§15. Macro-Particle Simulation of Collisionless Parallel Shocks Generated by Solar Wind and Planetary Plasma Interactions

H.Shimazu, S.Machida (Dept. of Geophysics, Kyoto University), and Motohiko Tanaka

Super Alfvenic plasma flow creates a shock when its motion is disturbed by the stationary plasma or magnetic field. This actually occurs when the solar wind encounters the earth's magnetosphere (bow shock). For the Venus and Mars, the solar wind penetrates to the ionosphere to form the shock as the planets have no intrinsic magnetic field.

A formation of the collisionless parallel shock on such planets [1] has been simulated using the one-dimensional macro-particle code [2]. This simulation adopts the "stationary" ionosphere with dense plasma (righthand-side) which balances dynamical pressure of the super-Alfvenic solar wind (lefthand-side). The ambient magnetic field is along the $z-$(simulation) axis. The present geometry is realistic compared to the piston-driven shock in which the shock front travels rapidly in space [3].

Figure 1 shows behaviors of the solar wind ions, the ionospheric ions, and electrons together with the amplitude of the wave magnetic field. The electromagnetic waves with right-hand circular polarization (R^+ waves) are generated at the interface of the two plasmas which decelerate the solar wind to form the parallel shock. The measured wave characterisitics agree well with the linear dispersion relation of the beam ion-cyclotron instability.

The shock transition region is not monotonic but consists of two distinct regions, a pedestal and a shock ramp. The length of the transition region which contains the ionopause is a few thousand electron skin depths. The parallel shock varies in time and repeats collapse and re-formation periodically.

Nonlinear wave-particle interactions between the solar wind and the R^+ waves cause wave condensation and density modulation. These R^+ waves that make up the shock are possibly sweeping away the downstream plasma to suppress its thermal diffusion across the shock. The electrons at the shock ramp exhibit a "flat-topped" velocity distribution along the magnetic field owing to the ion acoustic-like electrostatic waves.

References

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