

Measure the weighted cross correlation between GeV and MeV fluxes of Blazars

Abstract

An active galactic nucleus with a relativistic jet pointing within 10° of the line of the sight of the earth is known as a Blazar. Normally a Blazar has two relativistic jets. These jets are linear features instigating very close to the super massive black hole (SMBH) at the center of an Active Galactic Nucleus (AGN). A broad region of energies consist in these jets from radio rays to gamma rays. Blazars emitting energies due to non-thermal processes called the inverse Compton Effect and Synchrotron radiation. The model for blazars were proposed in 1978 by Blandford and Rees. Even though it has taken almost 40 years still the model is incomplete. This research is an effort to complete the model of Blazars. In this research a weighted cross correlation was calculated using a python script. Mrk421 and Mrk501 was selected as sources for this research. Three-day bin analysis has been used for 22 months. Data was taken for two energy ranges, 100MeV – 1000MeV for MeV file and 1GeV to 100GeV for GeV file. Then weighted cross correlation was taken. As the results of this project two weighted cross correlation graphs were plotted. First graph was plotted to Mrk501 and second graph was plotted to Mrk421. Mrk501 was showed nothing but the plot of Mrk421 had a six day lag between GeV and MeV fluxes. There are three possibilities to explain this kind of lag. First one is there might be two different places for triggering MeV and GeV fluxes, second one is there might be different triggering mechanisms and the third one is the possibility of having Lorentz Invariant Violation (LIV).

Introduction

A blazar is an active galactic nucleus (AGN) which is in the line of the sight of the earth. Blazars have large spectral energy distribution (SED) cause from two non-thermal processes. These non-thermal processes produce two peaks in SED. The low energy peak ranging from radio to UV (ultra violet) sometimes up to soft X-rays, and high energy peak ranging from X rays to Gamma rays sometimes up to TeV energy range. The process called synchrotron is the cause for the low energy peak of SED and Inverse Compton (IC) effect is the cause the high energy peak of SED. Normally a blazar has two relativistic jets which are opposite to each other. The photons of these jets are moving in velocities which are almost equal to the speed of light. That is why they known as relativistic jets.

Data and Results

Fermi LAT satellite is the source that used to get data. MRK 421 and MRK 501 are the extra galactic sources selected. These two sources are the most commonly using because they have high activity. Femi science tool is the software used to analyse the data and finally got three day bin analysis. Using python script weighted cross correlation was measured and correlation plots were generated.

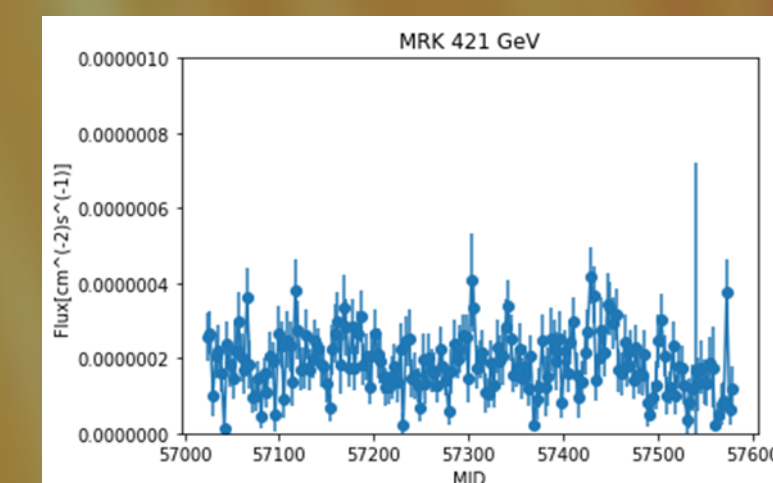


Figure 1: The GeV light curve of MRK 421 for 22 months , 3 day bin analysis using likelihood analyzing method from Fermi Telescope

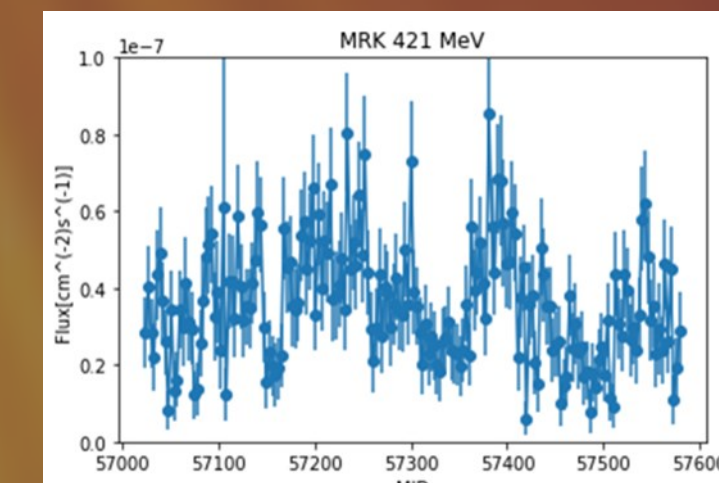


Figure 2: The MeV light curve of MRK 421 for 22 months , 3 day bin analysis using likelihood analyzing method from Fermi Telescope

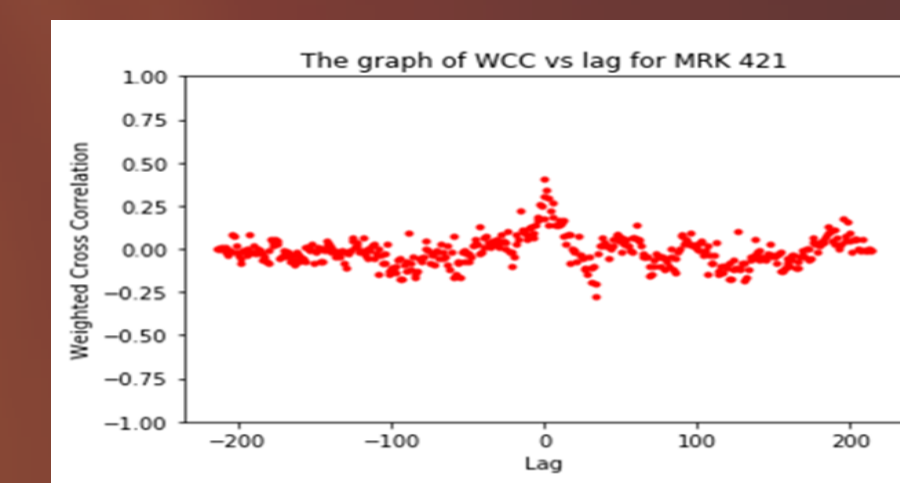


Figure 3: weighted cross correlation of MRK 421 Blazar's between high energy gamma rays and low energy gamma rays which has the characteristic peak at 0th lag

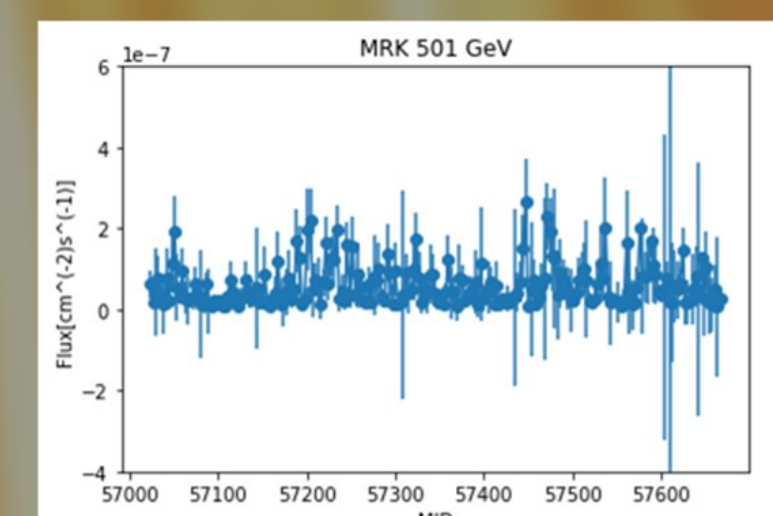


Figure 4: The GeV light curve of MRK 501 for 22 months , 3 day bin analysis using likelihood analyzing method from Fermi Telescope

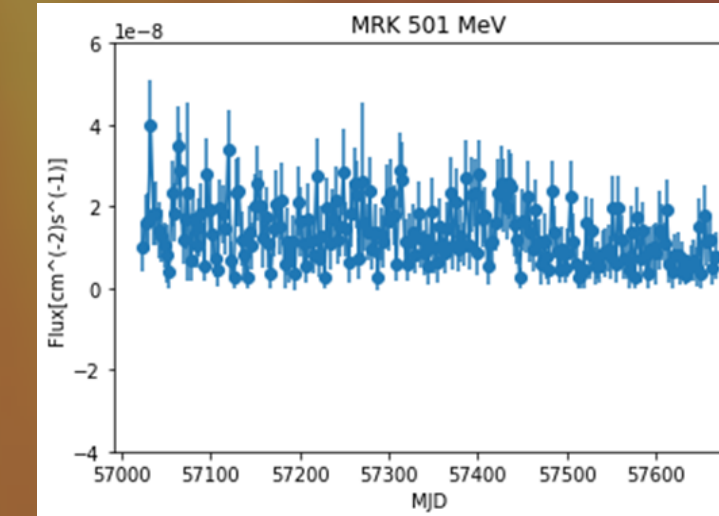


Figure 5: The MeV light curve of MRK 501 for 22 months , 3 day bin analysis using likelihood analyzing method from Fermi Telescope

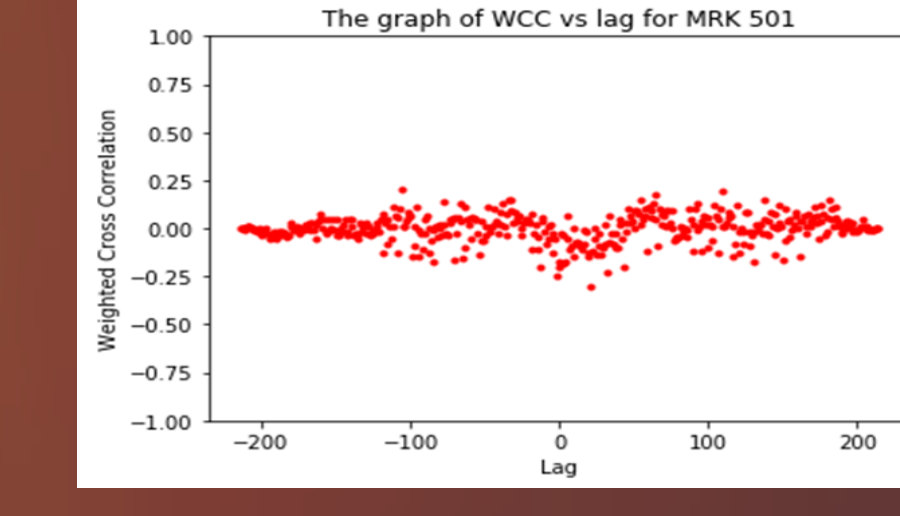


Figure 6: weighted cross correlation of MRK 501 Blazar's between high energy gamma rays and low energy gamma rays which has the characteristic peak at 0th lag

Discussion

The main focus of this research was directed in to the weighted cross correlation of MeV and GeV fluxes of two extragalactic sources MRK421 and MRK501. The standard method for construction of blazar is finding correlations between high energy and low energy fluxes. The main reason for selecting these two sources are very active. When taking data there are lots of noises included in the results. Therefore, when finding correlations those background noises also added to the results. To get rid of that mistake in this research weighted cross correlation was used. The reciprocal of the systematic error of the flux was taken as the weight.

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Methodology

The currently acceptable method of Blazars was developed by Blandford and Reed in 1978. Although it has been 40 years from the invention still the model is not completed. Large number of physicists are trying to complete the model all around the world. Most scientists are measuring correlations to get an idea about relativistic jets and processes like IC and synchrotron. Most of them used CCF and ACF to compare high energy and low energy data sets. In this research weighted cross correlation function was used to find the correlation.

$$R_{wk} = \frac{\sum(w_i)(x_i - x_{wavg})(w_j)(y_{i+k} - y_{wavg})}{n \sum w_i \sigma_{wx} \times w_j \sigma_{wy}}$$

Equation 1 : Weighted Cross Correlation Function

In order to get data sets MRK 421 and MRK 501 extragalactic sources were used. They are very active AGNs that is the reason they have selected. MRK 421 is 414.8 million light years away from the earth and MRK 501 456 million light years away from the earth. Data was taken from Fermi LAT satellite which belongs to NASA. The data was published in NASA Fermi LAT web site. The data was stored in there as FIT format. We have to convert data into DAT format. In order to analyse this data set Fermi Science Tool software was used. Data set was selected for 22 months and 3 day bin analysis was done. A python script was built to measure weighted cross correlation.