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Particle acceleration in core-collapse supernova remnant expanding inside the wind bubble

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Supernova Remnants (SNRs) are considered as the primary sources of galactic cosmic rays (CRs), where CRs are assumed to be accelerated by diffusive shock acceleration (DSA) mechanism, specifically at SNR shocks. In the core-collapse scenario, the SNR shocks expand inside the complex ambient environment as the core-collapse SNRs have massive progenitor stars ($> 8M_{\odot}$) and those stars generate wind-blown bubbles during their different evolutionary stages as a consequence of their mass-loss in the form of stellar wind. Additionally, as the evolution of massive stars depends on the Zero Age Main Sequence (ZAMS) mass, rotation, and metallicity the structures of created circumstellar medium are considerably different. Therefore, **the CR acceleration and the radiation from the core-collapse SNRs should differ significantly not only from the SNR, evolving in the uniform environment but also from one another, depending on their progenitor stars.**

We aim to observe the influence of the ambient medium of core-collapse SNRs on the particle spectra and radiation as well as to probe the change in spectral shape if SNRs have progenitors with lower($> 8M_{\odot}$), intermediate, and very high ZAMS mass.

We applied the hydrodynamic structures of wind-blown bubbles at the pre-supernova stage created by **massive stars with $20M_{\odot}$, $35M_{\odot}$, and $60M_{\odot}$ ZAMS masses** to form the ambient environment for supernova explosions. The evolution of those stars through notably different stages from Zero Age Main Sequence (ZAMS) to the pre-supernova stage results in the formation of structurally different wind bubbles, **hence preferable to observe the spectral shape dependency on the mass of progenitor stars**. Then, the transport equation for cosmic rays, hydrodynamic equations have been solved simultaneously in 1-D spherical symmetry.

We have obtained the modifications in particle spectra are significantly determined by the hydrodynamic structure of SNR ambient medium. The spectral shape depends considerably on the interplay of SNR shock interactions with different discontinuities inside the wind bubble and the temperature of the bubble. The $60M_{\odot}$ star ends life as a Wolf-Rayet star and creates a very hot bubble ($> 10^8\ K$). As consequence, we have found softer particle spectra with spectral index close to 2.5. For comparison, $20M_{\odot}$ star becomes a Red-Supergiant at pre-supernova stage and hence the created bubble would not be hot enough to provide the spectral softness as for the SNR with $60M_{\odot}$ progenitor. Furthermore, the circumstellar magnetic field structure, as well as the considered particle diffusion coefficient in the simulation effectively influence the particle acceleration as well as emission morphology of SNRs.

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