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Multi-Band Spectral Properties of Fermi Blazars

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Abstract. The multi-band data covering optical, X-ray and γ-ray energy regions of 130 Fermi blazars in the First LAT AGN Catalog (1LAC) were collected to investigate the broadband spectral properties. The composite spectral indices show that HBLs have convex optical-to-X-ray continua and concave X-ray-to-γ-ray continua, $\alpha_{\gamma X\gamma}>0$ and $\alpha_{XOX}<0$, while FSRQs and LBLs have $\alpha_{\gamma X\gamma}<0$. The α_{XOX} distribution of FSRQs and LBLs extends from negative to positive values. We suggest $\alpha_{\gamma X\gamma}>0$ and $\alpha_{XOX}<0$ could be considered as a criterion for HBLs. Moreover, HBLs have narrow distribution of peak interval of $\log\nu_{\rm p}^{\rm ic}-\log\nu_{\rm p}^{\rm syn}$, and FSRQs have significant anti-correlation between $\log\nu_{\rm p}^{\rm ic}-\log\nu_{\rm p}^{\rm syn}$ and $\log\nu_{\rm p}^{\rm syn}$. This indicates that SSC model is responsible for high energy emission of HBLs, while EC for FSRQs. Our results also indicate that FSRQs with larger break energy of electrons have smaller bulk Lorentz factor of dissipation region.

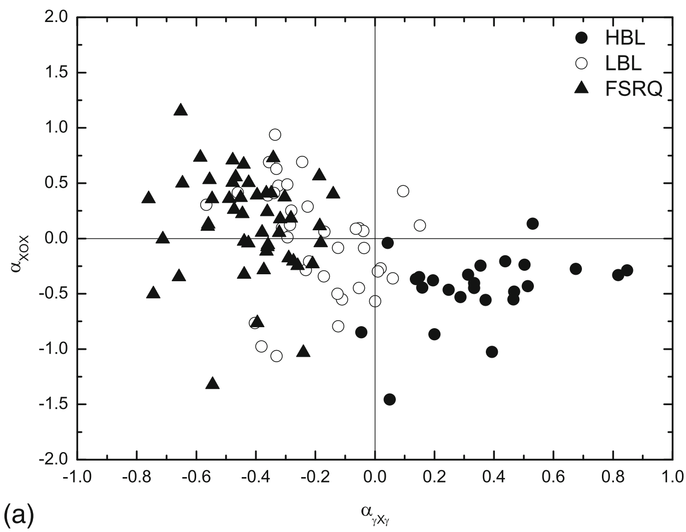
Key words. Galaxies: active—BL Lacertae objects—general—gamma rays—observations.

1. Introduction

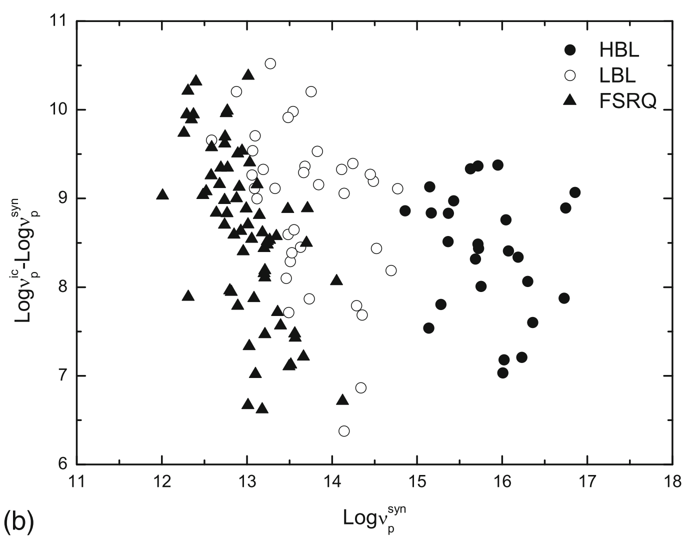
The First Fermi-LAT Catalogue (1LAC) of AGN, corresponding to 11 months of data collected in scientific operation mode, includes 709 AGNs, comprising 300 BL Lacs, 296 FSRQs, 41 AGNs of other types and 72 AGNs of unknown type (Abdo *et al.* 2010a). This large sample enable us to investigate the spectral shapes of blazars from optical to X-ray to γ-ray in more detail than has been done before. For this purpose, we collected data for all Fermi blazars having available spectral information in optical and X-ray bands. The frequencies of synchrotron peak, $\nu_{\rm p}^{\rm syn}$ and IC peak, $\nu_{\rm p}^{\rm ic}$ were calculated using the empirical relationships derived by Abdo *et al.* (2010b). The integrated GeV flux is transformed into the monochromatic flux at 1 GeV.

2. Results and discussions

It can be found that HBLs and FSRQs occupy different regions, and LBLs bridge the gap between HBLs and FSRQs (see Fig. 1a). HBLs have $\alpha_{\gamma X\gamma}>0$ and $\alpha_{XOX}<0$. FSRQs and LBLs have $\alpha_{\gamma X\gamma}<0$, however, the α_{XOX} of FSRQ/LBL extends from negative to positive values. This suggests that optical and X-ray emission of HBLs



(a)



(b)

Figure 1. (**a**) Distribution of composite spectral indices $\alpha_{\gamma X\gamma} - \alpha_{XOX}$. (**b**) The correlation between $\log \nu_{\mathrm{p}}^{\mathrm{ic}} - \log \nu_{\mathrm{p}}^{\mathrm{syn}}$ and $\log \nu_{\mathrm{p}}^{\mathrm{syn}}$.

are produced by different branches of the synchrotron emission and the energy of IC peak $E_{\mathrm{p}}^{\mathrm{ic}} > 1$ GeV. All FSRQs have negative $\alpha_{\gamma X\gamma}$ and most FSRQs have positive α_{XOX} indicating that X-ray emission of FSRQs is contributed by IC. The X-ray emission of LBLs is more complicated, however, the negative $\alpha_{\gamma X\gamma}$ suggests that the LBLs have a smaller $\nu_{\mathrm{p}}^{\mathrm{ic}}$ than HBLs. We suggest that in addition to $\alpha_{RX} \leq 0.75$, $\alpha_{\gamma X\gamma} > 0$ and $\alpha_{XOX} < 0$ could be considered as a criterion for selecting HBLs. The distribution of $\log \nu_{\mathrm{p}}^{\mathrm{ic}} - \log \nu_{\mathrm{p}}^{\mathrm{syn}}$ is quite different (see Fig. 1b). On the one hand, for FSRQs and LBLs the distribution is wide, spanning the interval between 6.5 and

10.5, and we find a significant anti-correlation between $\log \nu_{\rm p}^{\rm ic} - \log \nu_{\rm p}^{\rm syn}$ and $\log \nu_{\rm p}^{\rm syn}$ with $r = -0.619$ and $p < 10^{-4}$ and $\log \nu_{\rm p}^{\rm ic} - \log \nu_{\rm p}^{\rm syn} = -1.372 \times \log \nu_{\rm p}^{\rm syn} + 26.440$ in FSRQs. For HBLs, on the other hand, the value of $\log \nu_{\rm p}^{\rm ic} - \log \nu_{\rm p}^{\rm syn}$ distributes in a relative narrow region of 7–9.5 and no correlation is found. Our results indicate that SSC model is responsible for high energy emission of HBLs, while EC for FSRQs. In the case of EC process, the IC peak is $\nu_{\rm p}^{\rm EC} = \frac{4}{3}\Gamma\delta\nu_{\rm EC}\gamma_{\rm b}^2$, where $\nu_{\rm EC}$ is the frequency of the external photon for IC and Γ is the bulk Lorentz factor. Our result implies that for FSRQs the higher the energy of γ_b, the smaller the bulk Lorentz factor.

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References

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