Development of numerical code of the electron transport equation with spectral method

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An acceleration process of non-thermal particles is one of the fundamental subjects of space physics. The standard theory of cosmic ray electrons is the diffusive shock acceleration (DSA). However, DSA cannot explain an acceleration of non-relativistic electrons. Although the alternative acceleration process is needed to generate higher energy electrons, it has still been unclear.

We proposed the stochastic shock drift acceleration model (SSDA, Katou and Amano 2019) as this acceleration process. In the previous study, we calculated the energy dependence of electron function under the assumption of the spatial dependence and isotropic pitch-angle distribution. The result is consistent with observations of Earth's bow shock by the MMS spacecraft (Amano et al. submitted). Comparing with observations more precisely, we need to solve the electron transport equation, and derive both the spatial and pitch-angle dependence of distribution function. However, it is not easy to calculate analytically, then we must calculate numerically.

We developed the numerical code to derive spatial, energy, and pitch-angle dependence of the electron distribution function by solving the electron transport equation. We used a 5th order finite-difference method with MP5 for spatial and energy dependence, and 3rd order Runge-Kutta method for calculating time dependence. On the other hand, we used the pseud-spectral method for determining pitch-angle dependence by expanding into Legendre polynomials. It makes the calculation of the pitch-angle scattering process simpler. We calculated the energy and spatial distribution of electrons under DSA by our code and compared with analytical solutions. In this presentation, we report the result of this test.

Keywords: Acceleration of particles, Earth, Shock wave

