DISSIPATION PROCESS AT COLLISIONLESS SHOCK IN THE ELECTRON SCALE

Tooru Sugiyama, Hiroshi Matsumoto and Yoshiharu Omura

Radio Science Center for Space & Atmosphere, Kyoto University, Gokasho, Uji, Kyoto 611-0011, JAPAN
E-mail : tsugi@kurasc.kyoto-u.ac.jp

ABSTRACT

The electron dynamics in producing dissipation in collosionless shocks is investigated by numerical simulations. It is well-known that an anomalous dissipation is necessary in the super-critical shocks. The reflected ions are mainly considered to produce the dissipation. However, in the case where the electrons carry larger energy density around shocks, we have to include the electron kinetic effects in dissipation process. Here we have investigated a cross scale coupling between the electron kinetic scale and the global MHD scale.

SIMULATION RESULTS

We have performed one-dimensional shock simulations by using full-particle method. A shock wave with Alfvén Mach number about 7, the upstream plasma beta: 0.1 for both ions and electrons is set up by the current piston method. In the upstream region, electrons have the larger energy density than the cases in the typical hybrid simulations [1]. Quasi-parallel (shock angle : 10 deg.) and quasi-perpendicular (70 deg.) shocks are investigated.

In the quasi-perpendicular shock, reflected ions are clearly observed at the shock surface as reported in the satellite observations and hybrid simulations. The density of reflected ions is so dense over 10 % of the incoming upstream thermal ions that the total pressure of ions suddenly increases in the upstream region where reflected ions are observed. On the other hand, electron pressure gradually increases as the intensity of the magnetic field increases because the pressure of electron is mainly controlled by the adiabatic heating process. Resultantly, the pressure ratio (Pr) of electrons to proton decreases from unity to 0.01 at the shock surface. In the far downstream region, the ion pressure is continuously high so that Pr is smaller than 0.1 in the present simulation. Electron thermalization is weaker than proton.

In the quasi-parallel shock, reflected ions are also observed at the shock surface. The density of the ions, however, is much smaller than that in the quasi-perpendicular shock. The ion pressure increases gradually in the upstream region. And there is an additional electron heating [2]. From these two effects, the pressure ratio (Pr) weakly decreases to 0.1 at the shock surface. Another interesting difference from the quasi-perpendicular shock is that in the downstream region the ratio Pr increases upto the level of upstream region. Electrons are also themalized in the downstream region as protons. This means the electron dynamics which is not only controlled by the adiabatic process but also an additional process in quasi-parallel shocks is more important than quasi-perpendicular shocks. Since the critical Mach number in a quasi-parallel shock is smaller than that in a quasi-perpendicular shock, the anomalous heating process can be seen more frequently in the quasi-parallel shock. Present result is consistent with simple MHD model. The detail of the additional process is discussed at the conference.

ACKNOWLEDGEMENTS

Computation in the present study was performed with the KDK system of Radio Science Center for Space and Atmosphere (RASC) at Kyoto University as a collaborative research project.

REFERENCES

[1] T. Sugiyama, M. Fujimoto, and T. Mukai, "Quick ion injection and acceleration at quasi-parallel shocks" *J. Geophys. Res.*, vol. 106, pp. 21,657-21,673, 2001.
[2] M. Iwata, "Study of Plasma Wave Generation in the vicinity of Earth's Bow Shock via Computer Experiments" Master thesis, Kyoto Uni., 2002.