Research investigates variability of the blazar Mrk 421

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Sloan Digital Sky Survey image of blazar Markarian 421. Credit: Sloan Digital Sky Survey

Astronomers from Switzerland and Germany have performed multiwavelength observations of a high-synchrotron-peaked blazar known as Mrk 421. Results of this observational campaign provide more insights into the variability of gamma-ray emission from this source. The study was published January 26 on arXiv.org.

Blazars are very compact quasars associated with supermassive black holes at the centers of active, giant elliptical galaxies. In general, blazars belong to a larger group of active galaxies that host active galactic nuclei (AGN), and their characteristic features are relativistic jets pointed almost exactly toward the Earth. Based on their optical emission properties, astronomers divide blazars into two classes: flat-spectrum radio quasars (FSRQs) that feature broad, prominent optical emission lines, and BL Lacertae objects (BL Lacs), which do not.

Some FSRQs are high-synchrotron-peaked (HSP) sources as their synchrotron peak is above 1,000 THz in the rest frame. Observations show that particles are efficiently accelerated up to very high energies (VHEs) in the jets of HSPs, which makes such sources very interesting for astronomers studying extreme blazars.

At a redshift of about 0.031, Mrk 421 is a HSP blazar with a low-energy synchrotron component peaking above 100,000 THz. It showcases bright and persistent GeV and TeV emission with frequent ?aring activities. Previous observations have shown that gamma-ray emission from Mrk 421 is rapidly variable and its origin is still debated.

In order to shed more light on the origin of this emission, a team of astronomers led by Axel Arbet-Engels of the Swiss Federal Institute of Technology in Zurich, Switzerland, decided to analyze observational data obtained between December 2012 and April 2018, using nine different instruments spanning from radio to gamma-ray band.

"We used 5.5 years of unbiased observing campaign data, obtained using the FACT telescope and the Fermi LAT detector at TeV and GeV energies, the longest and densest so far, together with contemporaneous multi-wavelength observations, to characterize the variability of Mrk 421 and to constrain the underlying physical mechanisms," the researchers wrote in the paper.

The study found that the strongest variations of Mrk 421 occur in the hard X-rays and in the TeV energy band. It turned out that X-ray and flares in the TeV energy band are very well correlated. The TeV and X-ray fluxes measured simultaneously were also found to be correlated.

According to the paper, the average lag between

the TeV and X-ray variations is at a level of less than 0.6 days. The variations in the GeV energy band appear to be strongly and widely correlated with optical and radio variability. It was found that the radio variations are lagging these in the GeV band by 30 to 100 days.

Summing up the results, the astronomers concluded that X-ray and TeV emissions are driven by the same population of high-energy particles. They added that such variability could be caused by variations of the electron maximal energy, or by, for instance, the magnetic field affecting electrons and protons.

More information: The relentless variability of Mrk 421 from the TeV to the radio, arXiv:2101.10651 [astro-ph.HE]
arxiv.org/abs/2101.10651

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