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PeV Cosmic Ray acceleration in the supernova post breakout expansion phase: kinetic-magnetohydrodynamic simulations

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Origin of cosmic rays (CRs) is still not known. In this work we argue that PeV cosmic rays can be accelerated during the early phase of a supernova blast wave expansion in dense red supergiant winds. We solve in spherical geometry a system combining a diffusive-convection equation which treats CR dynamics coupled to magnetohydrodynamics to follow gas dynamics. The fast shock expanding in a dense ionized wind is able to trigger the fast non-resonant streaming instability over day timescales. We investigate the maximum energy CRs can reach in this configuration accounting for pp losses. Multi-PeV energies can be reached if the progenitor mass loss rates are of the order of, or larger than, 10^{-3} solar masses/year. It has been recently invoked that prior to the explosion hydrogen rich massive stars can produce enhanced mass loss rates. These enhanced rates would then favor the production of a Pevatron phase in early times after the shock breakout. We discuss observational tests to probe our model using future radio and gamma-ray facilities.

Keywords

kinetic-MHD simulations, Pevatron, cosmic-ray streaming instability

Collaboration

other Collaboration

Subcategory

Theoretical Results

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