Analyzing Gravitationally Lensed Blazars with Fermi LAT

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Abstract:

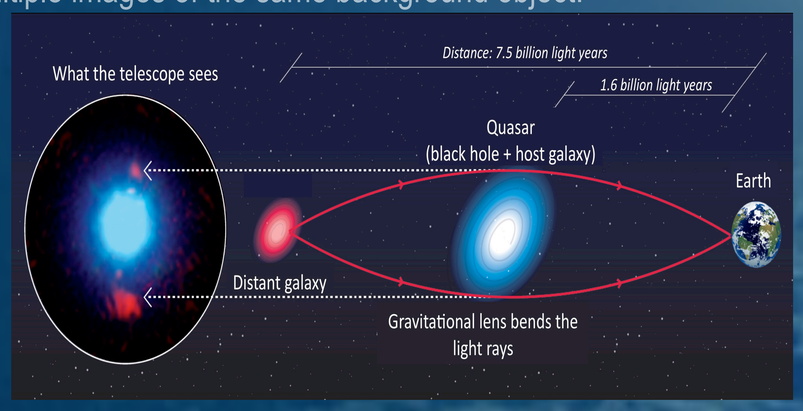
Active galactic nuclei (AGN) are the dense compact region of a galaxy that present extreme luminosity. The central nucleus is a supermassive black hole that accretes the surrounding material and may accelerate particles at relativistic speeds, forming two opposite jets of plasma. This project aims at learning about the physical processes occurring in AGNs and how it can produce large amounts of gamma rays. It is mainly focused on blazars, i.e. AGNs with one jet pointing at the observer, whose radiation outshines that produced by all the other components of the AGN. Blazars emit radiation throughout the entire electromagnetic spectrum and can be very variable. The task of the project is to use Fermi-LAT observations of one blazar, B0218+357, study the gamma-ray light curves in order to characterise the variable behavior of the blazar. The study of these AGNs can lead scientists to understand the way that power is produced in these objects.

Introduction:

The blazar B0218+357 has shown tremendous gamma-ray outbursts in late 2012 and again in July of 2014. The former observation recorded the source having a highly variable flux over a four month period, the latter evidenced an incredibly hard gamma-ray spectrum during the short 2-days flares. B0218+357 is a well known gravitationally lensed system with an estimated time delay of about 11.5 days. The source was initially discovered in radio data and confirmed being a lensed system by independent groups. The most precise measurement of the delay to date, i.e. 11.46 days ± 0.16, has been obtained by Cheung et al (2014) using the Fermi-LAT gamma-ray data. Being a lensed object, the light curve displays a superposition of the two lensed components. An autocorrelation function was applied where a single dominant correlation peak was identified (see Fig. 1). After a period of relative quiescence, more recently in 2016/2017, the source showed some renewed gamma-ray activity. We aim to explore this more recent, not-yet investigated enhanced activity.

What is Gravitational Lensing?

Gravitational lensing happens when a highly massive (foreground) object stands between the observer and the (background) source of interest. As a result the light originating from the source bends approaching the foreground object and the observer may see in multiple images of the same background object.



What is *Fermi* LAT?

The *Fermi* Large Area Telescope (LAT) is one of NASA's high energy space instruments capable of measuring particles between 20 MeV and 300GeV. The LAT has silicon coated tungsten strips that cause the incoming astrophysical gamma rays to convert into an electron and positron pair. At the bottom of the tracker is placed a calorimeter for the energy to be recorded. The pair tracks recorded by the LAT allow reconstruct the point of origin.

Methods:

We analyzed the LAT data with the standard analysis tool gtlike/ pyLikelihood, which are part of the Fermi Science Tools software package (version v10r0p5). The P8R2 SOURCE V6 set of instrument response functions (IRFs) was used. We selected the corresponding source-class events above 100 MeV. In this analysis, photons were selected in a 10◦ radius region of interest (ROI), centered at the position of 3C 454.3. The isotropic and galactic background were included in the model of the ROI, as well as all 3FGL catalog sources. The source variability was investigated by producing a lightcurve with weekly binning (see Fig. 3).

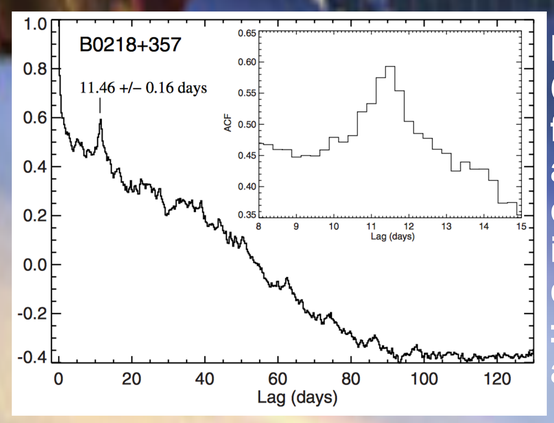


Figure 1: Auto Correlation function: applied to a 6-hrs binned light curve of B0218+357 it evidenced a time delay of days 11.46 ± 0.16. (Cheung et al. 2014).

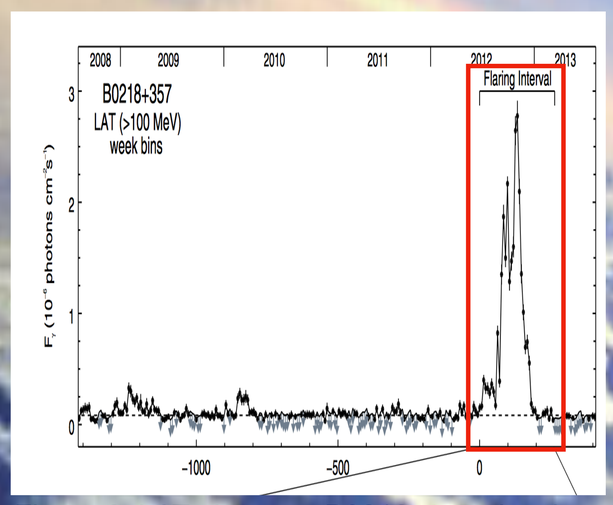


Figure 2: LAT observes B0218+357 showing signs of flaring activity (weekly time bins, Cheung et al 2014).

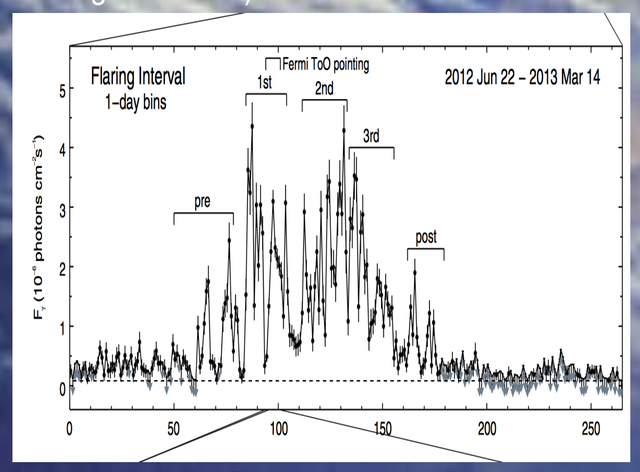


Figure 3: Zoom of the 2012-2013 flaring interval of B0218+357 (1-day binning, Cheung et al 2014).

Results

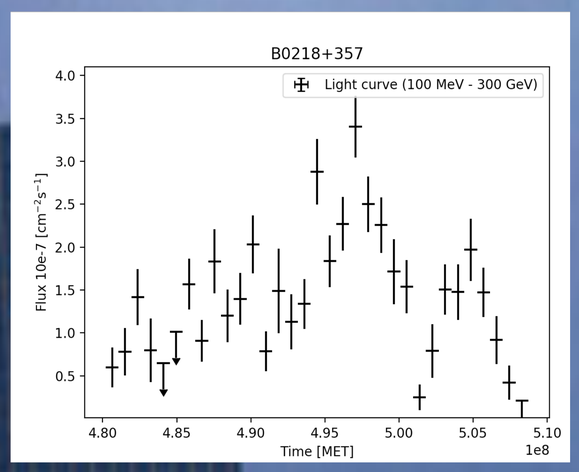


Figure 4: This work: light curve with weekly time bins shows recent enhanced gamma-ray activity.

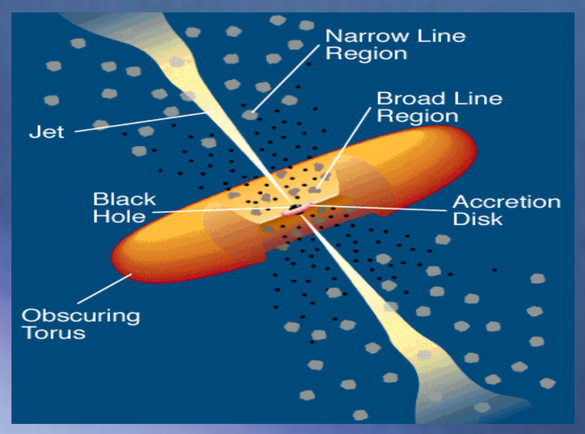


Figure 5: The above image shows the different components of a blazar.

Conclusion & Future Work:

- B0218+357 is a peculiar gravitationally lensed source, with a delay of ~11.5 days
- Strong gamma-ray activity was observed in 2012/2013 and in 2014. Afterwards it returned to quiescence.
- Lately, in 2016, the blazar showed evidence for renewed gamma-ray activity. To investigate this, a weekly-bin lightcurve was produced.
- The lightcurve shows clues for higher-than-average gamma-ray activity.
- Further efforts will focus in studying in more details the recent gamma-ray activity, and comparing it with previous ones.

References & Acknowledgements:

- Buson, S. et al. 2014
- Cheung, C.C. et al. 2014

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