# X-ray rapid variability of MKN 421

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The bright close-by BL Lac object MKN 421 was observed at several epochs with BeppoSAX. Here we concentrate on the campaign of April-May 1997 (Fossati et al 1998, Guainazzi et al 1999), and on that of April 1998, which was simultaneous with a TeV flare (Maraschi et al 1999a, b, Fossati et al 1999).

We consider rapid variability focussing on the issue of lags between a soft band (LE: 0.1-1.5 keV) and a medium energy band (ME: 3.5-10 keV). Light curves are reported in the quoted references. The analysis follows the procedures adopted for PKS 2155-304 (Zhang et al 1999). Lags have been searched for using the Discrete Correlation Function (DCF), and the Modified Mean Deviation (MMD) techniques (e.g. Edelson et al 1995). The resulting distributions are fitted with Gaussians. The position of the peak is taken as the lag, positive if ME precedes LE. Following Peterson et al (1998), the uncertainties depending on photon statistics are evaluated through Monte Carlo simulations, considering "flux randomization" and "random subset selection", see Fig. 1. From the distribution the 90% confidence intervals are deduced. Results are summarized in Table 1. The discovery of a negative lag in 1998 observation and the evaluation of its uncertainty appears as a noticeable result.

In the quoted observations of PKS 2155-304 the lag was always positive and its value decreased with increasing source intensity. The 1998 state of MKN 421 ($F_{2-10\ keV} \simeq 3 \times 10^{-10}$ erg cm$^{-2}$ s$^{-1}$) was indeed quite higher than that of 1997 ($F_{2-10\ keV} \simeq 0.7 \times 10^{-10}$ erg cm$^{-2}$ s$^{-1}$). The sign inversion may be related to the same phenomenology noted in PKS2155-304 (see the GINGA observation reported in Sembay et al. 1993). An interpretative picture requires a rather complex model on the line of those proposed by Tashiro et al. (1995), Dermer (1998), Kirk et al. (1998), Chiaberge & Ghisellini (1999), Georganopoulos & Marscher (1999) and Kataoka et al. (1999).



**Fig. 1.** Results of the Monte Carlo simulations for the DCF method (solid line) and the MMD method (dashed line) for the 1997 and 1998 data.

| | DCF | | MMD | |
|---|---|---|---|---|
| | Lag | 90% C.L. | Lag | 90% C.L. |
| **Mkn 421 *Beppo*SAX 1997** | | | | |
| Gaussian fit | -0.19 | -0.26,-0.11 | 0.16 | 0.04,0.27 |
| MC Simulation | -0.10 | -0.45,0.23 | 0.14 | -0.39,0.59 |
| **Mkn 421 *Beppo*SAX 1998** | | | | |
| Gaussian fit | -0.82 | -0.91,-0.73 | -0.60 | -0.73,-0.47 |
| MC Simulation | -0.75 | -1.48,0.02 | -0.62 | -1.06, -0.17 |

**Table 1.** Results from Cross Correlations and Monte Carlo simulations for the 1997 and 1998 *Beppo*SAX observations of Mkn 421. The lags (in hours) and the 90% confidence levels are given for both methods.

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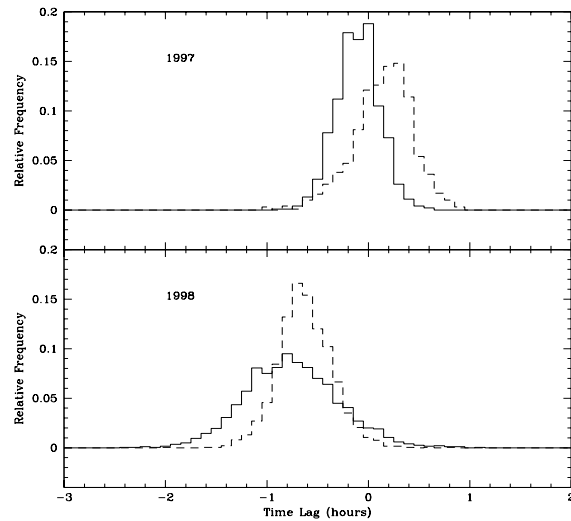Georganopoulos, M., Marscher, A.P.: 1999, Astrophys. J. 506, L11
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