Galactic Cosmic Rays: From Earth to Sources

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For nearly 100 years we have known that cosmic rays come from outer space, yet proof of their origin, as well as a comprehensive understanding of their acceleration, remains elusive. Direct detection of high energy (up to 10^15eV), charged nuclei with experiments such as the balloon-born, antarctic Trans-Iron Galactic Element Recorder (TIGER) have provided insight into these mysteries through measurements of cosmic ray abundances. The abundance of these rare elements with respect to certain intrinsic properties suggests that cosmic rays include a component of massive star ejecta.

Supernovae and their remnants (SNe & SNRs), often occurring at the end of a massive star's life or in an environment including massive star material, are one of the most likely candidates for sources accelerating galactic comic ray nuclei up to the requisite high energies. The Fermi Gamma-ray Space Telescope Large Area Detector (Fermi LAT) has improved our understanding of such sources by widening the window of observable energies and thus into potential sources' energetic processes. In combination with multiwavelength observations, we are now better able to constrain particle populations (often hadron-dominated at GeV energies) and environmental conditions, such as the magnetic field strength. The SNR CTB 37A is one such source which could contribute to the observed galactic cosmic rays. By assembling populations of SNRs, we will be able to more definitively define their contribution to the observed galactic cosmic rays, as well as better understand SNRs themselves. Such multimessenger studies will thus illuminate the long-standing cosmic ray mysteries, shedding light on potential sources, acceleration mechanisms, and cosmic ray propagation.