Exploring the Variability Properties of gamma-ray Emission from Blazars

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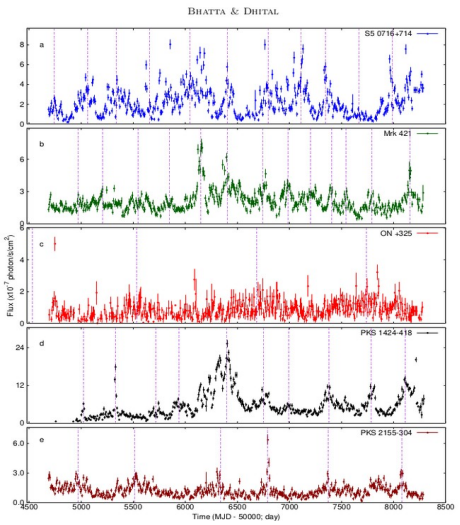
Abstract

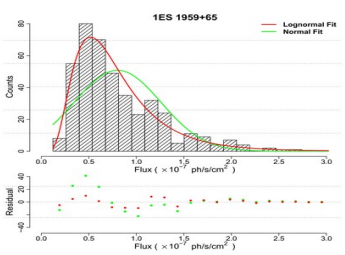
I present results of variability study of a sample of 20 powerful blazars using Fermi/LAT (0.1-300 GeV) observations. We studied decade-long observations applying various analysis tools such as flux distribution, symmetry analysis, and RMS-flux relation. It was found that the Î‡-ray flux distribution closely resembles a log-normal probability distribution function and can be characterized by linear RMS-flux relation. The power spectral density analysis shows the statistical variability properties of the sources as studied are consistent with flicker noise, an indication of long-memory processes at work. Statistical analysis of the distribution of flux rise and decay rates in the light curves of the sources, aimed at distinguishing between particle acceleration and energy-dissipation timescales, counterintuitively suggests that both kinds of rates follow a similar distribution and the derived mean variability timescales are on the order of a few weeks. The corresponding emission region size is used to constrain the location of Î‡-ray production sites in the sources to be a few parsecs. Additionally, using Lomb-Scargle periodogram and weighted wavelet z-transform methods and extensive Monte Carlo simulations, we detected year-timescale quasi-periodic oscillations in the sources S5 0716+714, Mrk 421, ON +325, PKS 1424-418, and PKS 2155-304. We also performed recurrence quantification analysis of the sources and directly measure the deterministic quantities, which suggest that the dynamical processes in blazars could be a combination of deterministic and stochastic processes, while some of the source light curves revealed significant deterministic content.

Decade-long Fermi/LAT (0.1-300 GeV) blazar light curves



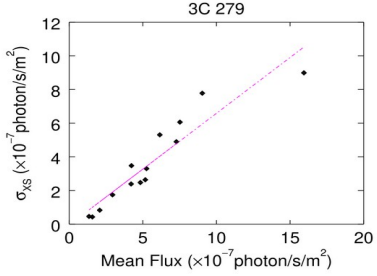
Flux distribution:

Presence of log-normal PDF suggests possible multiplicative processes driving the observed variability, as opposed to the independent shot-noise like processes. Observed positively skewed heavy tail of the Log-normal PDF could a key to the production of UHECR, that distribution of the accelerate particle might follow similar PDF.



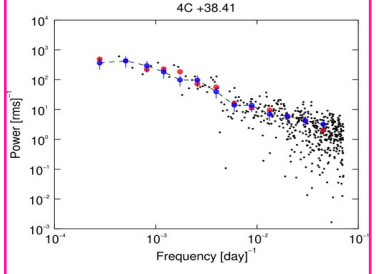
Linear RMS-Flux relation:

In the current models of blazar, he observed linear RMS-flux relation is best explained in term of the longer timescales accretion rates at the larger radii of disk modulating the shorter timescale instabilities close to the central engines.This is possible indication of the strong disk-jet connection, in the sense that the disk modulations are imprinted in the observed flux variability from the jets..



Power spectral density:

The power spectral density slopes of the gamma-ray light curve turn out be near 1, indicating the presence of flicker noise (P \prop 1/f). The analysis points to the presence of long-memory processes at work, in confirmation with the observed log-normal PDF and linear RMS-flux relation



Summary and Conclusions:

A detailed time series analysis of 20 powerful blazar was carried out using the observations from Fermi/LAT gamma-ray telescope

Blazar are found to be highly variable in decade long timescales

The properties of the variability include log-normal PDF, linear RMS-flux relation and presence of year timescale QPOs.

These properties suggest that the variability is correlated over large spatial and temporal timescales through multiplicative process and strong disk-jet connection.

QPOs could make an excellent probe to the innermost regions of AGN including the extreme physical conditions near the supermassive black hole

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