Particle Acceleration and Transport at Collisionless Shocks

T. Amano [1)], Y. Matsumoto[2)], and M. Hoshino[1)]

[1)] Department of Earth and Planetary Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113-0033, Japan
amano@eps.s.u-tokyo.ac.jp
[2)] Department of Physics, Chiba University, 1-33 Yayoi-cho, Inage-ku, Chiba 263-8522, Japan

Abstract

The collisionless shock has been a primary candidate for the production of nonthermal particles in space. The diffusive shock acceleration (DSA) has been considered as the standard shock-acceleration theory that predicts a power-law spectrum, whose index is sorely determined by the shock compression ratio. The theory assumes (1) injection or pre-acceleration providing a seed population for subsequent acceleration, (2) nearly isotropic distribution in momentum space via efficient pitch-angle scattering, leading to diffusive transport of energetic particles, (3) energetic particles are test particles that do not affect the dynamics of the thermal plasma. Validity of these assumptions has been extensively studied over the decades, as they provide the key ingredients of the acceleration process. Indeed, these issues are intimately linked with each other, making it extremely difficult to understand the overall picture of the whole nonlinear system.

We will present recent theoretical and numerical effort toward understanding the key issues in the shock acceleration theory. In particular, the electron injection processes involving a variety of nonlinear and kinetic plasma waves in the shock transition layer is discussed. In addition, we also present results of kinetic simulations on turbulence driven by energetic particles streaming in the precursor region of the shock. Implications of the result will be discussed in relation to the transport of solar energetic particles in the interplanetary space.