New X-Ray clues from blazars could provide insights on powering of active galaxies

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Astronomers tracked some of the blazars with the highest energy radiations revealing new clues about the sources of X-ray emission in these energetic objects.

This can help in the study of extreme physical conditions around these astronomical objects and also provide insights into how active galaxies are powered.

Blazars are among the most energetic objects in the Universe. They are active galaxies powered by Super Massive Black Holes (SMBHs) at their centers. As matter falls toward the black hole, enormous amounts of energy can be released, while powerful jets of relativistic particles are launched almost directly toward Earth. Because of this orientation, blazars can appear extraordinarily bright. A particularly extreme group of these objects are TeV blazars, which produce very-high-energy gamma rays reaching tera-electron volt energies.

As the powerful jets from blazars are directed almost toward Earth, their X-ray spectra are generally dominated by emission from the jet. This makes it difficult to identify radiation from other parts of the galaxy, such as the accretion disk around the black hole.

In order to overcome this difficulty, researchers from the Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, an autonomous institute of the Department of Science and Technology (DST) studied four classical blazars - Mrk 421, Mrk 501, PG 1553+113, and PKS 2155-304, that emit very high-energy radiation. Using observations from NASA's NICER and NuSTAR space telescopes, Riya Bhowmick and Alok C. Gupta studied the X-ray radiation from these objects to better understand how these energetic galaxies behave.

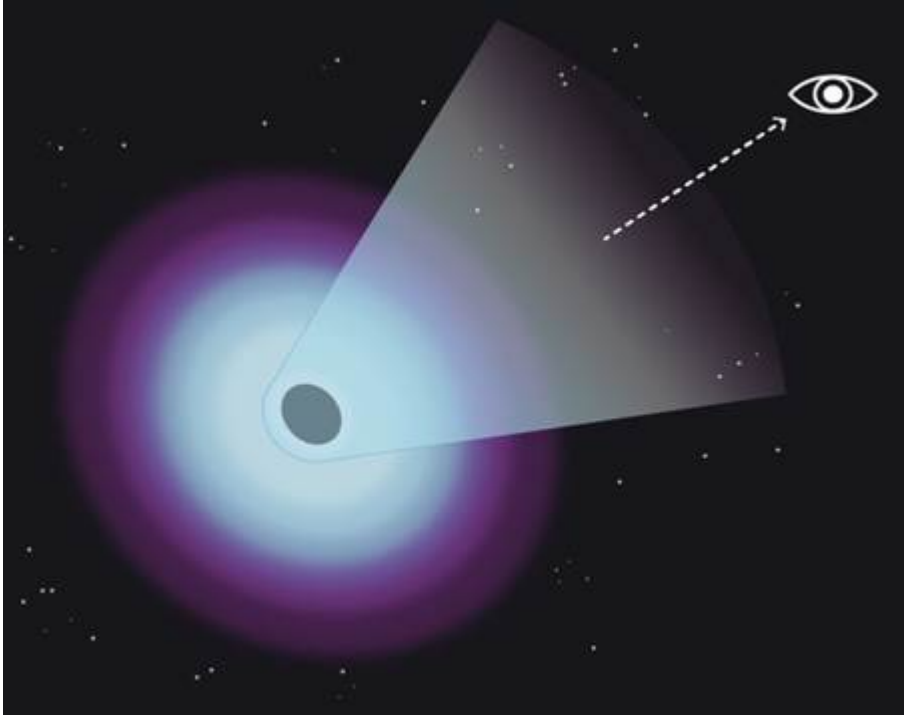

Fig 1: *An illustration of blazar, or an active galactic nucleus that emits a powerful jet along the observer's line of sight. The colours depicted in this illustration are for artistic purposes only.*

Image Credit*: NASA.*

The researchers analysed 13 sets of X-ray observations of four TeV blazars using NASA's NICER and NuSTAR space telescopes. NICER observed lower-energy X-rays, while NuSTAR covered a higher-energy range. Combining the observations gave the researchers a broader view of the X-ray emission from these energetic objects.

Most of the X-ray spectra could be explained by the usual model for blazar emission. However, a few observations of Mrk 421 and Mrk 501 showed an additional component at lower X-ray energies. Notably, both Mrk 421 and Mrk 501 were observed in moderate- to low-active states during these phases.

This suggests that, when these two blazars were relatively in less active phase, emission from the accretion disk contributed to the X-ray spectra alongside the emission from the jet. While such evidence has been reported earlier for Mrk 421, this is the first indication of a possible similar contribution from Mrk 501. Further observations are needed to confirm this finding. The observations of Mrk 421 also showed a small additional gaussian feature or a small extra peak in the X-ray spectrum (representing a slight excess of X-ray radiation at a particular energy). Its exact origin is not yet clear and may be related to the instrument or background effects.

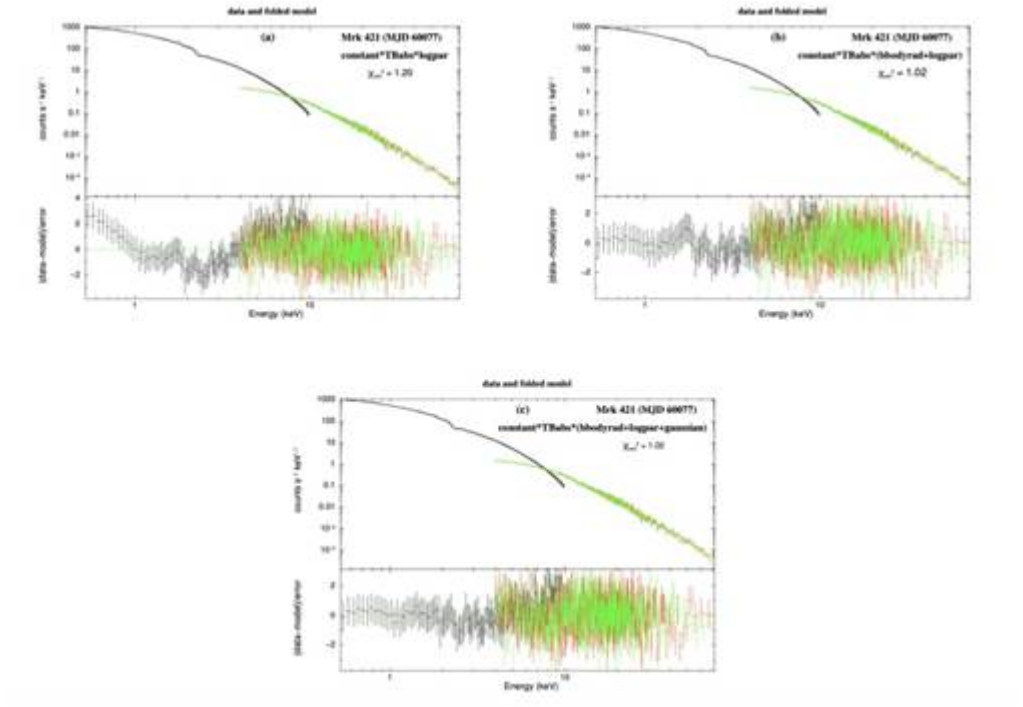

Fig 2: *The combined NICER (black) plus NuSTAR (red points denote FPMA and green points denote FPMB) fitted spectrum of Mrk 421 during MJD 60077. The fitting models are shown in the panels. (Adapted from Bhowmick & Gupta, 2026)*

The X-ray observations of the other two blazars, PG 1553+113 and PKS 2155-304, were well explained by the standard model. The curved shape of their X-ray spectra may be caused by the fact that particles of different energies gain energy at different rates and lose energy through radiation.

This study published in The Astrophysical Journal recently provides a better understanding of how four powerful blazars produce X-rays. The findings show that X-ray spectra of blazars are not simply dominated by a single source of radiation and that when the emission from their powerful jets becomes weaker, emission from the accretion flow may become detectable.

Observing these objects when they are both active and relatively quiet can help astronomers understand how these two sources of radiation contribute.

Further observations using different types of telescopes will help to confirm the contribution of the accretion disk in X-ray emission during moderate-low active states.

Apart from understanding the powering of active galaxies it can help comprehend the interaction of black holes with their surrounding environment.

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