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Cosmic-ray acceleration and propagation

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The origin of cosmic rays (CRs) has puzzled scientists since the pioneering discovery by Victor Hess in 1912. In the last decade, however, modern supercomputers have opened a new window on the processes regulating astrophysical collisionless plasmas, allowing the study of CR acceleration via first-principles kinetic simulations; at the same time, new generations of X-ray and gamma-ray telescopes have been collecting evidence that Galactic CRs are accelerated in the blast waves of supernova remnants (SNRs).

I present state-of-the-art particle-in-cells simulations of non-relativistic shocks, in which ion and electron acceleration efficiency, and magnetic field amplification, are studied in detail as a function of the shock parameters. I then discuss the theoretical and observational counterparts of these findings, comparing them with predictions of diffusive shock acceleration theory, and with multi-wavelength observations of young SNRs; I especially outline some major open questions, such as the (possible) causes of the steep CR spectra inferred from gamma-ray observations of SNRs, and the origin of the knee in the Galactic CR spectrum. Finally, I put such a theoretical understanding in relation with CR propagation in the Galaxy, in order to bridge the gap between acceleration in sources and measurements of CRs at Earth.

Collaboration

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