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Imprint of local opacity effect in gamma ray spectrum of Blazar jets : Constraining the gamma-ray emission site - [REMOTE]

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Black hole-driven relativistic astrophysical jets, such as blazars and gamma-ray bursts (GRBs), are powerful sources of electromagnetic radiation. When these jets are directed toward observers, they intensify emitted radiation, condensing the entire output into a focused, point-like object. Blazars exhibit emissions across the electromagnetic spectrum, spanning from radio frequencies to very high energies. The GeV spectrum within the jets of blazars is shaped primarily by the non-thermal emission processes internal to the jet. However, the external thermal environment surrounding the high-energy emission site is expected to leave an imprint of pair production absorption at high energies, especially if the emission region lies within the influence of the nearby external jet environment. This could potentially refine our understanding of the gamma-ray dissipation sites in blazars.

Our study reveals **GeV breaks at energies above 10 GeV**, explained by gamma-ray absorption through photon-photon pair production on H-alpha or H-beta photons, specifically during the high state of the source. The high redshift of PKS 1424-418 (z=1.522) suggests that the Extragalactic Background Light (EBL) is the primary source of the observed absorption feature. Remarkably, **this feature is absent during the low flux state, indicating an additional absorption effect during the high activity period beyond the expected EBL absorption**. The presence of a GeV break in the high state, contrasted with its absence in the low state, supports the idea that gamma-ray emission sites within or at the edge of the Broad Line Region (BLR) transition to fainter gamma-ray emission zones beyond the BLR.
The detection of high-energy photons in FSRQs is typically believed to occur outside the influence of BLR to avoid pair production. Towards the edge of BLR, the emergence of kink instability could produce magnetic islands, leading to particle acceleration due to magnetic reconnection. Variabilities associated with magnetic reconnection are expected to follow a mini jet-in-jet model, resulting in a log-normal flux distribution observed during high states, in contrast to the Gaussian distribution during low states in our work.
The inferred location of the γ-ray emission zone is consistent with the observed variability timescale of the brightest flare in 2022, assuming the flare is due to external Compton scattering with BLR photons. This supports the interpretation that the **high-energy emission region is primarily confined to the edge of the BLR.**

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