Contribution ID: **553** Type: **Talk**

Unveiling a Binary system's Supernova Aftermath: A Cosmic Duel of Hadronic & Leptonic Gamma Rays from the IC 443 complex region

Friday 18 July 2025 13:20 (15 minutes)

Despite IC 443 being among the most studied Galactic supernova remnants (SNRs) across the entire electromagnetic spectrum, the complex region around it has yet to be clarified. A detailed analysis of IC 443 surroundings yielded the detection of extended GeV gamma-ray emission spatially coincident with the G189.6+3.3 SNR. Despite the lack of a complete radio continuum image, the position and morphology of the gamma-ray emission, detected using 16 years of Fermi-LAT data, clearly matches the newly detected G189.6+3.3 X-ray shell with eROSITA, constituting compelling evidence for the gamma-ray emission origin. This study examines regions of the remnant potentially interacting with the S249 HII cloud to determine if gamma-ray emission originate from the same or different particle populations. The northeastern region, coinciding with a molecular cloud and a conspicuous Hα filament, shows spectral curvature best described by a LogParabola model. In contrast, the southeastern region, not overlapping with the molecular cloud, exhibits a steeply rising gamma-ray spectrum, resembling an inverse Compton (IC) peak near TeV energies. Such evidence make G189.6+3.3 SNR the first example of an SNR that actively demonstrates how interaction with molecular gas triggers hadronically induced gamma-ray emission from its regions overlapped with the molecular cloud, whereas its regions that are free of molecular gas emit leptonically induced gamma-rays. Furthermore, its interaction with the S249 HII cloud is evidenced by both the hadronic origin of the gamma-ray emission from the northern part of the remnant and the precise spatial correlation of the latter component with a conspicuous Hα filament. Combined with the morphology analysis results, this correlation strongly supports gamma-ray production through proton (re)-acceleration via adiabatic contraction within the filament and positions G189.6+3.3 at the same distance as IC 443, lending support to the hypothesis of a binary system in which both components underwent supernova events.

Collaboration(s)

Fermi-LAT collaboration

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Session Classification: GA

Track Classification: Gamma-Ray Astrophysics