Environment and properties of emitting electrons in blazar jets: Mkn 421 as a laboratory

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We implemented a χ^2 minimization fitting method on spectral energy distribution (SED) and applied it on nine multi-λ (MWL) data sets of Mkn 421 in order to study the correlation of Synchrotron-Self-Compton (SSC) parameters as a function of source activity.

Introduction

The broad-band non-thermal emission of blazar jets is commonly interpreted within a Synchrotron-Self-Compton (SSC) model. One of the important issues that has not been widely studied is the behavior of emission parameters as a function of source activity. Thanks to the low redshift and extensive multi-λ (MWL) campaigns, Mkn 421 is a suitable candidate for such a study. Here we describe our recent analysis (Mankuzhiyil et al. 2011).

χ^2 minimization

We use a fully-fledged χ^2-minimization procedure instead of the commonly used *eye ball* fit procedure. The SED data sets are fitted to the SSC model applying the Levenberg-Marquardt method to χ^2 minimization. The flow chart of the minimization algorithm is shown in Fig. 1.

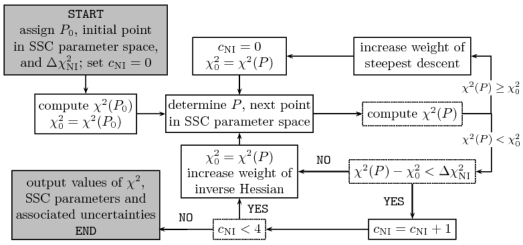

Fig. 1: Flow chart of the SED fitting algorithm.

SED fits

To model the SEDs we use an SSC model (Tavecchio et al. 1998) characterized by nine free parameters that describe the source as a spherical blob of radius R, moving with a Doppler factor δ towards the observer and threaded with a magnetic field B. The injected relativistic particle population is described as a broken power-law spectrum with electron number density K, Lorentz factor extending from $\gamma_{\rm min}$ to $\gamma_{\rm max}$ with indices n_1 and n_2 below and above $\gamma_{\rm break}$. The fitted SEDs are shown in Fig. 2.

In addition to the χ^2 test, we also checked the goodness of the fit using the Kolmogorov-Smirnov (KS) test. Considering the occurrence of different physical processes (synchrotron and inverse Compton, at substantially different energies), and the different quality of low- and high-energy data, we used a *piecewise KS test*, *i.e.* we applied the KS test separately to low- and high-energy data. Then the KS test always confirms that the fit residuals are normal at 5% confidence level.

Result

Our results suggest that in Mkn 421, B decreases with source activity whereas $\gamma_{\rm break}$ and δ increase (Fig. 3 top). This can be interpreted in a frame where the synchrotron power and peak frequency remain constant with varying source activity by decreasing magnetic field and increasing the number of low energy electrons. This mechanism results in an increased electron-photon scattering efficiency and hence in an increased Compton power. Other emission parameters appear uncorrelated with source activity. In Fig. 3 (bottom), the B-$\gamma_{\rm break}$ anti-correlation results from a roughly constant synchrotron peak frequency. The B-δ correlation suggests that the Compton emission of Mkn 421 is always in the Thomson limit. The δ-$\gamma_{\rm break}$ correlation is an effect of the constant synchrotron and Compton frequencies of the radiation emitted by a plasma in bulk relativistic motion towards the observer.

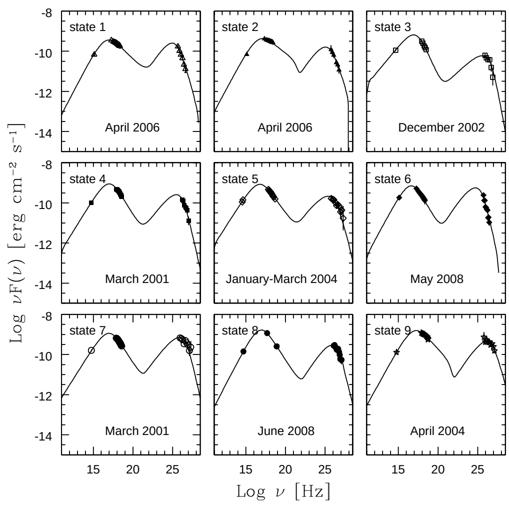

Fig. 2: Fitted SEDs of Mkn 421 for different activity levels.

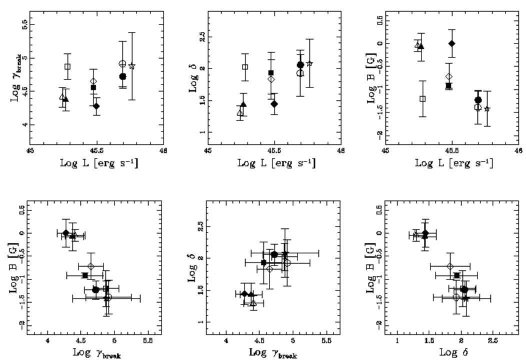

Fig. 3: Correlations between source activity and parameters.

References

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[2] Tavecchio, F., Maraschi, L. and Ghisellini, G., ApJ, 509, 608 (1998)

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