Multiwavelength Observations of Mrk 421
So what is this guy?

- AGN

- Blazar – Jet pointing toward Earth, and the observed flux can change rapidly. Non-thermal emission spectrum.

- BL Lac – No optical absorption lines.
Fig. 1. Schematic view of XTE showing the fields of view of the Proportional Counter Array (PCA), the High-Energy X-ray Timing Experiment (HEXTE), the All-Sky Monitor (ASM) with its rotation axis, and the Explorer Platform.
Snapshot of the monitors 2

- Whipple!
- Atmospheric Čerenkov detector
- 100 GeV - 10 TeV
- 14 day on-off cycle due to moon
FIG. 2.— Simultaneous optical (V band, bottom), X-ray (2–10 keV, middle) and TeV γ-ray (E > 0.4 TeV, but see §2.3, top) (top) light curves for Mrk 421 for the March 18–March 25 period. *Rosa* XTE/PCA data are shown here in 256 s bins. HEGRA data (dark triangles) are integrated over 1800 s bins, Whipple data (white circles) over 1680 s bins. HEGRA data precede Whipple’s. The optical data have been rebinned to yield a s/n ratio of at least 8, but with bin length not exceeding 1500 s. The logarithmic scales span a factor of $\sqrt{10}$, 10 and 100 for the optical, X-ray and γ-ray light curves, respectively. The length of axes scale accordingly ($\times 2$ between them), so that relative amplitude variability can be directly compared.
Fig. 3.— Simultaneous 2–10 keV X-ray and TeV (see text) γ-ray light curves for individual nights. Triangles are HEGRA data, in ≈1800 s bins. White circles are Whipple data, integrated over ≈1680 s bins. Dense dark points are RXTE/PCA, in 128 s bins. The shaded boxes represent the average and variance of the X-ray data for each (longer duration) TeV bin, that are the values used in the Flux–Flux correlation analyses. The rate scales for the X-ray data are on the left Y-axes, and the flux scales for the TeV data on the right Y-axes. The time span is the same for all panels, 50 ks. The vertical scales are not the same in all panels, but are adjusted to show each day in the best possible detail. The X-ray dynamic ranges are (time ordered) × 6, × 5, × 2, × 4, × 4, × 4. In order to allow for an easier comparison of the relative variability amplitude, in all panels, the Y-axis range for the γ-ray light curve is the square of that used to plot the X-ray data. The source shows strong, highly-correlated variability in both energy bands, with no evidence for any interband lag (see however §3.3).
II. THE DISCRETE CORRELATION FUNCTION

For two continuous, statistically stationary stochastic functions, \( a(t) \) and \( b(t) \), the classical correlation function is defined as

\[
CF(\tau) = \frac{E\{[a(t) - \bar{a}][b(t + \tau) - \bar{b}]\}}{\sigma_a \sigma_b}, \quad (2)
\]

where \( E\{f\} \) is the expectation value of the function \( f \), \( \bar{f} \) is its mean, and \( \sigma_f \) is its standard deviation (Oppenheim and Schafer 1975).

For two discrete data trains, \( a_i \) and \( b_j \), we collect the set of unbinned discrete correlations

\[
UDCF_{ij} = \frac{(a_i - \bar{a})(b_j - \bar{b})}{\sqrt{\sigma_a^2 - e_a^2}(\sigma_b^2 - e_b^2)}, \quad (3)
\]

for all measured pairs \((a_i, b_j)\). Each of these is associated with the pairwise lag \( \Delta t_{ij} = t_j - t_i \). The parameter \( e_f \) is the measurement error associated with the data set \( f \). For noisy data, it is necessary to replace the \( \sigma_a \sigma_b \) in equation (2) with \( [(\sigma_a^2 - e_a^2)(\sigma_b^2 - e_b^2)]^{1/2} \) to preserve the proper normalization (A. Lawrence, private communication). We emphasize that every point represents real information.

Binning this result in time allows the directly useful function \( DCF(\tau) \) to be measured. Averaging over the \( M \) pairs for which \( \tau - \Delta \tau/2 \leq \Delta t_{ij} < \tau + \Delta \tau/2 \),

\[
DCF(\tau) = \frac{1}{M} \text{UDCF}_{ij}. \quad (4)
\]

[The DCF(\( \tau \)) is not defined for a bin with no points.]
Looking at the Fossati et al. DCF

**Fig. 3.** Cross correlation between the X-ray and the TeV light curves. (a) 2–4 keV vs. TeV (Whipple+HEGRA) for the whole campaign (computed over 2048 s bins, from X-ray data on 256 s bins, and TeV data on \(\sim 750-900\) s bins). (b) 9–15 keV vs. TeV (Whipple+HEGRA) for the whole campaign (computed over 2048 s bins, from X-ray data on 256 s bins, and TeV data on \(\sim 750-900\) s bins). (c) 2–4 keV vs. TeV (Whipple) for the night of March 18–19 (the flare of Figure 3a) (computed over 1024 s bins, from X-ray data on 128 s bins, and Whipple data on 256 s bins). (d) 9–15 keV vs. TeV (Whipple) for the night of March 18–19 (computed over 1024 s bins, from X-ray data on 128 s bins, and Whipple data on 256 s bins).
Let's try another DCF

Fig. 2. Discrete correlation function of the complete X-ray and gamma-ray data set. A positive time lag means the gamma-ray flux precedes the X-ray flux.

Fig. 7.— As in Fig. 6, but for the 2003/2004 season. Two ZDCF{s} are shown: (top) for the entire season and (bottom) for the time period before the giant outburst (or MJD 53100; see Fig. 1).

From Blazejowski et al. arXiv.astro-ph/0505325v1
Looking at the spectrum: Synchrotron-Self-Compton, but could something else be going on also?
Power of Inverse Compton scattering goes as $\gamma^2$ of the electrons, so finding the TeV flux (IC) goes as the square of the x-ray (synchrotron) flux supports SSC.