

NEW EXTREME SYNCHROTRON BL LAC OBJECTS

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ABSTRACT We report on the *BeppoSAX* observations of four “extreme” BL Lacs, selected to have high synchrotron peak frequencies. All have been detected also in the PDS band. For 1ES 0120+340, PKS 0548–322 and H 2356–309 the spectrum is well fitted by a convex broken power-law, thus locating the synchrotron peak around 1–4 keV. 1ES 1426+428 presents a flat energy spectral index ($\alpha_x = 0.92$) up to ~ 100 keV, thus constraining the synchrotron peak to lie near or above that value. For their extreme properties, all sources could be strong TeV emitters.

KEYWORDS: BL Lacertae objects: individual: 1ES 0120+340, PKS 0548-322, 1ES 1426+428, H 2356-309 — X-rays: general — TeV: general

1. INTRODUCTION

BL Lac objects are usually divided in two main classes, on the basis of their overall Spectral Energy Distribution (SED): LBL or HBL (low or high energy peaked BL Lacs), according as the peak of the synchrotron emission (in a νF_ν representation) is in the IR–optical or EUV–soft-X band, respectively. In the X-ray band this usually translates in a spectral index which is steep ($\alpha_x > 1$) for HBLs (corresponding to the tail of the synchrotron emission) and flat ($\alpha_x < 1$) for LBLs (corresponding to the upcoming of the Inverse Compton emission). In 1997, the *BeppoSAX* observations of Mkn 501 (Pian et al. 1997) and 1ES 2344+514 (Giommi et al. 1997) revealed that, at least in a flaring state, the peak of the synchrotron emission can actually reach very high energies, around 100 keV, with a consequently flat synchrotron X-ray spectral index. In order to find and study other sources with such “extreme” properties, we have selected several candidates from the Einstein Slew Survey and the Rosat All Sky Survey Bright Sources Catalogue (RASSBSC). The selection criteria were based on properties suggesting a high ν_{peak} :

a) very high F_x/F_{radio} ratio ($> 3 \times 10^{-10}$ erg cm⁻² s⁻¹ / Jy, at [0.1–2.4] keV and

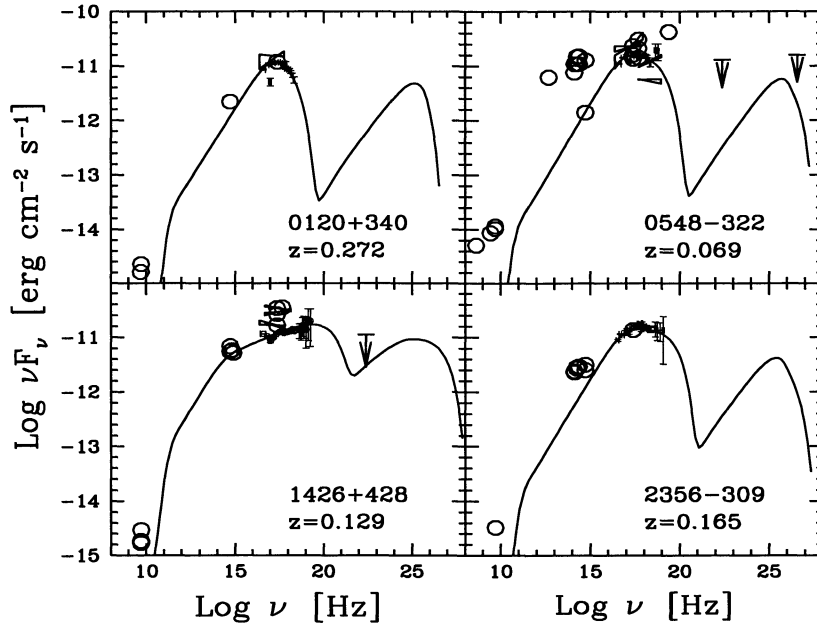


FIGURE 1. The SEDs of the 4 BL Lacs, made with *BeppoSAX* and literature data, together with a pure homogeneous SSC model (further details in Costamante et al., in prep.)

5 GHz respectively); b) flat X-ray spectrum (when available), connecting smoothly with the flux at lower frequencies; c) appropriate values of α_{ro} , α_{ox} and α_{rx} (Padovani & Giommi 1995). A high X-ray flux ($> 10^{-11}$ erg cm $^{-2}$ s $^{-1}$) in the 2–10 keV band was also requested, to achieve a good detection in the PDS instrument.

We used the *BeppoSAX* satellite, whose wide X-ray energy range (0.1–200 keV) is ideal to constrain the synchrotron peak. Four objects have been observed, between June 1998 and April 1999: 1ES 0120+340, PKS 0548–322, 1ES 1426+428 and H 2356–309. In Fig. 1 and Table 1 only the best fit results are reported (for a complete discussion, see Costamante et al., in preparation). LECS, MECS and PDS data have been reduced and analysed according to the SDC Cookbook instructions, using the latest calibration matrices available. Standard extraction radii of 4' and 8' for MECS and LECS were used, except for the PKS 0548–322 observation of 20/2/99: in this case a 6' radius for the LECS has been used, due to the presence of a contaminating source in the field of view (identified as the star GSC_07061_01558 in the Guide Star Catalog, probably flaring).

The PDS instrument doesn't have imaging capabilities, and its f.o.v. (radius $\sim 45'$) is larger than LECS and MECS ($\sim 28'$ for the MECS). Therefore there is the possibility for PDS spectra to be contaminated by hard serendipitous sources in the f.o.v., not visible in the MECS images. Analyzing PDS data, we have taken this into account, also checking in the NED database for potentially contaminating sources.

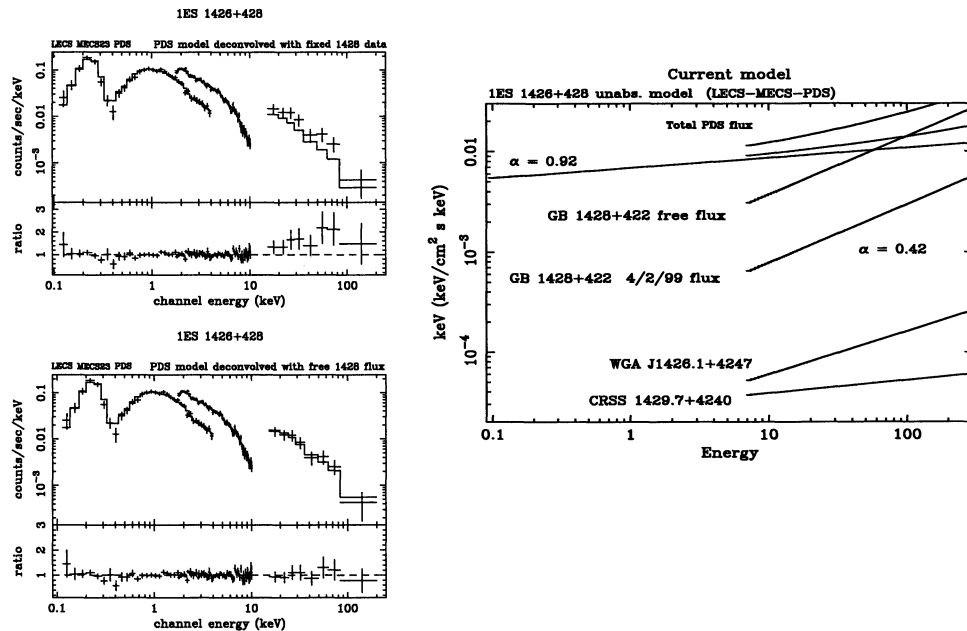


FIGURE 2. Left panel: LECS+MECS single powerlaw fits to 1ES 1426+428 data, with two different levels for GB 1428+422 flux. Right panel: the model used for PDS data.

2. 1ES 1426+428

At 41' from this source, thus in the PDS f.o.v., there is the quasar GB 1428+422 (Fabian et al 1998). To account for its contribution, we have added a component to the PDS model, based on the GB 1428+422 data from the *BeppoSAX* observation of 4/2/99 ($\alpha = 0.42$, $F_{1\text{keV}} = 0.30 \mu\text{Jy}$; Celotti & Iwasawa, priv. comm.). We have also checked in the NED and WGACAT databases for other potentially contaminating objects: we added the contributions of the two most important objects (WGA J1426.1+4247 and CRSS 1429.7+4240, Fig 2 right panel), according to the fluxes and spectral indices extrapolated from the ROSAT band (when data were not available in literature, we used galactic N_{H} and a HR- α conversion by Giommi, priv. comm.). Summing all components, the different off-axis response of the instrument has been taken into account. The PDS/MECS normalization has been fixed at 0.9. With this model (Fig. 2 right panel), adding the PDS data to the LECS+MECS fit yields a $\chi_r^2 = 1.06$, with the PDS points still slightly above the model (Fig.2 left upper panel). A better χ_r^2 (0.95) is obtained with GB1428+422 flux as a free parameter: in this case the resulting flux is $F_{1\text{keV}} = 1.44 \pm 0.54$, a factor more than 4 higher during this observation than the week before. *Anyway, in both cases, the spectrum of 1ES 1426+428 remains flatter than unity up to 100 keV.*

TABLE 1. LECS+MECS best fits parameters

Source, date, model	N_{H} 10^{20} cm^{-2}	α_1	E_{break} keV	α_2	$F_{1\text{keV}}$ μJy	F_{2-10} ergs/cm ² s	$\chi^2/\text{d.o.f.}$
1ES 0120+340							
2/2/99, BP	5.2 gal.	$0.82_{+0.26}^{-0.96}$	$1.4_{+1.2}^{-0.7}$	$1.32_{+0.08}^{-0.08}$	$4.5_{+2.1}^{-0.6}$	1.3×10^{-11}	0.92/93
PKS 0548-322							
20/2/99, BP	$4.2_{+1.1}^{-0.9}$	$0.91_{+0.10}^{-0.16}$	$4.4_{+1.8}^{-2.2}$	$1.38_{+0.59}^{-0.31}$	$5.7_{+0.5}^{-0.5}$	2.3×10^{-11}	0.95/82
1ES 1426+428							
8/2/99, SP	$1.5_{+0.4}^{-0.3}$	$0.92_{+0.04}^{-0.04}$	—	—	$4.6_{+0.2}^{-0.2}$	2.0×10^{-11}	1.00/89
H 2356-309							
21/6/98, BP	1.3 gal.	$0.78_{+0.06}^{-0.09}$	$1.8_{+0.6}^{-0.6}$	$1.10_{+0.05}^{-0.05}$	$6.2_{+0.5}^{-0.5}$	2.5×10^{-11}	0.94/35
SP: Single Powerlaw		BP: Broken Powerlaw		Errors at 90% conf. level for 2 par. of interest			

3. RESULTS

The main results for all sources are presented in Table 1. All have been detected in the PDS band. For three of them the spectrum is best fitted with a convex broken power-law: this locates the peak of the synchrotron emission in the X-ray band, around 1-4 keV, thus confirming the “extreme” nature of these sources. The spectrum of 1ES 1426+428 is instead well fitted by a single powerlaw, with a flat spectral index ($\alpha = 0.92$) up to 100 keV. **This constrains the synchrotron peak to lie near or above 100 keV.** Such high values of the synchrotron peak frequencies, flagging the presence of high relativistic electrons, make these sources good candidates for TeV emission through the Inverse Compton mechanism.

ACKNOWLEDGEMENTS

This research has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. We thank the *BeppoSAX* Science Data Center for their support in the data analysis. This research is financially supported by the Italian Space Agency. L.C. thanks the Cariplo Foundation and the Italian MURST for support.

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