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The formation of gamma-ray halos around supernova remnants through particle escape

Supernova remnants (SNRs) are known to accelerate particles to relativistic energies, from the detection of nonthermal emission. The particularities of the acceleration mechanism are still debated. Here, we discuss how particle escape modifies the observable spectra as well as morphological features that might be revealed by the observational progress from radio to gamma-ray energies.

We use our time-dependent acceleration code RATPaC to study the formation of extended gamma-ray halos around supernova remnants and the morphological implications that arise when the high-energetic particles start to escape from the remnant.

We find a strong difference in the morphology of the gamma-ray emission from supernova remnants at later stages, dependent on the emission process. At early times, both the inverse-Compton and the Pion-decay morphology are shell-like. However, as soon as the maximum-energy of the freshly accelerated particles starts to fall, the inverse-Compton morphology starts to become center-filled, whereas the Pion-decay morphology keeps its shell-like structure. Both emission-spectra show a spectral softening caused by the escape of the highest-energetic particles. Escaping high-energy electrons start to form an emission halo around the remnant at this time. There are good prospects for detecting this spectrally hard emission with the future Cerenkov Telescope Array, as there are for detecting variations in the gamma-ray spectral index across the interior of the remnant. Due to the projection effects there is no significant variation of the spectral index expected with current-generation of gamma-ray observatories.

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