SOFT X-RAY EMISSION FROM BL LAC OBJECTS

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Introduction

A program of observations of BL Lac objects is being carried out by means of the European X-ray satellite EXOSAT. In the following we will present preliminary results of three of these observations. We will deal with the LE telescope data only.

We will first report on the results we obtained from two observations of PKS 0548-322, which is a strong source, then we will discuss the limits of an observation of a weak source, namely AP Librae, and finally we shall briefly report on the peculiar image we obtained of BL Lac itself.

PKS 0548-322

This source had been observed three times with the "Einstein" Observatory between February 1979 and March 1980. The three observations did not reveal any intensity variations and the spectrum between 0.2 and 10 keV can be well represented by a single power law with absorption column $N_H \sim 4.5 \times 10^{20}$ cm^{-2} and energy spectral index $\alpha \sim 1.1$ (Maccagni, Maccacaro and Tarenghi 1983).

The two EXOSAT observations took place on 1983 November 2 and 30. The thin lexan, aluminum/parylene and boron filters were used both times in conjunction with the LE telescope 1 CMA. The source has always been detected above the 5 σ level in all filters and this has allowed us to infer the spectral parameters on the assumption of a single power law between 0.02 and 2 keV. We note that the counting rates in the three filters represent integral fluxes in the same energy band corresponding to different effective areas and therefore the problem has no degrees of freedom whatsoever (see Maccagni et al. 1984 for a more detailed discussion). In Figure 1 we show contours in the α, N_H plane inside which the three ratios computed from the counting rates in the three filters used are simultaneously satisfied whithin 1 σ statistical errors. It is sufficient to bring the constraint to 2 σ for the November 30 observation (dotted line) for a full compatibility of the two observations with the same spectral parameters. Furthermore, the resulting parameters (and the flux that can be calculated from them) are also compatible with the "Einstein" best-fit (indicated by a cross in Figure 1).

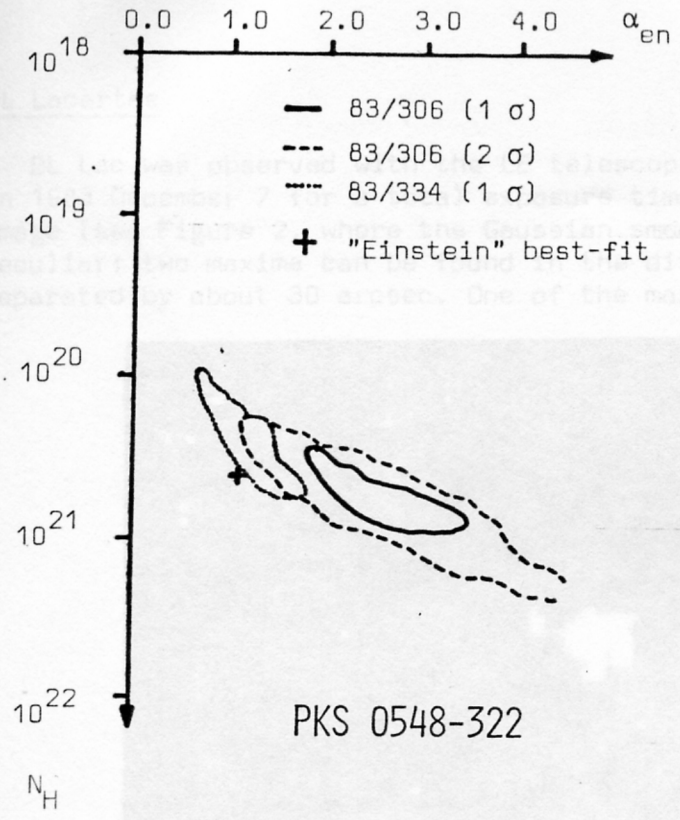

FIGURE 1

We can thus conclude that PKS 0548-322 has shown no flux and/or spectral variations on time scales ranging from 26-28 days (two "Einstein" and two EXOSAT observations respectively) to 4.6 years (from the comparison between "Einstein" and EXOSAT observations). This makes PKS 0548-322 a remarkably constant BL Lac object, at least in the soft X-ray range, and suggests to look for variations on time scales of a week or less.

AP Librae

We observed this object on 1983 August 17-18 with the LE telescope 1 CMA in conjunction with the thin lexan filter and with the LE telescope 2 CMA in conjunction both with the thin lexan and the aluminum/parylene filters. In telescope 1 the source has been detected at the 5.6 σ level in 30,677 sec of effective exposure time; in telescope 2 the signal was 4.6 σ with the thin lexan filter (exposure time: 16,814 sec) and 3.1 σ with the aluminum/parylene filter (exposure time: 15,302 sec). The information collected on this source is not sufficient to self-consistently derive the spectral parameters and therefore we computed fluxes by assuming the amount of absorption in the direction of the source to be $N_H = 8 \times 10^{20}$ cm^{-2} (Heiles 1975). We find that for reasonable values of the energy index α, the flux of AP Librae between 0.02 and 2 keV ranges between 1.5×10^{-12} ($\alpha = 0$) and 2×10^{-13} erg cm^{-2} s^{-1} ($\alpha = 4$). With such uncertainties, no comparisons are useful with the "Einstein" observations of the same object and variability studies can only rely on future EXOSAT observations.

BL Lacertae

BL Lac was observed with the LE telescope 1 CMA and the thin lexan filter on 1983 December 7 for a total exposure time of 25,954 sec. The resulting image (see Figure 2, where the Gaussian smoothing is shown) is rather peculiar: two maxima can be found in the distribution of the photon density, separated by about 30 arcsec. One of the maxima (in the center of the field

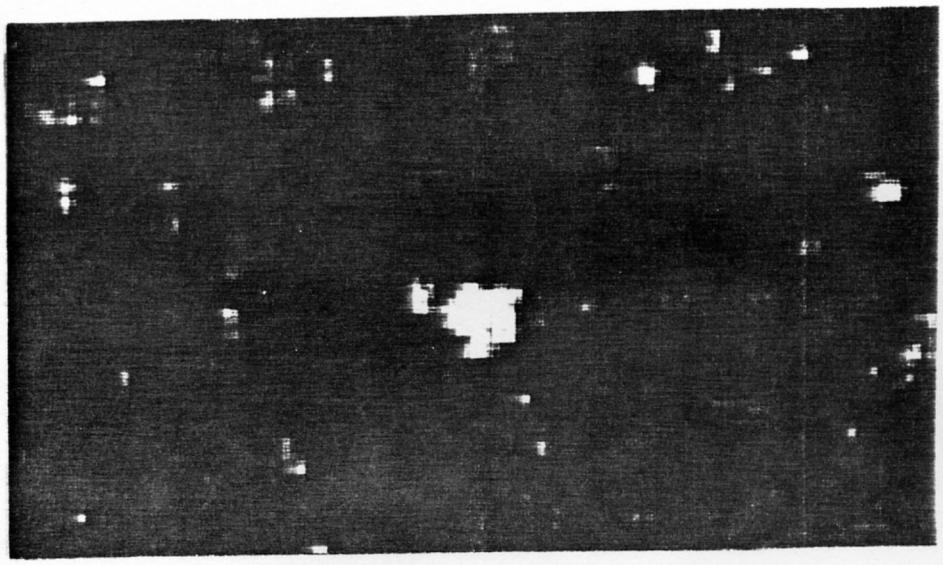

FIGURE 2: Smoothed image of the central part of the field of BL Lac

of view) has a significance of 7.1 σ and its centroid corresponds with the optical position of BL Lac whithin 4 arcsec (1 pixel). The "side blob" looks well separated, with 1950 coordinates $\alpha = 22^h 00^m 41^s.51$ and $\delta = 42^o 01' 43''.01$, but its statistical significance is only 2.5 σ. At its position on a 4m plate taken by Kinman (1975) there is only one uncatalogued stellar object, the magnitude of which can be estimated to be 17-18. At least one other fluctuation of the background of the same statistical significance is present in the central part of the field of view and therefore, unless future spectroscopic studies of the "candidate" stellar object could suggest a possible identification, we are not claiming that we detected a serendipitous source. We would note however that the field of BL Lac has never been observed at this angular resolution and that in our observation the ratio of counts between BL Lac and the "side blob" is 5:1 which could have led to an oversestimation of the flux of BL Lac in past observations.

As for BL lac itself, since we could observe with only one filter, we can only give a rough estimate of its flux. Assuming $N_H = 2 \times 10^{21}$ cm^{-2} (Heiles 1975) and for reasonable values of the energy index α, the flux of BL Lac between 0.02 and 2 keV ranges between 3×10^{-12} (α = 0) and 9×10^{-13} erg cm^{-2} s^{-1} (α = 4) with a statistical error of the order of 15%.

References

Heiles, C. 1975, Astron. Astrophys. Suppl. 20, 37.
Kinman, T.D. 1975, Ap. J. 197, L49.
Maccagni, D., Maccacaro, T., and Tarenghi, M. 1983, Ap. J. 273, 70.
Maccagni, D., Chiappetti, L., Garilli, B., Giommi, P., and Rampini, A. 1984, to be published in the Proceedings of the Symposium "X-ray Astronomy 1984", Bologna.