R008-28
Zoom meeting D ：11/4 PM2 (15:45-18:15)
16:45〜17:00

Condition for Electron Injection via Stochastic Shock Drift Acceleration

#Takanobu Amano[1)]
[(1]Univ. Tokyo

The acceleration of high-energy particles is commonly seen in heliophysics and astrophysics. The diffusive shock acceleration (DSA) process has been the standard mechanism for particle acceleration at collisionless shock waves. It is, however, well known that DSA cannot explain the acceleration of low-energy electrons because of the lack of efficient scatterers. We have proposed stochastic shock drift acceleration (SSDA) as a plausible mechanism to resolve the problem of electron injection [Katou & Amano, 2019]. The energy gain mechanism of SSDA is essentially the same as the conventional shock drift acceleration (SDA), but the presence of stochastic pitch-angle scattering makes the acceleration more efficient. Good agreements between theoretical predictions based on SSDA and in-situ observations by Magnetospheric MultiScale (MMS) spacecraft have been reported [Amano et al. 2020]. Furthermore, electron acceleration signatures found in fully kinetic Particle-In-Cell (PIC) simulations have also been found [Matsumoto et al. 2017, Kobzar et al. 2021]. Motivated by these previous studies, we will present results of more sophisticated theoretical and numerical analyses.

We use a diffusion-convection equation derived consistently from a fully relativistic pitch-angle diffusion equation. We formulate the problem essentially as a shock acceleration at an oblique shock of finite thickness. This includes the standard DSA as the special case, in which the diffusion length is much longer than the shock thickness. We find that SSDA is understood as the particle acceleration process for which the diffusion length is comparable to the thickness. SSDA, in general, predicts a steeper-than-DSA power-law index. The spectral index is dependent on the diffusion length and becomes steeper as decreasing the ratio between the diffusion length to the shock thickness. The diffusion lengths of low-energy particles accelerated by SSDA may eventually become longer than the shock thickness. As a result, the particles with loner diffusion lengths may be further accelerated by DSA, which is essentially the injection. The present model can describe the continuous transition of acceleration regimes both below and above the injection threshold energy. Using the MMS measurements, we will discuss the condition required for the electron injection at realistic collisionless shocks of various environments.