Simulation analysis on the electron dynamics in the magnetosphere boundary above a lunar crustal magnetic anomaly

*Hideyuki Usui[1], Takuma Matsubara[1], Yohei Miyake[1], Masaki Nishino[2]

1.Graduate school of system informatics Kobe University, 2.Institute for Space-Earth Environment Research

The objective of this research is to study the response of solar wind plasma to a lunar crustal magnetic anomaly, particularly the electron behavior in the boundary current of a mini-magnetosphere by performing three-dimensional full particle-in-cell simulations. In the simulation domain, we set one magnetic dipole under the lunar surface as the Reiner Gamma magnetic anomaly. We define the size of the magnetic anomaly L as the distance between the dipole center and a position where the solar wind dynamic pressure balances the magnetic pressure. At the location of L above the magnetic anomaly, the Larmor radius of electrons is much smaller than L while that of ions is larger than L. As reported in the previous works, we confirmed the formation of a mini-magnetosphere above the magnetic anomaly. In the simulations, we observed strong current around the boundary layer of the magnetosphere. The boundary current mainly consists of electrons flow.
In the low latitude region, electrons flux points to the dawn-to-dusk direction. In the mid- and high- latitude regions, on the other hand, the direction of the electron flux is reversed. It seems that a rotational current structure is formed in the dayside magnetopause both in the Southern and Northern hemisphere. Along the equator from the dawn to the dust region intense electron flux is observed. The flux splits at the dusk side and each flux turns to the higher latitude region in both hemispheres, returning to the dawn region. We particularly focused on the electron dynamics at the magnetopause in the equator plane to figure out the mechanism of the intense electron flux from the dawn to dusk side. As reported in the previous works, intense electric field is induced by the difference of dynamics between the solar wind electrons and ions at the magnetopause where the electron density decreases to zero. Due to the intense electric field perpendicular to the local magnetic field, the incoming solar wind electrons are accelerated toward the lunar surface and the Larmor radius is eventually enlarged. At the edge of the magnetopause, the maximum velocity to the duskward direction is observed because of the electron gyrations. This maximized velocity of electrons can be the source of the intense electron current in the boundary layer. The width of the intense electron current at the magnetopause approximately agrees with the local Larmor radius of the accelerated electrons.

Keywords: plasma particle simulation, magnetic anomaly, electron dynamics

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