SPECTRAL EVOLUTION OF MKN 501: THREE YEARS OF BEPPOSAX OBSERVATIONS

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ABSTRACT. We present results from the BeppoSAX observations of the TeV emitting blazars Mkn 501 between April 1997-June 1999. During this period the peak of the Synchrotron component moved from about 100 keV in 1997 to 0.5 keV in 1999 June and its position appears to be correlated with luminosity. We discuss the results within a simple picture in which the variation of the maximum Lorentz factor of emitting electrons drives the observed long-term variability.

1. Introduction

Blazars (BL Lac objects and Flat Spectrum Radio Quasars) form a small but interesting group of AGNs characterized by a strong non thermal continuum produced in a relativistic jet pointing toward the observer (Urry & Padovani 1995). They are the best laboratory to study physical processes in jets such as particle acceleration and cooling. Mkn 501 is one of the four BL Lac objects known as TeV emitters (e.g. Catanese & Weekes 1999). Special interest for this source has been triggered by the *Beppo*SAX observation of April 1997, when the source showed a large flare and the synchrotron peak (usually located in the soft X-ray band) was found at about 100 keV (Pian et al. 1998). Since that time Mkn 501 has been the target of several observation in X-rays (Krawczinsky et al. 2000, Catanese & Sambruna 2000). Here we report the results of 7 *Beppo*SAX observations (1997 Apr-1999 June) and we briefly discuss a simple picture for the spectral variability. A complete description of the work will be reported in Tavecchio et al. (2000, in preparation).

2. *Beppo*SAX observations and Spectral fits

Since the major flare shown in the spring of 1997 Mkn 501 has been the target of repeated observations with *Beppo*SAX. In total we have 7 observations, 3 during 1997 April, 3 in 1998 April and a long pointing in 1999 June.

X-ray spectra have been fitted using the curved model introduced for the study of Mkn 421 by Fossati et al. (2000). A complete description of the fitting procedure can be found in Tavecchio et al. (2000). The unfolded spectra at four selected epochs are shown in Fig. 1. From this figure it is clearly apparent that with the decreasing total flux thepeak of the X-ray spectral energy distribution shifts to lower frequencies. This

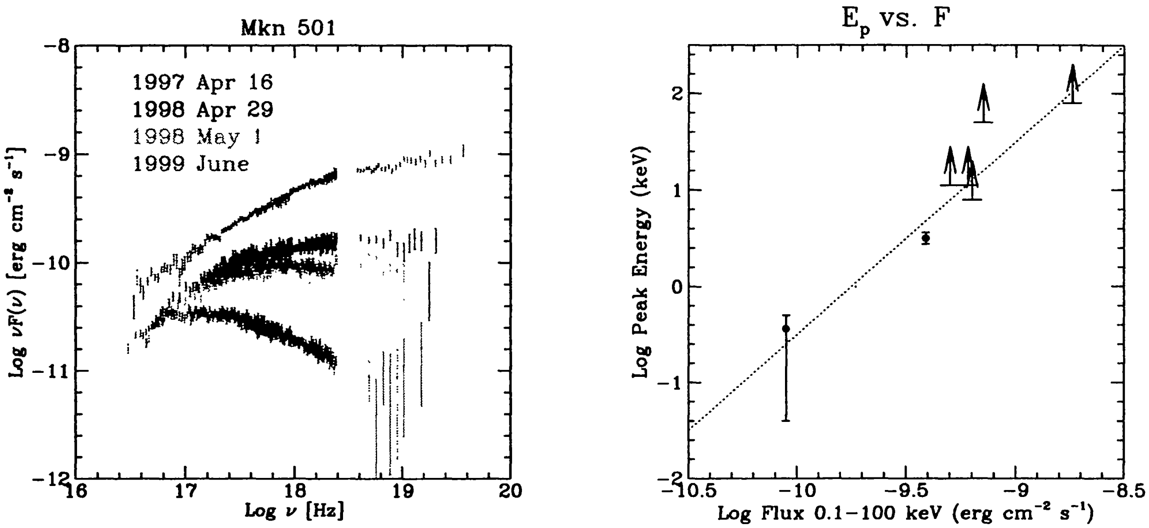

Fig. 1. *Left:* X-ray SEDs for four selected epoches.*Right:* Energy of the synchrotron peak vs the flux in the SAX band (0.1-100 keV). The dashed line with slope 2 and arbitrary normalization indicates that a relation $E_p \propto L_s^2$ is consistent with the observations (see text).

spectral evolution appers rather continuous despite the fact that the different epochs are separated by large gaps and the ASM light curve clearly shows periods of larger activity between them . The continuity in the evolution is confirmed by the clear correlation between the spectral index at 10 keV and the flux and by the correlation between the energy of the synchrotron peak and the flux for all observations (Fig.1).

3. The long-term variability: a simple picture

The correlations discussed in the previous section suggest that only few parameters are responsible for the long-term variability in Mkn 501. In particular the observed relation between E_p and the flux (although its significance is limited by the presence of lower limits) can be consistent with a relation of the form $E_p \propto L_s^2$. This relation can be easily reproduced in a simple picture in wich the physical quantities in the emitting region are almost constant and only the Lorentz factor γ_p of electrons emitting at the synchrotron peak varies. In fact in that case the synchrotron peak frequency will be $\nu_p \propto \gamma_p^2$, while the synchrotron luminosity can be written $L_s \propto \gamma_p^{3-n}$, where n is the index of the assumed power-law electron energy distribution. Usually for blazars $n = 2$ and then one naturally finds $\nu_p \propto L_s^2$.

In order to test in a more quantitative way the proposed picture we have reproduced the observed SEDs by using the homogeneous SSC model described in Tavecchio et al. (1998). The model assumes a homogeneous emitting region filled by a relativistic electrons and magnetic field. Electrons emit radiation through Synchrotron and

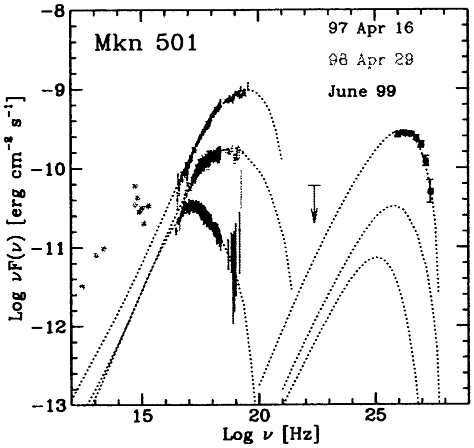

Fig. 2. Overall SEDs of Mkn 501 measured in 1997, 1998 and 1999. The TeV data are simultaneous with the 1997 Apr 16 X-ray data. Dots at low frequency are taken from historical records. Dotted lines are the spectra calculated with the SSC model described in the text.

Synchrotron-Self Compton mechanisms.

For the epoch around the flare of 1997 Apr 16 we have the simultaneous TeV data (given by Djannati-Atai et al. (1999)) and therefore we can fully constrain the model parameters as explained in Tavecchio et al. (1998). Then we have reproduced the spectra of 1998 and 1999 by varing only γ_p (and the normalization of electrons which is slighly different for the 1997). The calculated spectra are in good agreement with the X-ray data as can be seen in Fig 2. With this procedure we obtain also the predicted TeV spectra for the 1998 and 1999: the comparison between our predictions and the TeV measures will be a very test for the picture proposed here.

4. Conclusions

We have shown that the long-term variability of Mkn 501 appears to be very regular, despite its light curve shows a high degree of activity. We propose that the observed evolution can be explained in a simple picture where the parameter regulating the variability is the Lorentz factor of the elctrons emitting at the synchrotron peak, while the magnetic field and the bulk Lorentz factor are almost constant. Future TeV observations could confirm our proposal.

References

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