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ORIGINAL ARTICLE

Luminosity–redshift ($L - z$) relation and the blazar sequence for low power blazars

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Abstract This paper presents an alternative interpretation for the wide scatter and apparent lack of anti-correlation in the relationship between the spectral luminosity (L_ν) and synchrotron peak frequency (ν_{peak}) in a sample of BL Lac Objects contained in Wu et al. (Astron. Astrophys. 466:43, 2007) compilation. The apparent lack of correlation between the parameters contradicts the blazar sequence proposed by Fossati et al. (in Mon. Not. R. Astron. Soc. 299:433, 1998), which predicts a general decline in L_ν with increasing ν_{peak}. Analysis of the radio luminosity and synchrotron peak frequency data of the sample reveals a strong selection effect, due to Malmquist bias. We show that a clear anti-correlation ($r \sim -0.7$) between the radio luminosity at synchrotron peak (L_{peak}) and ν_{peak} exists for the BL Lac sample above some redshift cut-off ($z_c = 0.3$), which may correspond to the flux limit of the sample. The results are not only in agreement with FRI–BL Lac unification, but also suggest that the present data is consistent with the blazar sequence.

Keywords BL Lac objects: general · galaxies; blazars

1 Introduction

Blazars are the most violent type of active galactic nuclei (AGNs), which are characterized by the strong variability of radiation fluxes, flat radio spectra, optical polarization and frequent superluminal motion. They are very prominent across the entire electromagnetic spectrum, from radio to gamma-ray bands. The paradoxes associated with the extreme properties of blazars, especially, violent variability of radiation fluxes at all wavebands has been interpreted in the light of relativistic jets in AGNs (e.g. Urry 1998). Thus, their perculiar properties are believed to be caused by Doppler-boosted radiation emanating from the relativistic jets aligned close to the line of sight. Two broad subclasses of the AGNs make up blazars—the flat spectrum radio quasars (FSRQs) at the high luminosity end and BL Lacertae objects (BL Lacs) at the low luminosity regime. However, BL Lacs differ from FSRQs in many respects, namely: absence of strong (if any) optical lines (e.g. Stocke et al. 1991); on average, lower redshift and luminosity distribution than FSRQs (e.g. Murphy et al. 1993).

The long-standing orientation-based unification scheme for radio-loud AGNs proposes BL Lacs and FSRQs as counterparts to Fanaroff-Riley type I and II (FR I and FR II) radio galaxies, respectively, based on similar spectra, morphologies and range in extended radio luminosity (Urry and Padovani 1995). However, violations to this scheme are well-known, and findings of powerful FR II-like BL Lacs, low-power FSRQs and BL Lacs exhibiting broad lines in low continuum states (e.g. Kharb et al. 2010; Landt and Bignall 2008; Raiteri et al. 2007) appear to break this simple dichotomy between the powerful edge-brightened FR II galaxies and low-power edge-darkened FR Is.

Two search strategies are commonly used to find BL Lacs. One is to search among flat spectrum radio sources leading to radio selected BL Lacs (RBLs) and the other is to search for strong X-ray sources, leading to X-ray selected BL Lacs (XBLs). These two subclasses of BL Lacs show different observational properties. For instance, RBLs are known to be more variable, more luminous at radio and opti-

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