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PIC simulation on the solar wind interactions with meso-scale magnetic dipole and its application to Reiner Gamma

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We have been studying the solar wind interactions with a small-scale magnetic dipole by means of plasma particle simulations. In the current presentation, we will report some of the simulation results including a case of magnetic anomaly found in Reiner Gamma on the moon. If we define the dipole size L as the distance between the dipole center and a position where the solar wind dynamic pressure balances the magnetic pressure, L of our interest is in the meso-scale which implies the size smaller than the ion's inertia length and sufficiently larger than the electron Larmor radius in the solar wind. Contrary to the Earth's magnetosphere, difference of dynamics between ions and electrons with respect to the local magnetic field play an important role in the magnetosphere formation. In other words, electron-ion coupling through a dipole field becomes important. However, very little analysis has been done so far on the interactions between meso-scale dipole field and plasma flows.

Plasma particle simulation is appropriate for the investigation on the interactions between the solar wind and meso-scale dipole magnetic fields because plasma kinetics is considered. The simulation results obtained with the plasma particle simulations we performed so far show that electron interactions are important in the process of meso-scale magnetosphere formation. Around the distance of L from the dipole center, charge separation occurs because of the difference of dynamics between electrons and ions. Then intense electrostatic field is induced and ions, which can be assumed unmagnetized in the present dipole size, are eventually influenced by this electric field. At the distance of L from the dipole center, magnetic fields are also compressed. The width of the boundary current layer as well as the spatial gradient of the local magnetic field compression found on the dayside can be characterized by the electron Larmor radius. When IMF is considered, it is found that the formation of shock structure and magnetic field reconnection can affect the formation of the magnetosphere.

As one application, we studied the solar wind interactions with magnetic anomaly found in Reiner Gamma by performing plasma particle simulations. Since the magnetic field is almost perpendicular to the solar wind, increase of plasma and magnetic field densities is found at the dayside region in the simulation results. When the direction of IMF changes, their increase fluctuates because of the magnetic field reconnection. One of the interesting findings is that the solar wind ions do not reach the moon surface in Reiner Gamma. We will discuss this point by considering the plasma dynamics as well as the electrostatic field observed over the Reiner Gamma region.

Keywords: Plasma particle simulation, magnetic anomaly, small-scale magnetic dipole, solar wind, Reiner Gamma