Geophysical Research Abstracts
Vol. 15, EGU2013-8121, 2013
EGU General Assembly 2013

Full Particle-In-Cell simulations on the solar wind interactions with a small-scale magnetic dipole

Hideyuki Usui (1,3), Toseo Moritaka (2), Masaharu Matsumoto (1,3), and Multi-scale PIC Simulation team (3)
(1) Kobe University, Graduate School of System Informatics, Kobe, Japan (h-usui@port.kobe-u.ac.jp), (2) Osaka University, Institute of Laser Engineering, (3) Japan Science and Technology Agency (JST) /CREST

The Earth's magnetosphere which is caused by global interactions with the solar wind has been intensively investigated both by in-situ observations with satellites and global MHD simulations. Since the size of the Earth's magnetosphere is much larger than the ion inertia length in the solar wind, the formation of the magnetosphere and the associated macroscopic plasma phenomena can be examined in the MHD scale. However, as the magnetic dipole scale becomes comparable or smaller than the ion inertia length, plasma kinetics such as the finite Larmor radius effect and the electron-ion coupling cannot be ignored and will play important roles in the formation of a magnetosphere.
In the current study, we have been investigating solar wind interactions with a small-scale magnetic dipole by means of a full particle-in-cell electromagnetic simulation. This study is motivated by one of the next-generation interplanetary flight systems which utilizes the momentum transfer of the solar wind to a spacecraft which creates an artificial small-scale magnetic dipole by a superconducting coil. In the simulation, we focus on a magnetic dipole whose size is less than the ion inertial length in the solar wind. In this situation, electron interaction becomes important in the process of the magnetosphere formation. The simulation result shows that the width of the boundary current layer as well as the spatial gradient of the local magnetic field compression found at the dayside can be characterized by the electron Larmor radius. At the boundary region where the magnetic fields are compressed, electrons basically stagnate and form a high density region while ions' trajectories are little affected because of large Larmor radius. However, owing to the electrostatic force induced by the difference of dynamics between electrons and ions, ions dynamics are also indirectly influenced by the presence of the small magnetosphere.
In addition, IMF effect such as the formation of shock structure and magnetic field reconnection can affect the formation of the magnetosphere. For example, in northward IMF case, magnetic reconnection takes place at the night side and the reconnected fields are transferred and piled up in the dayside region. Some solar wind electrons are trapped in the dayside magnetosphere and the density becomes high. Some shock like structure is also found as a result of the solar wind interaction. However, unlike the Earth's bow shock, the structure is not clearly seen because the transition or interaction region has a width around the ion inertia length which is larger than the magnetic dipole. The obtained results can be applied to the plasma phenomena observed above the magnetic anomalies on the moon surface.