Z219b Interacting Supernova as Super PeVatrons: spectrum and composition

Nick Ekanger, Tohoku University

The mechanisms responsible for producing high-energy cosmic rays, including their power-law spectrum and the energy-dependent evolution of nuclear composition, remain mysterious. Interacting supernovae offer a promising candidate to explain these observables. We build upon a self-consistent model of the shock formed as supernova ejecta encounter the surrounding circumstellar medium, to track the acceleration of nuclei with realistic compositions. Our results show that supernovae embedded in particularly dense environments, such as Type IIn systems, can drive particle acceleration to super-PeV energies if the magnetic field in the wind is amplified by the non-resonant streaming instability. The predicted cosmic-ray spectra and fluxes align with recent observations from LHAASO, Telescope Array, and IceTop over the $\sim 10^{16}$ to $\sim 10^{17}$ eV range. By incorporating the preferential injection of partially ionized ions, whose efficiency depends on their mass and charge, we demonstrate that a solar-abundance progenitor can naturally reproduce the trend toward heavier compositions at these energies. We conclude by discussing how interacting supernovae may contribute to the broader landscape of multi-messenger sources.