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The Correlation between γ-Ray and Radio Emissions for the Fermi Blazars

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Abstract. Based upon the Fermi blazars sample, the radio and γ-ray emissions are compiled for a sample of 74 γ-ray loud blazars to calculate the radio to γ-ray effective spectrum index $\alpha_{R\gamma}$. The correlations between $\alpha_{R\gamma}$ and γ-ray luminosity, and between radio and γ-ray luminosity are also investigated.

Key words. BL Lacs—quasars—γ-ray emissions.

1. Sample and method

Based on LAT Bright AGN Sample (LBAS) (Abdo *et al.* 2009), we obtained a new sample including 46 FSRQs and 28 BL Lacs consisting of 22 RBLs and 6 XBLs.

We converted the γ-ray photon fluxes, namely F_{100} ($E > 100$ MeV, photon $\cdot$ cm^{-2} $\cdot$ s^{-1}) to γ-ray flux densities at 1 GeV, by the relation $\mathrm{d}F/\mathrm{d}E = F_0 E^{-\Gamma}$. The γ-ray fluxes are k-corrected according to $F_{1\,\mathrm{GeV},\,k} = F_{1\,\mathrm{GeV}}(1+z)^{(\Gamma-2)}$.

The luminosities of radio (5 GHz) and γ-ray emission at 1 GeV are calculated using $\nu L_\nu = 4\pi d_L^2 \nu F_\nu$, where d_L is the luminosity distance (Pedro & Priyamvada 2007).

We calculated the radio (5 GHz) to γ-ray emission at 1 GeV effective spectrum index values, $\alpha_{R\gamma} = -\log(F_{5\,\mathrm{GHz}}/F_{1\,\mathrm{GeV},\,k})/\log(\nu_R/\nu_\gamma)$.

2. Results

The radio to γ-ray effective spectrum indices ($\alpha_{R\gamma}$), the radio and γ-ray luminosities for all sources are as follows:

For FSRQs, $\overline{\log(\nu L_\gamma)} = 46.97 \pm 0.70$, $\overline{\log(\nu L_R)} = 44.58 \pm 0.60$, $\overline{\alpha_{R\gamma}} = 0.826 \pm 0.033$. For RBLs, $\overline{\log(\nu L_\gamma)} = 45.57 \pm 1.22$, $\overline{\log(\nu L_R)} = 43.21 \pm 1.23$, $\overline{\alpha_{R\gamma}} = 0.828 \pm 0.035$. For XBLs, $\overline{\log(\nu L_\gamma)} = 44.33 \pm 0.64$, $\overline{\log(\nu L_R)} = 41.60 \pm 0.71$, $\overline{\alpha_{R\gamma}} = 0.801 \pm 0.040$.

The plan of $\log(\nu L_\gamma)$ *vs.* $\alpha_{R\gamma}$ is shown in Fig. 1. When we performed the linear regression analysis for the radio and the γ-ray luminosities, we received the result

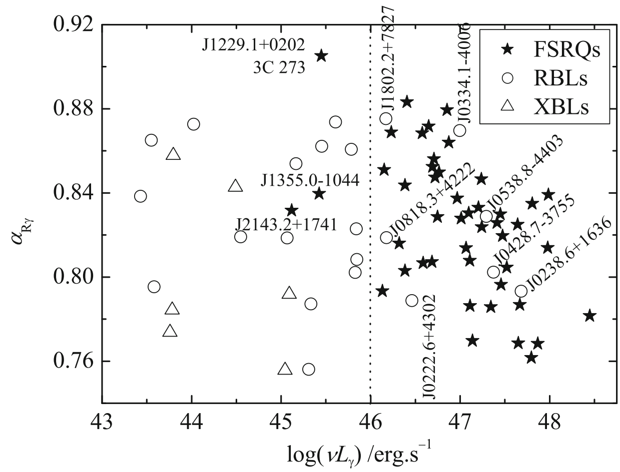

Figure 1. Plan of the effective spectrum index *vs.* γ-ray luminosity.

that $\log(\nu L_R) = (0.94\pm0.04)\log(\nu L_\gamma)+(0.24\pm2.06)$, with a correlation coefficient of $r = 0.93$, and a chance probability of $p < 0.0001$.

3. Discussion and conclusions

From the above results we found that the average value of radio to γ-ray spectrum index for FSRQs is similar to the RBLs, namely, $\overline{\alpha}_{R\gamma}^{FSRQs} \simeq \overline{\alpha}_{R\gamma}^{RBLs} \approx 0.83$, but the average of the spectrum index for XBLs is more flat than that for FSRQs and RBLs (here $\overline{\alpha}_{R\gamma}^{XBLs} = 0.80$). The average radio and γ-ray luminosity from the regular sequence is $\overline{\log(\nu L_\nu)}^{FSRQs} > \overline{\log(\nu L_\nu)}^{RBLs} > \overline{\log(\nu L_\nu)}^{XBLs}$. A clear correlation between radio and γ-ray luminosity is found.

In Fig. 1, BL Lacs and FSRQs occupy different regions. The division between these two groups are indicated by $\log(\nu L_\gamma) = 46\ \mathrm{erg}\cdot\mathrm{s}^{-1}$ in Fig. 1. Most sources of the BL Lacs occupy left area, and most FSRQs occupy the right area.

Having made this analysis, we consider that the RBLs is the bridge connect between XBLs and FSRQs, and RBLs is the middle state of FSRQs and XBLs. The γ-ray is associated with the radio emission from the jet. Ghisellini *et al.* (2009) suggested that this division had its origin in the different accretion regimes of the two classes of object. The spectral separation in hard (BL Lacs) and soft (FSRQs) objects can therefore be seen to result from the different radiative cooling suffered by the relativistic electrons in jets propagating in different ambients.

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