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Phenomenology and theory of galactic cosmic-ray propagation

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Cosmic rays are the most energetic particles in the local Universe as they are known to reach energies above few Joules. How and where they are produced have been a science puzzle for several decades now, whose solution has been driving the rising of multi-messenger astrophysics as well as novel theoretical approaches. Of particular interest is the energy range below ~PeV as we expect that these particles have been all accelerated in the most extreme objects in our own Galaxy. Additionally, the past decade has seen an unprecedented improvement in the quality and quantity of data about their energy spectrum and chemical composition, allowing us to infer global properties as the galactic grammage and the average residence time. These quantities are crucial to test any more fundamental description of the transport of charged particles in the interstellar plasma. Even more thrilling, these new measurements, together with a deeper scrutiny of the diffuse gamma-ray emission from the Galactic plane, have revealed unexpected new features in the cosmic-ray elemental spectra that are challenging the commonly accepted scenario of how these particles are energized and propagate through interstellar space. In my talk I will provide an overview of these recent findings, and discuss some of the new ideas proposed to explain these anomalies.

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