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ORIGINAL ARTICLE

Linear size–extended radio luminosity (D–P_E) correlation in BL Lacertae objects: evidence for large scale beaming?

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Abstract In this paper, we use the distributions of projected linear size (D), core- (P_C) and extended- (P_E) radio luminosities, to investigate a consequence of relativistic beaming and radio source orientation scenario for low-luminosity extragalactic radio sources. In this scenario, BL Lacertae objects (BL Lacs) are believed to be Fanaroff-Riley type I (FR I) radio galaxies, but with radio axes aligned close to the line of sight. At this orientation, the core emission is greatly enhanced by relativistic Doppler boosting and linear size foreshortened due to geometrical projection. A simple outcome of this scenario is that the extended luminosity is expected to be orientation invariant, but a D–P_C correlation is envisaged. Results show that both the relative core dominance (R) and linear size are strongly correlated with extended luminosity ($r \geq 0.7$). Using the R-distribution and R–P_E anti-correlation, we show that the difference in radio core-dominance between FR I radio galaxies and X-ray selected BL Lacs can be accounted for by a bulk Lorentz factor $\gamma \sim 5$–13 and viewing angle $\phi \sim 5$–$15°$, which can be understood in terms of the scenario, with relativistic beaming persisting at largest scales.

Keywords Active galaxies · BL Lac objects—general

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1 Introduction

BL Lacertae objects (BL Lacs) are among the most violent active galactic nuclei (AGNs). They are characterized by extreme properties such as rapid variability of radiation flux at all wavelengths, core-dominated radio morphology, flat radio spectra and frequent superluminal motion. These extreme properties which they share with optical violently variable quasars (OVVQs) are believed by many authors to be caused by Doppler-boosted radiation emanating from relativistic jets aligned at close angles to the line of sight (Kollgaard 1994; Giroletti et al. 2006). The relativistic beaming model has been remarkably successful in explaining the observational properties of the AGNs. In this model, the emission from AGNs is composed of two components, namely: the boosted core component and the isotropic lobe/extended component. The ratio of the two components defines the core-dominance (R) parameter which is a measure of relativistic beaming in AGNs (e.g. Orr and Browne 1982; Fan and Zhang 2003). In a popular unification scenario for low luminosity AGNs based on relativistic beaming, BL Lacs are believed to be the beamed counterparts of Fanaroff-Riley type I (FR I) radio galaxies, which presumably, form their unbeamed parent population (Urry and Padovani 1995). For BL Lacs in which the core emission is expected to be Doppler boosted, R is large ($R \gg 1$), while for FR I galaxies in which Doppler boosting is expected to be less important, R is small ($R \ll 1$). Thus, many properties of BL Lacs can be attributed to relativistic Doppler boosting effects when observed at small angles to the line of sight (Kollgaard et al. 1996). In addition, the projected radio sizes (D) of BL Lacs are expected to be foreshortened due to geometrical projection effects at such small viewing angles (Orr and Browne 1982).

Similarly, Neff and Hutching (1990) have shown from the studies of extended morphology of powerful radio sources