PIC simulation on the plasma environment of a weakly magnetized small body with heavy ion emission

*Hideyuki Usui[1], Satoki Oki[1], Naoki Terada[2], Yohei Miyake[1], Yuto Katoh[2], Manabu Yagi[3]

1. Department of computational science, Graduate school of system informatics, Kobe University, 2. Department of Geophysics, Graduate School of Sciense, Tohoku University, 3. Advanced institute for computational science (AICS), RIKEN

The objectives of this study is to study the plasma environment of a weakly magnetized small body with heavy ion emission immersed in the solar wind by performing three-dimensional particle simulation. The BepiColombo Mercury mission will observe various plasma phenomena occurring in the small-scale magnetosphere of Mercury. Based on the previous observations, it is reported that the intrinsic magnetic field of Mercury is weak and the magnetic dipole moment is approximately 1/2000 of that of the Earth, which causes a small magnetosphere whose size is 1/20 of that of the Earth. In addition, Mercury owns no ionosphere but an exosphere. The small magnetosphere has a large proportion of Mercury’ s body and the structures of magnetospheric regions, particularly at the dayside and in the cusp region, may have spatial scale almost equal to the ion Lamor radius of the solar wind. In such a situation, it is important to consider the plasma kinetics in the analysis of plasma phenomena in the association with the small-scale magnetosphere. In this study, we started investigating the kinetic phenomena in the small magnetosphere by performing full particle simulations. In the simulation model, we have a small body with a small magnetic dipole moment immersed in a plasma flow representing the solar wind. In the vicinity of the surface of the small body, we keep emitting heavy ions as well as photoelectrons. We define L as the distance between the dipole center and a position where the solar wind dynamic pressure balances the magnetic pressure at the dayside. In this study, we set the ratio of the ion Larmor radius to L is between unity and 0.1. In Mercury case, the ratio will be 0.01 which implies the ion Lamor radius is 1/100 smaller than L. However, as stated earlier, it is highly possible that the kinetic effect can play an important role for the dayside physics. Therefore, we emphasize the kinetic effect by adopting larger ion Lamor radius in the simulation. Other important parameters in the simulation are the ratio of the body’ s radius to L, the density, and the velocity of the heavy ions and photoelectrons emitted from the surface. In the preliminary simulation results, we could confirm the fundamental physics in the small magnetosphere such as the formation of a small-scale magnetosphere with asymmetric density profile between the dawn and dusk regions, circular current around the body in the magnetic equator and the electric field enhancement near the surface due to the charge separation between heavy ions and photoelectrons emitted from the surface. We would like to investigate the dependency of these phenomena on the parameters stated above. We are also interested in the formation of exoionosphere which can be represented by the spatial distribution of the heavy ions.

Keywords: plasma particle simulation, weakly magnetized planet, Mercury's magnetosphere, exosphere

