

BEPPO SAX OBSERVATIONS OF PKS 2155-304 DURING AN ACTIVE GAMMA-RAY STATE

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ABSTRACT. PKS 2155-304 was observed with BeppoSAX in November 1997 for 64 ksec (total elapsed time 33.5 hours) and, for the first time, simultaneously in γ -rays with EGRET on board the Compton Gamma Ray Observatory and with the ground based TeV telescope CANGAROO, during a phase of high brightness in the X-ray band. The LECS and MECS light curves show a pronounced flare (with an excursion of a factor 3.5 between min and max), with evidence of spectral hardening at maximum intensity. The source is weakly detected by the PDS in the 12-100 keV band with no significant evidence of variability. The broad band X-ray data from Beppo SAX are compared with the gamma-ray results and discussed in the framework of homogenous synchrotron self Compton models.

1. Introduction

PKS 2155-304 is one of the brightest BL Lacertae objects in the X-ray band and one of the few detected in γ -rays by the EGRET experiment on CGRO (Vestrand et al. 1995). No observations at other wavelengths simultaneous with the gamma-ray ones were ever obtained for this source, yet it is essential to measure the Compton and synchrotron peaks at the same time in order to constrain emission models unambiguously (e.g Dermer et al. 1997, Tavecchio et al. 1998a,b). For these reasons having been informed by the EGRET team of their observing plan and of the positive results of the first days of the CGRO observation, we asked to swap a prescheduled target of our *BeppoSAX* blazar program with PKS 2155-304. During November 11-17 1997 (Sreekumar & Vestrand 1997) the γ -ray flux from PKS 2155-304 was very high, roughly a factor of three greater than the previously published value from this object. *BeppoSAX* pointed PKS 2155-304 for about 1.5 days starting Nov 22. Here we report and discuss the data obtained from the *BeppoSAX* observation. A complete paper including a detailed description of the data analysis procedure is in preparation (Chiappetti et al. 1998) and we plan to submit it jointly with a full EGRET paper (Vestrand et al. 1998).

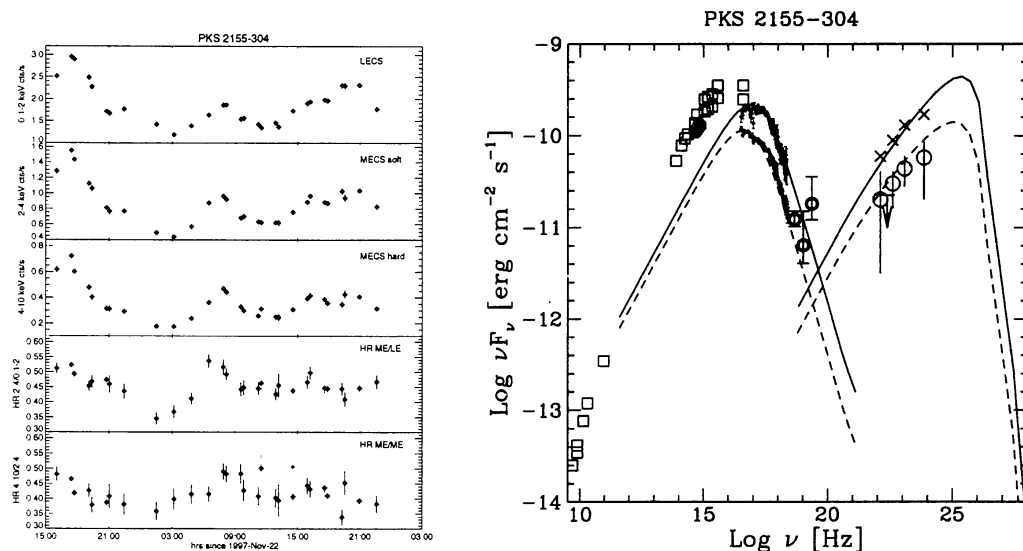


Fig. 1. Left frame: The first three panels show the light curves in the 0.1-2 keV (LECS) and 2-4 keV and 4-10 keV (MECS) energy bands respectively. The last two panels show the 2-4 keV /0.1-2 keV and the 4-10 keV/2-4 keV hardness ratios. Right frame: SED of PKS 2155-304 with the spectra calculated with the SSC model. The value of the parameters (see text) are: $\delta = 18$, $B=1$ G, $K = 10^{4.68}$, $R = 3 \cdot 10^{15}$ cm, $\gamma_b = 10^{4.49}$, $n_1 = 2$, $n_2 = 4.85$ (low state, dashed line) and $\delta = 18$, $B=1$ G, $K = 10^{4.8}$, $R = 3 \cdot 10^{15}$ cm, $\gamma_b = 10^{4.65}$, $n_1 = 2$, $n_2 = 4.85$ (high state, solid line)

2. Results

2.1. Light curves

Here we summarize some of the results. Fig 1 (left frame) shows the light curves binned over 1000 sec obtained in different energy bands. The light curves show a clear high amplitude variability: three peaks can be identified. The most rapid variation observed (the decline from the peak at the start of the observation) has a halving timescale of about 2×10^4 s, similar to previous occasions (see e.g. Urry et al. 1997). No shorter time scale variability is detected although we would have been sensitive to doubling timescales of order 10^3 s. The variability amplitude is energy dependent as shown by the hardness ratio histories plotted at the bottom of Fig 1. The HR correlates positively with the flux, indicating that states with higher flux have harder spectra.

2.2. Spectral analysis

We found that the LECS and MECS spectra are individually well fitted by a broken power law model with galactic absorption ($N_H = 1.36 \cdot 10^{20} \text{cm}^{-2}$), while single power law fits are unacceptable. The fitted spectral parameters are given in Table 1. The change in slope between the softest (0.1-1 keV) and hardest (3-10 keV) bands is $\simeq 0.8$. A broken power law fit to the combined LECS and MECS spectra yields unsatisfactory results indicating that the spectrum has a continuous curvature.

Fitting together the MECS and PDS data yields spectral parameters very similar to those obtained for the MECS alone. The residuals show that the PDS data are consistent with an extrapolation of the MECS fits up to about 50 KeV. Above this energy the PDS data show indication of an excess, indicating a flattening of the spectrum.

Tab. 1 - Spectral parameters

Data Set	Power-law		Broken Power-law			
	Γ	χ_r^2	Γ_1	Γ_2	E_{break}	χ_r^2
LECS 0.1-4 keV	2.21 ± 0.01	10.8	2.06 ± 0.02	2.54 ± 0.04	1.1 ± 0.7	1.221
MECS 2-10 keV	2.78 ± 0.02	2.1	$2.64^{+0.06}_{-0.08}$	$2.88^{+0.07}_{-0.03}$	3.2 ± 0.8	1.384

3. Spectral Energy Distributions and Discussion

The deconvolved spectral energy distributions (SED) measured by SAX (0.1-300 keV) at maximum and minimum intensity during this observation are compared in Fig. 1 (right frame) with non simultaneous data at lower frequencies and with the gamma-ray data from the discovery observation (Vestrand, Stacy and Sreekumar 1995). The latter are also shown multiplied by a factor three to represent the gamma-ray state of November 1997 as communicated in IAU circular (Sreekumar & Vestrand 1997). The final γ -ray data are not available yet. From the public X-ray data obtained by the All Sky Monitor on XTE we infer that the source was brighter during the first week of the EGRET pointing, which yielded the high γ -ray flux (Sreekumar & Vestrand 1997) than during the *Beppo* SAX observations. We therefore suppose that the γ -ray flux simultaneous to our observations could be intermediate between the two states reported in the figure. Note also that the PDS data refer to an "average" state over the SAX exposure time.

In order to estimate the physical parameters of the emitting region in PKS 2155-304 we fitted the observed SEDs in the full X-ray range with a simple SSC model involving a homogeneous spherical region of radius R , magnetic field B , filled with relativistic particles with energy distribution described by a broken power law (4 parameters: n_1 , n_2 , γ_b and a normalization constant, K) and with Doppler factor δ . This seven parameter model is strongly constrained by the data which yield a determination of the two slopes (X-ray and gamma-ray slope) the frequency and flux of the synchrotron peak, a flux value for the Compton component and a lower limit to the Compton peak frequency. Assuming $R = ct_{var}$ with $t_{var} = 2$ hours the system is practically closed. A general discussion of

the parameter determination procedure for this class of models, with analytic formulae is given in Tavecchio et al. (1998a, b).

In Fig.1 we show two models representing the high and low X-ray intensity intervals in our observation. We arbitrarily assumed that the lower intensity state corresponds to the gamma-ray intensity reported in 1995 and we chose not to fit the low frequency data since there the variability time scales are longer and they could refer to a larger emission region. In order to account for the flaring state the break energy of the electron spectrum was shifted to higher energies, leaving the other parameters unchanged. Correspondingly also the Compton peak increases in flux and shifts to higher energies. Both effects are however reduced with respect to the "quadratic" relation expected in the Thomson limit, since for these very high energy electrons the Klein-Nishina limit plays an important role. The predicted TeV flux is $F(> 1TeV) = 10^{-11}$ ph cm⁻² s⁻¹ and $F(> 1TeV) = 2.5 \cdot 10^{-12}$ ph cm⁻² s⁻¹ in the two states respectively. Unfortunately the CANGAROO telescope did not detect PKS 2155-304 in November 1997, but the upper limits are consistent with the predicted values (Kifune, priv. comm.). The sensitivity of the CANGAROO observatory is expected to improve significantly in the next year, with the addition of new telescopes. It will therefore be worthwhile to repeat the "experiment" of simultaneous X-ray and TeV observations to verify whether the predicted TeV flux is actually observed.

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