Rapid heating and acceleration mechanism in the shock transition region

Nobue Shimada[1], Masahiro Hoshino[2]

[1] Univ. of Tokyo, [2] Earth and Planetary Phys., Univ of Tokyo

Physics in the high-Mach number shock transition region is studied by one-dimensional full-particle simulation. We focus on especially particle dynamics of electron scale. Two-stream instabilities between incident electrons and reflected ions, and between incident electrons and incident ions play an important role to rapid heating and acceleration of particles through their resultant large-amplitude electrostatic field. We will discuss how particles are energized with nonlinear evolution of the electric field utilizing also three-beam periodic simulation modeled to mimic the shock transition region.

We investigated the physical process in high-Mach number shock transition regions by using one-dimensional full-patricle simulation with electron time and space scales. Electrons play an important role to the dissipation at the shock transition region as Mach number goes up (under same plasma beta condition). An example of this dissipation mechanism is nonlinear evolution of electrostatic waves, which emitted toward upstream from the region where clear reflected ion population exist. Trapped electrons with these waves are quickly thermalized by flactuations due to another instability and become part of downstream population. The main mechanism dominates particle heating process is two-stream instability between electrons and ions (both of reflected and incident). Fields supplied by this strong instability couple electrons and ions and enhance energy exchange between them. This paper will also include the result from periodic simulation mimics to the shock transition region (three beam system - incident electrons and ions, and reflected ions) and discuss the following points.

(a) The origin of non-thermal population created rapidly during nonlinear evolution of two-stream instabilities.

(b) Phase hole (generated by the large amplitude electric field due to the two-stream instabilities) properties. Electron holes are formed in the upstream side of the overshoot and ion holes are in the downstream side.

(c) Electron energization dependence on the reflection ratio.

In the last we will also discuss the electron inertia effect on the macro shock dynamics, though it is the case of small mass ratio (20).