

Gamma-rays from young SNRs in dense circumstellar environments

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Supernova remnants are known to accelerate cosmic rays from their non-thermal emission of radio waves, X-rays, and gamma rays. However, the ability to accelerate cosmic rays up to PeV energies has yet to be demonstrated. The presence of cutoffs in the gamma-ray spectra of several young SNRs led to the idea that PeV energies might only be achieved during the earliest stages of a remnant's evolution. We use the time-dependent particle-acceleration software RATPaC to study the acceleration of cosmic rays in dense circumstellar environments (CSE) of massive stars, where the dense target material could produce gamma-rays bright enough for detection by current and future experiments. We performed spherically symmetric simulations in which we simultaneously solve equations for the transport for cosmic rays, evolution of magnetic turbulence, and hydrodynamical flow of the thermal plasma, in the test-particle limit. We investigated typical CSE conditions for freely-expanding winds around Red Supergiants and Luminous Blue Variables, as well as structured ambient media due to photoionization-confined shells or episodes of enhanced mass loss prior to the SN explosion. Potentially detectable gamma-ray signals can be expected in the Fermi-LAT band weeks to months post-explosion for wind CSE. Likewise, the interaction with dense shells enhances the gamma-ray luminosity, which is accompanied by a re-brightening in thermal X-rays that might be used as trigger for dedicated gamma-ray observations. The maximum achievable energy may be limited even in the presence of strong magnetic fields close to the progenitor star because of enhanced damping of turbulence due to cascading.

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Theoretical Results

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