.42	8.21
0528+134	FSRQ	2.06	25.7	2.22	24	2.91	7.61
0537-441	BL	0.894	371	2.01	16	3.41	7.71
0650+453	FSRQ	0.933	34.5	2.28	66	1.70	8.02
0735+178	BL	0.424	51.6	2.05	24	1.59	7.68
0851+202	BL	0.306	35.5	2.23	1	2.03	6.45
1101+384	BL	0.031	297	1.77	2	1.35	6.67
B1127-145	FSRQ	1.187	18	2.7	6	2.34	7.06
1156+295	FSRQ	0.729	60.4	2.29	11	2.19	7.40
1219+285	BL	0.102	55.4	2.02	3.6	1.25	6.87
1226+023	FSRQ	0.158	151	2.45	24	1.12	7.62
1253-055	FSRQ	0.537	256	2.22	12	2.41	7.53
1502+106	FSRQ	1.83	401	2.15	12	4.89	7.57
1510-089	FSRQ	0.361	406	2.29	8	2.26	7.38
1520+31	FSRQ	1.487	176	2.25	6.7	4.06	7.29
1633+382	FSRQ	1.814	116	2.25	16	3.67	7.57
1652+398	BL	0.033	87.7	1.74	6	0.94	6.99
1700+6830	FSRQ	0.301	38	2.4	7.4	1.42	7.16
2022-070	FSRQ	1.388	101	2.15	113	2.35	8.30
B2155-304	BL	0.117	235	1.84	3.3	1.87	7.00
2200+420	BL	0.07	105	2.11	3.2	1.19	6.81
2230+114	FSRQ	1.04	28.8	2.33	48	1.81	7.89
2251+158	FSRQ	0.859	965	2.23	1.9	4.99	6.96

L_{45}^{ob}(erg/s) $= \mathrm{L}^{\mathrm{ob}}/10^{45}$. From the available data, we can get the results for the central black hole masses and the Doppler factors, and listed them in Table 1. In Table 1, column (1) gives the name of the source, column (2) classification (BL, FSRQ-flat spectrum radio quasars), column (3) the redshift, column (4) and (5) the γ-ray photons in 1-100 GeV in units of 10^{-10} photon/cm^2/s and photon spectrum index from Ackermann, *et al.*, (2011) and Nolan, *et al.* (2012), column (6) the time scale ΔT in units of hours (Yang & Fan 2010), column (7) the γ-ray Doppler factor, column (8) the central black hole mass, log $(M/M_\odot)$.

Discussions and Conclusion From Table 1, we can see that the central black hole masses have a range of $\log(M/M_\odot) = 6.45$ to 8.30. $< log(M/M_\odot) > = 7.23 \pm 0.60$ for BLs, and $< log(M/M_\odot) > = 7.58 \pm 0.40$ for FSRQs. For the Doppler factors, $< \delta_\gamma >= 1.83 \pm 0.74$ for BLs and $< \delta_\gamma >= 2.65 \pm 1.22$ for FSRQs. The results are similar to those in our previous work (Yang & Fan 2010). There is no clear difference in masses or Doppler factors between BLs and FSRQs. Does that mean that the central black hole mass is not an important factor in the evolution process if there is really an evolution between FSRQs and BLs?

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