Numerical simulations of particle acceleration in supernova remnants

Invited Talk //

Supernovae and Supernova Remnants

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For over five decades, supernova remnants (SNRs) have been extensively studied as potential sources of Galactic cosmic rays. However, the demonstration of their capability to accelerate cosmic rays to sufficiently high energies remains a challenge, leaving many questions regarding the microphysics of the acceleration process unanswered.

The intricate interplay between particle transport, the amplification of magnetic turbulence for cosmic ray scattering, and the hydrodynamic evolution of SNRs, particularly in realistic circumstellar media, presents a highly nonlinear and multiscale problem. While particle-incell and hybrid simulations provide insights into microphysical shock structures, particle injection, and electron pre-acceleration, they are limited to small fractions of the spatial and temporal scales involved. On the other hand, kinetic simulations cover all relevant scales but necessitate sub-grid models for the microphysics involved.

Nonetheless, numerical simulations of particle acceleration in SNRs have made significant strides in advancing our understanding of the underlying mechanisms and their astrophysical implications. These simulations have contributed to our knowledge of particle acceleration processes and their connection to the observed phenomena in SNRs.

In this talk, we provide an overview of recent advancements and present results from numerical simulations that aim to investigate the intricate processes involved in particle acceleration within SNRs. We discuss the challenges associated with this complex problem and highlight the progress made in understanding the microphysics of particle acceleration through computational modeling.