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Does black hole spin play a key role in the FSRQ/BL Lac dichotomy?

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Abstract Blazars are characterized by large intensity and spectral variations across the electromagnetic spectrum It is believed that jets emerging from them are almost aligned with the line-of-sight. The majority of identified extragalactic sources in γ-ray catalogs of EGRET and Fermi are blazars. Observationally, blazars can be divided into two classes: flat spectrum radio quasars (FSRQs) and BL Lacs. BL Lacs usually exhibit lower γ-ray luminosity and harder power law spectra at γ-ray energies than FSRQs. We attempt to explain the high energy properties of FSRQs and BL Lacs from Fermi γ-ray space telescope observations. It was argued previously that the difference in accretion rates is mainly responsible for the large mismatch in observed luminosity in γ-ray. However, when intrinsic luminosities are derived by correcting for beaming effects, this difference in γ-ray luminosity between the two classes is significantly reduced. In order to explain this difference in intrinsic luminosities, we propose that spin plays an important role in the luminosity distribution dichotomy of BL Lacs and FSRQs. As the outflow power of a blazar increases with increasing spin of a central black hole, we suggest that the spin plays a crucial role in making BL Lac sources low luminous and slow rotators compared to FSRQ sources.

Key words: BL Lacertae objects: general — quasars: general — galaxies: jets — black hole physics — relativistic processes — gravitation

1 INTRODUCTION

During its first two years of observation, around 700 blazars were detected by the Large Area Telescope (LAT) onboard the Fermi Gamma-ray Space Telescope (Fermi). Unlike EGRET (onboard the Compton Gamma Ray Observatory, CGRO), Fermi detected a significant number of Flat Spectrum Radio Quasars (FSRQs) and BL Lacs (310 FSRQs and 395 BL Lacs) during its full sky survey (Nolan et al. 2012; Ackermann et al. 2011). Based on its broadband spectral energy distribution (SED), BL Lac sources are classified further into low synchrotron peak (LSP), intermediate synchrotron peak (ISP) and high synchrotron peak (HSP) BL Lacs (Abdo et al. 2010c). Utilizing this improved source catalog, one can conduct a detailed study of properties of FSRQs and BL Lacs in a high energy regime in order to understand their emission mechanism. Earlier, Ghisellini et al. (2009) carried out a comparison of these two source classes using data from the first three months of Fermi observations. From observed γ-ray luminosities and spectral indices they proposed that there exists a critical mass accretion rate ($\dot{M}_{\rm cric}$): FSRQs accrete at a rate higher than $\dot{M}_{\rm cric}$, while BL Lacs accrete at a rate below $\dot{M}_{\rm cric}$. However, SED modeling indicates that γ-ray emissions from jets of FSRQs are dominated by the external Compton (EC) process. The low energy photons from external sources are upscattered by ultra-relativistic particles present in the jet and produce γ-ray photons. The low-energy photons might be produced from the accretion disk, the broad-line region (BLR), the dusty torus, etc. (Dermer & Schlickeiser 1993; Dermer et al. 1992; Marscher & Jorstad 2010; Poutanen & Stern 2010; Ghisellini & Tavecchio 2009; Sikora et al. 2009; Malmrose et al. 2011; Błażejowski et al. 2000; Foschini et al. 2011; Tavecchio et al. 2010), depending on the position of the γ-ray emitting region.

The SEDs of BL Lac sources can be better represented with the synchrotron self Compton (SSC) emission model, where ultrarelativistic particles in the jet upscatter the low energy synchrotron photons via inverse Compton processes. Hence, SED modeling of observational data indicates that the relativistic beaming that occurs in FSRQs and BL Lacs is not the same and the fundamental parameter to be compared is the intrinsic γ-ray luminosity, not the observed one. Here, we define intrinsic luminosity as the luminosity which only depends on the intrinsic jet and disk parameters but not on the beaming. This definition is used throughout this paper.

In this paper, we try to explore whether some fundamental properties of black holes are responsible for the differences in intrinsic luminosities and beaming.

Bhattacharya et al. (2010, hereinafter BGM) showed that spin of the central black hole plays an important role in outflow. For a disk outflow coupled region, they showed that the total mechanical power of the outflow increases with the increase of the black hole spin. Hence, even for the same accretion rate, the differences in the black hole spin can produce a noticeable difference in luminosities. Note that the spin, a purely general relativistic property of the black hole, is essentially the specific angular momentum of the black hole denoted by a (with magnitude in the range $0 - 1$).

We arrange our paper as follows. In the next section, we discuss γ-ray luminosities and relativistic Doppler beaming of FSRQs and BL Lacs. In Section 3, we derive intrinsic (unbeamed) luminosities of FSRQs and BL Lacs in γ-rays, and subsequently in Section 4, discuss the implications of our findings. We conclude with Section 5.

2 γ-RAY LUMINOSITIES OF FERMI DETECTED BLAZARS

We derive the γ-ray luminosities of all blazars from the second year Fermi active galactic nuclei (AGN) catalog (Ackermann et al. 2011). The photon luminosities (L_γ) are calculated using the relation

$$L_\gamma = \frac{4\pi D_L^2 F_\gamma}{(1+z)^{1-\alpha_\gamma}}\,, \tag{1}$$

where $D_{\rm L}$ is the luminosity distance, α_γ the energy spectral index and F_γ the γ-ray photon flux (>1 GeV) in the unit of ph cm^{-2} s^{-1}. Multiplying L_γ of each source by the corresponding average photon energy, we calculate the γ-ray luminosity in erg s^{-1}. Here we adopt a cosmology with $\Omega_\Lambda = h = 0.7$ and $\Omega_m = 0.3$.

Figure 1 shows the distribution of observed γ-ray luminosities and photon spectral indices for blazars. It is evident from Figure 1 that the γ-ray luminosities of FSRQs are more than those of BL Lac sources and they have a steeper average photon spectrum. The LSP sources have luminosities closer to those of FSRQs. Also, it can be noticed that the γ-ray spectra of most of the FSRQs and LSPs deviate from a single power law and indicate the presence of a break in the spectra, but ISPs and HSPs do not show such a feature (Abdo et al. 2010c). From the relationship between broadband spectral indices, Li et al. (2010) showed that FSRQs and LSPs follow a continuous trend whereas ISPs and HSPs follow a separate distinct trend. Therefore, in this work, FSRQs and LSPs are considered as one group (FSRQ group henceforth) and ISPs and HSPs together are regarded as a separate group (henceforth referred to as the BL Lac group).

Figure 2(a) shows the histograms of γ-ray luminosities of the FSRQ and BL Lac groups. For the FSRQ group the average photon index ($\alpha_\gamma + 1$) is 2.25 ± 0.22 and that for the BL Lac group is 1.90 ± 0.23.

2.1 Distribution of Doppler Beaming for FSRQs and BL Lacs

The bulk Lorentz factor (Γ) and the Doppler beaming factor (δ) are very crucial jet parameters in understanding the observed luminosity of blazars. The values of Γ and δ can be determined by two methods: (a) SED modeling and (b) radio VLBI measurement.

The γ-ray emission region is believed to be situated near the central black hole. Therefore, the modeling of SED using high energy measurement seems to be more suitable than VLBI measurement. However, in the majority of cases, the SEDs in different wavelengths are not constructed simultaneously. Furthermore, there are a large number of parameters involved in the modeling of an SED which results in large uncertainties. Instead of measuring jet to line-of-sight angle ($\theta_{\rm jet}$), a typical value of $\theta_{\rm jet}$ is considered. More importantly, in most of the cases, the parameter values are not optimized by examining the goodness of fit. Ghisellini et al. (2010) determined the jet parameters of 85 blazars from the first three months of Fermi observation by modeling their SEDs. They found, for blazars, the values of Γ lie between 10 and 15. However, like all other SED modeling efforts, this study also involves large uncertainties due to the reasons mentioned earlier. As mentioned before, VLBI observations can be used to determine values of Γ and δ. Here, one directly observes the brightness temperature of the radio source ($T_{\rm b,obs}$). One can estimate δ by comparing $T_{\rm b,obs}$ with the intrinsic brightness temperature of the blazar ($T_{\rm b,int}$) (Hovatta et al. 2009; Savolainen et al. 2010). $\theta_{\rm jet}$ and Γ can be derived from the observed apparent velocity ($v_{\rm ap}$) and δ. Hovatta et al. (2009) and Savolainen et al. (2010) considered that $T_{\rm b,int}$, which is assumed to be the equipartition temperature, is the same for all sources. The values estimated for Γ and δ become less accurate due to this assumption.

Since observational data required to derive these parameters directly from γ-ray observations are limited, we examined other studies that enable us to use the extensive radio data on blazars to carry out our investigation. Jorstad et al. (2005) determined the jet parameters utilizing VLBI observations. They compared the timescale for flux density declination to the light travel time across the emission region to derive δ. They calculated $\theta_{\rm jet}$ and Γ using the derived values of δ and $v_{\rm ap}$. This method gives more appropriate values compared to other methods. However, they studied a limited number of blazars (eight FSRQs and

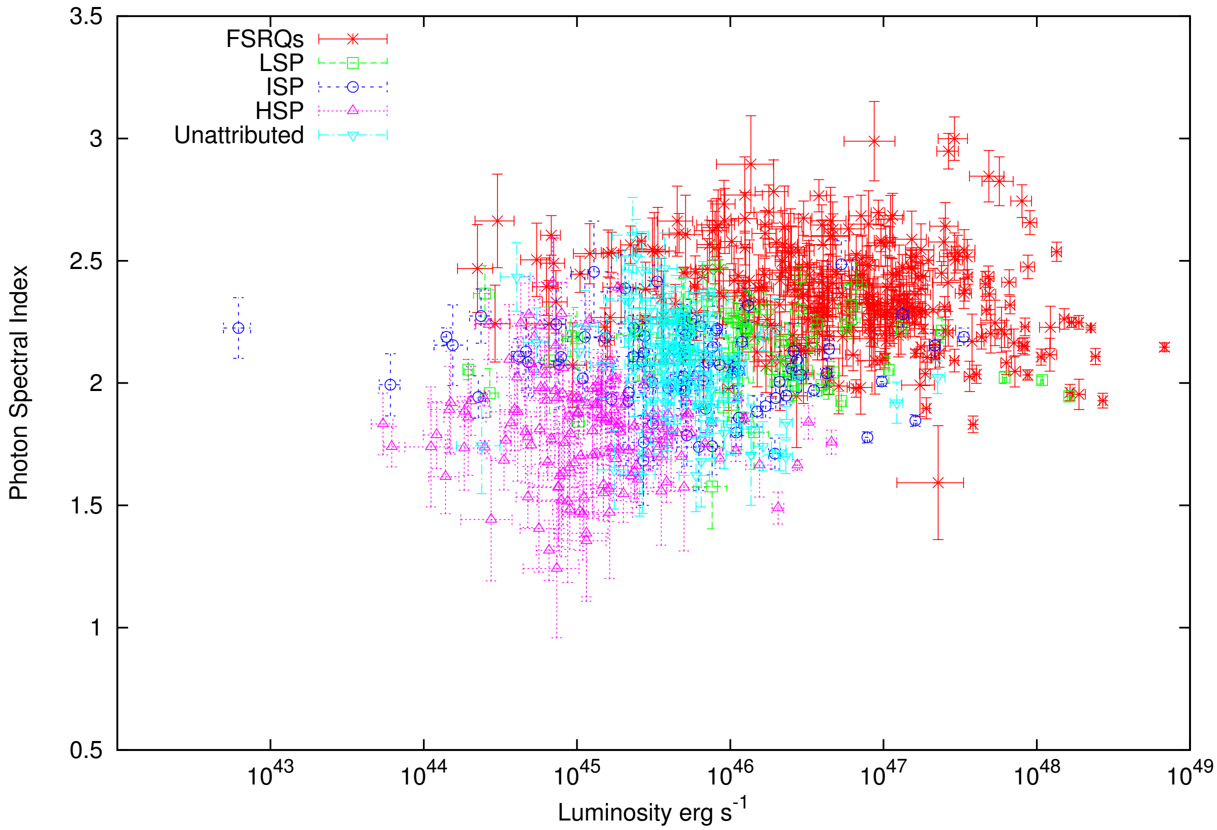

Fig. 1 Distribution of γ-ray luminosity and photon spectral index for different classes of BL Lacs and FSRQs. Red crosses represent FSRQs, green squares LSPs, blue circles ISPs, magenta triangles HSPs and cyan inverted triangles represent unattributed BL Lacs.

five BL Lacs). One can estimate the mean values of δ and Γ using Jorstad et al. (2005), assuming that the intrinsic δ (and also Γ) as well as their corresponding errors follow a Gaussian distribution (Venters & Pavlidou 2007 and Bhattacharya et al. 2009). The average values of δ and Γ for FSRQs are estimated to be 23.1 ± 8.9 and 17.3 ± 5.3 respectively. For BL Lacs, the average values of δ and Γ are 15.3 ± 5.5 and 12.5 ± 3.5 respectively. Due to the large errors, we have used the average values (for all blazars in the sample) of $\delta = 20.6 \pm 8.4$ and $\Gamma = 15.1 \pm 4.6$. If one considers the sample of Savolainen et al. (2010), the average value of δ comes out to be 14.9 ± 7.6 and 8.1 ± 4.5 for FSRQs and BL Lacs respectively. The average values of δ and Γ for all blazars (including FSRQs and BL Lacs) in their sample are 13.5 ± 7.5 and 15.6 ± 10.9, which are in agreement with those of Jorstad et al. (2005) within 1σ errors.

The location of the γ-ray emission region may be different from the region generating radio emission. However, the Γ values derived independently from SED modeling by Ghisellini et al. (2010) are consistent with the mean value adopted here from the work of Jorstad et al. (2005). This probably indicates that there is no significant variation in jet parameters between the two regions. The average δ values of 20.6 and 13.5 are used to estimate the intrinsic γ-ray luminosities in the following sections.

3 INTRINSIC γ-RAY LUMINOSITIES OF FSRQS AND BL LACS

The blazar luminosity is assumed to mostly originate from the jet. On the other hand, it is believed that the jet includes relativistic particles which can be either in the form of a continuous flow or may get ejected as blobs. As mentioned in Section 1, SSC and/or EC processes are thought to be responsible for γ-ray emission from the jet. As the jet emission is tightly beamed, the observed γ-ray luminosity ($L_{\rm obs}$) and the intrinsic luminosity ($L_{\rm intrinsic}$) are related by (Dermer 1995)

$$L_{\rm obs} = L_{\rm intrinsic} \times \delta^{m+n}, \tag{2}$$

where m is 2 for a continuous jet and 3 for a discrete jet. Here, $n = \alpha_\gamma$ for the SSC process and $n = 2\alpha_\gamma + 1$ for the EC process. As discussed in Section 2.1, for the calculation of intrinsic luminosities, the average values of δ (20.6 and 13.5) are used. In order to compare the intrinsic luminosities ($L_{\rm intrinsic}$) between FSRQs and BL Lacs, it is essential to correct for the beaming effect. We therefore calculate their intrinsic luminosities. As mentioned in Section

1, BL Lacs' SEDs are better fitted with pure SSC models (Mrk 501: Petry et al. 2000; Abdo et al. 2010c), while for FSRQs, a significant component has to come from external Compton processes (3C 279: Pian et al. 1999; Abdo et al. 2010c). We consider a continuous jet model for both FSRQs and BL Lacs. For the BL Lac group, a pure SSC emission process is considered. For the FSRQ group a combination of EC and SSC emission processes is considered. We examine three different scenarios: (a) 75% EC and 25% SSC emissions, (b) 90% EC and 10% SSC emissions, and (c) 100% EC emission.

Figure 2 shows the histograms of γ-ray luminosities for FSRQs and BL Lacs. Interestingly, the apparent large difference between the observed γ-ray luminosities of FSRQs and BL Lacs (as shown in Figs. 1 and 2(a)) is significantly reduced when intrinsic luminosities (considering $\delta = 20.6$) are compared. This is expected as, is evident from Equation (2), the beaming is more for EC than SSC emission processes and also FSRQs have steeper γ-ray spectra than BL Lacs.

4 DISCUSSIONS

One possible explanation for the observed luminosity mismatch in γ-ray between FSRQ and BL Lac source classes is the difference in their accretion rates (Cavaliere & D'Elia 2002; Ghisellini et al. 2009). According to this, FSRQs are regarded as high accreting systems and might exhibit optically thick Keplerian disks with enhanced radiation. Ghisellini et al. (2011) investigated the properties of a sample of Fermi-LAT BL Lacs having energy spectral index >1.2. They identified these sources as intermediate objects between pure FSRQs and pure BL Lacs.

On the other hand, BL Lacs are considered to be low accreting systems where the disks are optically thin and sub-Keplerian, leading to low radiation production. There are also a few attempts to connect FR I galaxies with the low/hard state and FR II galaxies with the very high state of X-ray binaries (e.g. Meier 2001).

Our analysis explicitly takes into account corrections to the observed γ-ray luminosities due to beaming. The difference in intrinsic luminosities between the FSRQ and BL Lac groups significantly decreases in comparison with the observed values. It is not possible to explain the small difference in intrinsic γ-ray luminosities of FSRQs and BL Lacs with theoretical models involving a large difference in accretion rates (thermal and advective accretion disk). We propose that the difference in the spin of the central black hole is more likely responsible for this luminosity mismatch. Earlier, BGM investigated a disk-outflow coupled region and from conservation equations they tried to connect the fundamental properties of the central black hole with accretion and outflow. They found that the total mechanical outflow power depends on the spin of the central black hole and increases with the increase in spin. Hence matter will flow out faster for a more rapidly spinning black hole which will make the outflow stronger with a larger flow density (see BGM). It is known (see e.g. Rajesh & Mukhopadhyay (2010), for one of the latest solutions) that for a fixed accretion rate, as the black hole spin increases, the Keplerian part of the accretion disk moves towards the black hole. Hence, the soft photon supply to the emission region of the jet increases with the black hole spin. This excess of soft photons will produce a significant amount of EC emission (as observed in FSRQ spectra). BGM showed that for a particular accretion rate, density of the disk-outflow coupled region depends on the spin of the black hole and it increases with increasing spin of the central black hole. Therefore, with increasing black hole spin, matter with higher density will interact more rapidly with the larger supply of soft photons. Therefore, electrons in the jet will lose more energy and, hence, will exhibit a steeper energy spectrum which will in turn produce a steeper radiation spectrum. It is observed that FSRQs have a peak in the synchrotron emission at relatively low energies, unlike most of the BL Lacs detected by Fermi. Also, the observed γ-ray spectra of FSRQs are steeper than the spectra of BL Lacs. This is consistent with the above explanation.

It can be noted that the SSC model is not sufficient to explain the broadband spectra of FSRQs. We therefore consider an additional contribution from EC emission processes for the FSRQ group. It is also very important to note that FSRQs have larger intrinsic powers than BL Lacs, based on the study of extended radio emission (e.g., Urry & Padovani (1995) and references therein), which is thought to be related to jet power (Kharb et al. 2010). Therefore, the intrinsic γ-ray luminosities of the FSRQs cannot be less than those of the BL Lacs, which also support the idea that the former have faster rotating black holes than the latter (see BGM). While considering a pure EC SED model for the FSRQ group (as shown in Fig. 2(d)), it is found that the average intrinsic γ-ray luminosity of the BL Lac group is larger than that of the FSRQ group. Therefore, we calculate that the maximum contribution for the EC process must be $< 94\%$ for $\delta = 13.5$ and $< 92\%$ for $\delta = 20.6$ to ensure that the average intrinsic γ-ray luminosity of the BL Lacs does not exceed that of the FSRQs.

According to the unification scenario (Urry & Padovani 1995; Antonucci 1993), FR II galaxies form the parent population of FSRQs while FR I galaxies constitute the parent population of BL Lacs. From radio observations, one can say that FR II galaxies exhibit more powerful and collimated jets than those of FR I galaxies. Considering that the magnetic field (B) plays a crucial role in jet collimation (Blandford & Znajek 1977; McKinney & Blandford 2009), one can expect to have more twisting of a B-field line, which will result in a more collimated jet for a faster spinning black hole. Sikora et al. (2007) investigated the dependence of the total radio luminosity of AGN-

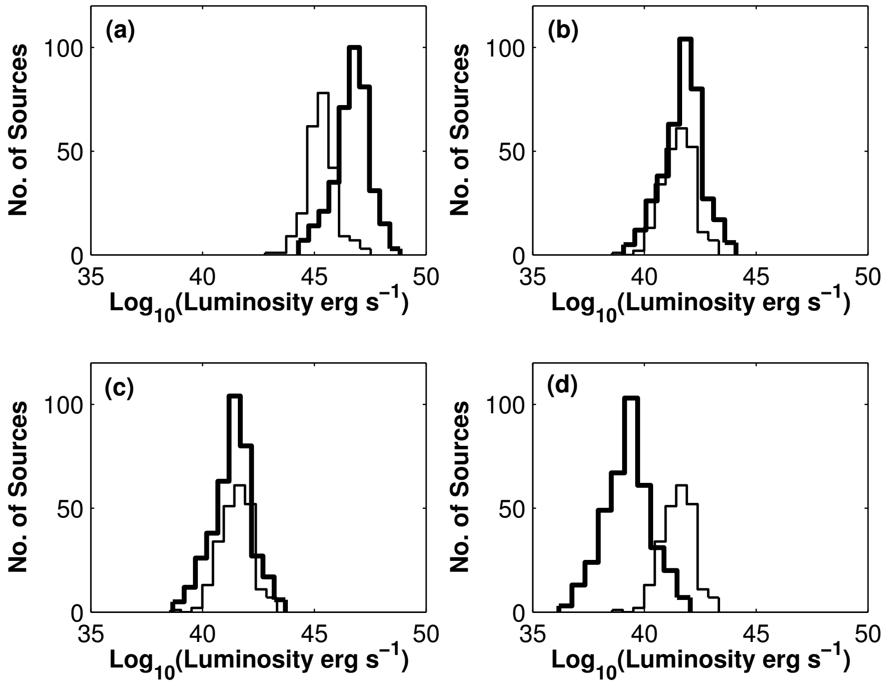

Fig. 2 Distribution of γ-ray luminosities for FSRQs and BL Lacs. The thick solid lines are for the FSRQ group and the thin solid lines are for the BL Lac group. (a) The distribution of γ-ray luminosities in the observer frame. In (b), (c) and (d), intrinsic γ-ray luminosities of the FSRQ group are calculated for 75%, 90% and 100% EC emission respectively and those of the BL Lac group are calculated considering SSC emission and a continuous jet model in which a Doppler beaming factor of 20.6 is considered for all cases.

powered radio sources on their accretion luminosities and the mass of the central black hole. They demonstrated that the radio selected AGNs hosted by giant elliptical galaxies can be $\sim 10^3$ times more radio loud than AGNs hosted by disk galaxies. Both galaxy groups show the same trend: an increase in radio loudness with a decrease of Eddington ratio ($L_{\rm Bol}/L_{\rm Edd}$). They proposed that the spin of the central black hole plays a crucial role in determining the radio loudness of AGNs, and that the central black holes in giant elliptical galaxies have (on average) much higher spin than black holes in spiral/disk galaxies.

Tchekhovskoy et al. (2010) investigated the role of the central black hole spin in the radio loud/quiet dichotomy. They found that, for a sub-Keplerian disk (similar to BGM), for radio quiet AGNs, a spin value of 0.15 can explain the luminosity mismatch of radio loud and radio quiet AGNs with the assumption that radio loud AGNs are maximally rotating. In order to understand the evolution of an AGN as a function of the spin of the black hole, Garofalo et al. (2010) modeled jets originating from all types of AGNs and connected them with the spin of the corresponding black holes and accretion rates. They concluded that radio loud and radio quiet AGNs both contain maximally rotating, but retrograde and prograde respectively, black holes. However, unlike BGM, they did not consider a complete disk-outflow coupled region which is important for a firm conclusion. A pure standard Keplerian disk, as they considered in formulating their model, might not exhibit an outflow or jet, as argued by them to be the case for high retrograde spinning FR II galaxies. Moreover, the change in spin of the black hole significantly alters the size/shape of the Keplerian/sub-Keplerian flow (Rajesh & Mukhopadhyay 2010) which was not included in their schematic formulation of the disk.

Celotti et al. (1997) estimated the kinetic luminosity in parsec-scale radio jets of a sample of radio loud AGNs and compared them in terms of BLR luminosity which is expected to be an indicator of ionizing luminosity. They found a weak hint of correlation between these luminosities and concluded that the magnetic field could be the possible factor responsible for the similarities found between kinetic luminosity and ionizing luminosity. Using the rough estimates of black hole masses and bolometric luminosities for a sample of 35 blazars, Wang et al. (2004) found that jet kinetic power is strongly related to accretion luminosity and black hole mass.

In a recent work, Xiong & Zhang (2014) analyzed a large sample of clean Fermi-LAT blazars. They concluded that after excluding the beaming effect and redshift effect, intrinsic γ-ray luminosity shows a significant correlation with broad-line luminosity, black hole mass and Eddington ratio. They also concluded that jet power has a close link with accretion. However, they considered a similar beaming effect for both FSRQs and BL Lacs.

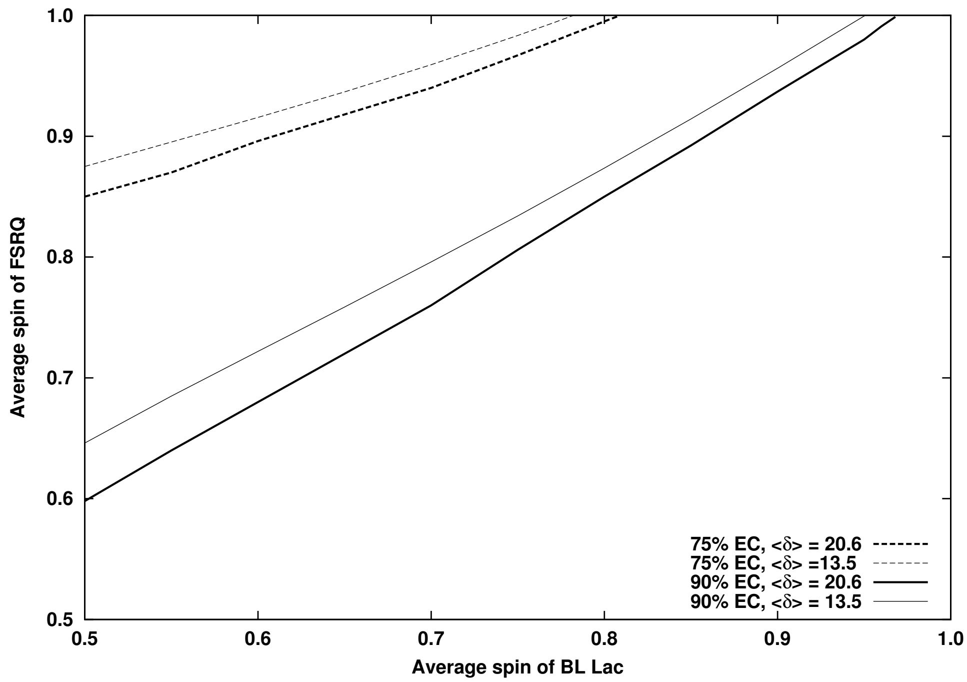

Fig. 3 The calculated average values of black hole spin in FSRQs versus average values of black hole spin in BL Lacs. The beaming effect is corrected considering SSC emission in BL Lacs. For FSRQs, different fractions of EC contribution (75% and 90%) are considered. The $\langle\delta\rangle$ are considered to be 20.6 and 13.5 at 75% (thick dashed line for 20.6 and thin dashed line for 13.5) and 90% (thick solid line for 20.6 and thin solid line for 13.5) contribution.

Mukhopadhyay, Bhattacharya and Sreekumar (2012, hereinafter MBS) investigated the spin of the central black holes of blazars utilizing first Fermi source catalog and AGN catalogs (Abdo et al. 2010a,b). They derived a simple relation between total mechanical power ($P_{\rm j}$) and the spin (a) utilizing equation (20) of BGM, by a third order polynomial function given by

$$P_{\rm j} = 10^{\xi a^3+\eta a^2+\chi a+\beta}, \qquad (3)$$

where

$$\xi = 2.87\pm0.26,$$
$$\eta = -4.08\pm0.40,$$
$$\chi = 2.88\pm0.17$$

and

$$\beta = 41.53\pm0.02\,.$$

Since BGM did not take into account any beaming effect while calculating $P_{\rm j}$ ($P_{\rm j}$ is calculated in the disk-outflow coupled frame), MBS assumed that $P_{\rm j}$ is proportional to the intrinsic luminosities

$$\left(\frac{P_{\rm j,FSRQ}}{P_{\rm j,BLLac}} = \frac{L_{\rm intrinsic,FSRQ}}{L_{\rm intrinsic,BLLac}}\right).$$

Following their approach, for a particular spin of a BL Lac, we calculate $P_{\rm j,BLLac}$ using Equation (3). Considering that the ratio of the intrinsic γ-ray luminosities of FSRQs and BL Lacs is equal to the ratio of $P_{\rm j}$s, the corresponding $P_{\rm j,FSRQ}$ is estimated from the average intrinsic γ-ray luminosities of the two classes. We calculate the average spin of a central black hole in FSRQs for a range of average central black hole spins of BL Lacs (Fig. 3) utilizing Equation (3).

FSRQs and BL Lacs, being radio loud AGNs, are expected to harbor faster spinning black holes than radio quiet AGNs (Tchekhovskoy et al. 2010). If one assumes that the central black hole spin of radio loud AGNs should not be less than 0.5, the minimum possible spin for FSRQs is estimated to be $\sim$0.85, 75% EC emission (and $\sim$0.6 for 90% EC emission) considering $\delta = 20.6$. For $\delta = 13.5$, assuming 75% EC emission, the values are estimated to be $\sim$0.87 for FSRQs ($\sim$0.65 for 90% EC emission).

On the other hand, if one assumes that FSRQs are maximally spinning objects, for $\delta = 20.6$, the maximum possible spin for BL Lacs is $\sim$0.81, for 75% EC emission ($\sim$0.97 considering 90% EC emission). For $\delta = 13.5$, the maximum possible spin for BL Lacs is $\sim$0.78, considering 75% EC emission (and $\sim$0.95 considering 90% EC emission).

In this work, it is evident that the difference in intrinsic γ-ray luminosities of FSRQs and BL Lacs is significantly smaller than that of observed γ-ray luminosities. The difference in central black hole spin can explain this small difference in average intrinsic luminosities of these two classes of sources.

Though the average values of δ of FSRQs and BL Lacs are not different (within 1σ error), there are indications that FSRQs may have higher average δ than BL Lacs. Linford et al. (2011) carried out a detailed study of jet properties using γ-ray and radio observations and concluded that the median core fraction of BL Lacs is lower than that of FSRQs. As a high core fraction can point to a high δ, this indicates that FSRQs may have higher values of δ than BL Lacs. Lister et al. (2009) reported that LAT detected FSRQs have more than a factor of two higher apparent jet speeds than LAT detected BL Lacs. In an earlier work, BGM found that the outflow velocity increases with the increase in spin of the black hole. However, due to the limitation of their model, their outflow velocities are non relativistic and, hence, it is not possible from their work to quantitatively predict the effect of black hole spin on Γ. Therefore, a more detailed modeling together with the observational measurement of Γ of many more sources will help to resolve this interesting problem.

5 CONCLUSIONS

The analysis in this work indicates that FSRQs and BL Lacs cannot have different accretion models involving a large difference in accretion rates (Keplerian disk and optically thin sub-Keplerian disk) because of the significantly reduced luminosity mismatch between these two classes after imposing the beaming correction. Alternatively, this small difference in average luminosities of these two classes can be well explained by the small difference in their central black hole.

We propose that the two classes of blazars, FSRQs and BL Lacs, harbor black holes of different spins. One can measure the mean difference in spin of the central black hole from the difference in the total outflow power and therefore intrinsic luminosity. Therefore, it can be argued that the spin of the central black hole plays an important role in jet emission. Our work indicates that the central black holes in FSRQs are faster rotators than BL Lac sources. Considering the difference in luminosities among different BL Lac sub-classes, LSPs harbor faster rotating black holes than ISPs, while HSPs are slow rotators.

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