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Collisionless Shocks and Particle Acceleration

TONY BELL, University of Oxford

In recent years, cosmic ray physics has made a transition from being a semi-detached part of astrophysics to become an essential part of observational astronomy. This increased prominence is due to the development of gamma-ray and x-ray astronomy which detect emission produced by TeV particles, the recognition that cosmic rays are probably responsible for the observed large magnetic fields accompanying shocks, the deduction of highly relativistic motion in gamma-ray bursts connected with supernovae, and the Auger project to identify the source of the very highest energy cosmic rays. Observational developments constrain the theory of cosmic ray acceleration by shocks and encourage consideration of acceleration in a wider range of environments. A non-resonant interaction between cosmic rays and the thermal plasma (Bell, MNRAS 353 550 (2004)) generates large magnetic fields and increases the maximum energy to which cosmic rays can be accelerated. This resolves important issues surrounding cosmic ray acceleration, and it also points to the possibility that forces exerted by cosmic rays may be dynamically important on a macroscopic scale with consequences for supernovae and gamma-ray bursts. Laboratory investigation may supplement observation and theory in this intriguing intersection of astrophysics and plasma physics.