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X-ray Emission as a Probe of Cosmic Ray Diffusion near Galactic γ-ray Sources

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Galactic γ-ray extension sources exhibit complex emission patterns, potentially dominated by either leptonic or hadronic processes. Pulsar halos, known as TeV halos, are extended γ-ray emissions around middle-aged pulsars. While the TeV emission is attributed to inverse Compton scattering, the transport mechanism within the halo remains debated.

This study explores the multiwavelength emissions from pulsar halos under various diffusion models. We predict that synchrotron radiation from escaping electrons can form an X-ray halo around the pulsar, showing distinct surface brightness profiles across different models. We advocate for sensitive X-ray detectors with wide fields of view (e.g., eROSITA/EP) to probe the particle transport mechanism, which is helpful in understanding interstellar turbulence and pulsar halo formation.

Additionally, we analyze the morphology of multiwavelength emissions from diffusive protons, highlighting how synchrotron radiation from secondary electrons could contribute to the X-ray background for γ-ray hadronic sources. Our findings suggest that spatial morphology in X-ray radiation could aid in distinguishing between leptonic and hadronic origins for sources with ambiguous energy spectra.

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