

TWO *BEPPOSAX* OBSERVATIONS OF BL LAC

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ABSTRACT. We present the results of two ToO *BeppoSAX* observations of BL Lac. During the first observation we detected both the synchrotron and the Compton components. Fast time variability was present, but **only** for the synchrotron component. During the second observation the spectrum was flatter and only the Compton component was present. Four different SED are presented and can be described by a blob moving along a jet and responsible for the SSC emission. The seed photons for the Compton scattering are the synchrotron photons themselves plus possibly external photons coming from the broad line region.

1. Introduction

BL lac objects are highly variable sources characterised by non thermal emission that dominates from the radio to the γ -rays. The overall Spectral Energy Distribution (SED) is dominated by two broad emission peaks: the lower frequency peak is believed to be produced by synchrotron emission, while the higher frequency peak is probably due to inverse Compton process. The variability for these sources is more pronounced at higher energies and the overall SED can change dramatically during strong flare events (e.g. Mkn 501, Pian et al. 1997; 1ES 2344+514, Giommi et al. 1997).

Here we report on the two *BeppoSAX* observations of BL Lac itself, during a campaign aiming to study other BL Lac objects while in a flaring state. BL Lac X-ray spectrum is quite hard with an energy spectral index of $\alpha = 0.4 - 0.9$ (Sambruna et al. 1999; Madejski et al. 1999). It has already been observed by *BeppoSAX*, in November 1997, with a 2-10 keV flux of $\sim 2 \times 10^{-11}$ erg s⁻¹ cm⁻² (Padovani et al. in preparation). This is comparable to the level observed by *RossixTE* during the 1997, July outburst. Our two *BeppoSAX* observations were triggered by two optical flare events (R magnitude brighter than 13 mag), although when the source was actually observed by *BeppoSAX* the optical flux was lower (R=13.4-13.6 mag).

Date	α_1	α_2	$F_{2-10\text{keV}}$ ergs cm ⁻² s ⁻¹	$\chi_r^2/\text{d.o.f.}$
5-7 June 1999	1.6 ± 0.25	0.15 ± 0.22	0.6×10^{-11}	1.03/122
5-6 December 1999	$0.6_{+0.04}^{-0.05}$		1.2×10^{-11}	1.02/130

N_{H} fixed at the value 2.5×10^{21} cm⁻². The two power laws cross at ~ 5.5 keV.

2. Observation and Results

On May, 1999, BL Lac was reported to be again in an optically bright state, thus we triggered our *BeppoSAX* ToO and BL Lac was observed the 5-7 of June, 1999. However, the source was about a factor of two weaker than the first *BeppoSAX* observation. The 0.1-100 keV X-ray spectrum cannot be fitted by a single power law. A broken power law gives a better fit with a concave shape (see Table 1). For the interstellar absorption we find a value of $N_{\text{H}} = 2.5 \times 10^{21} \text{ cm}^{-2}$, consistent with the values found in previous works (see Sambruna et al. 1999; Madejski et al. 1999). Thus, we probably detected both the synchrotron and the inverse Compton components. During this observation we also find very short time scale variability, with the **0.1-10 keV flux increasing by a factor of two in about 20 minutes**. This variation was not detected in the simultaneous R band light curve. This variability is seen only in the synchrotron part of the spectrum. In fact, both the LECS and the MECS instruments detect this variability only below the break, $\sim 4 \text{ keV}$ (see Fig. 1 in Tagliaferri et al. 2000a). This result is similar to what we observed during another *BeppoSAX* ToO observation of the BL Lac object ON 231 (Tagliaferri et al. 2000b).

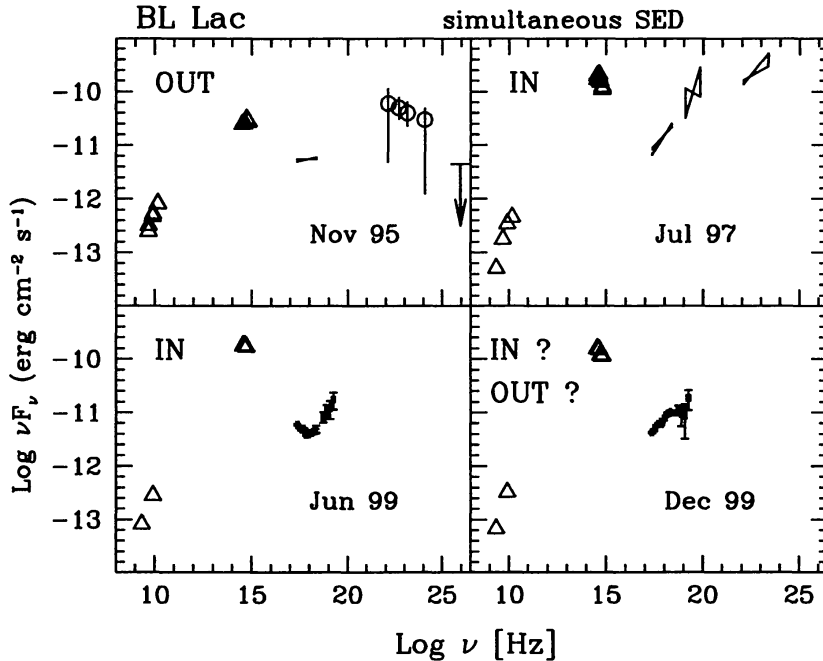


Fig. 1. We plot four different SED of BL Lac. For the 1995 SED see Sambruna et al. (1999), for the 1997 SED see Madejski et al. (1999). For the two *BeppoSAX* observations the simultaneous radio data are from NRAO, while the optical data are from our observations. The labels OUT or IN mean that the emitting blob is outside-inside the BLR (see Discussion).

After the *BeppoSAX* observation, the source remained active in optical with the R magnitude ranging between $\sim 12.6 - 13.8 \text{ mag}$. At the end of November, it brightened again to $R \sim 12.4$, thus we triggered a second *BeppoSAX* ToO observation. However,

again, when the source was observed in X-ray the R magnitude was down to $R \sim 13.5$. This time the 0.1-100 keV X-ray spectrum is well fitted by a single power law, with a flat energy index $\alpha = 0.6$. The total flux in the 2-10 keV energy band is about a factor of two higher, however the two spectra cross at about 1.5 keV, thus the flux in the softer X-ray energy band is actually lower. Clearly, the overall shape of the SED changed between the two observations and during the second one we detected only the Compton component. During this observation we did not detect fast variability.

3. Discussion

We plot in Fig. 1 four different SEDs corresponding to the multi-wavelength campaigns carried out during November 1995, during July 1997, when the source was in a very high state and during the two *BeppoSAX* observations. This figure clearly shows the high degree of variability and complexity of the BL Lac's SED. Probably different emission mechanisms are working at different times. Here we propose the presence of a blob moving along a jet, responsible for the SSC emission. If the moving blob is outside the broad line region (BLR), there will not be an extra Compton component. If instead the blob is inside the BLR, then there will also be external seed photons coming from the BLR that can be Compton scattered. These will be even more numerous if one or more clouds were inside the jet itself. The various scenarios are sketched in Fig. 2. In Fig. 1 the labels OUT/IN mean that the model that better represents the data is the one with the blob INSIDE or OUTSIDE the BLR.

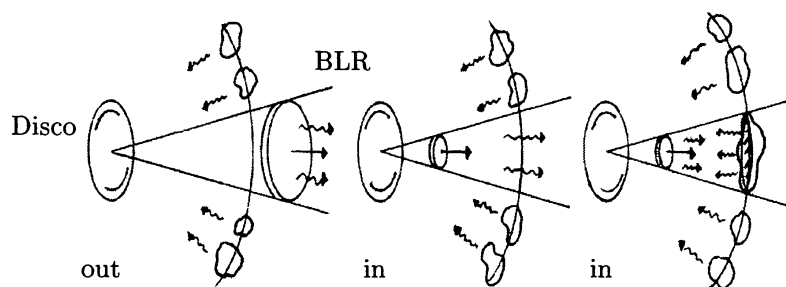


Fig. 2. We sketch here three different scenarios describing the position of the blob inside the jet with respect to the broad line region. The different situations can explain the SED observed at different epochs.

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