Numerical Simulations on Surface Charging Properties of Lunar Surface Cavities

*Nakazono Jin[1], Yohei Miyake[2], Hideyuki Usui[3]

1. Kobe University , 2. Education Center on Computational Science and Engineering, Kobe University, 3. Graduate school of system informatics Kobe University

Since the Moon has no atmosphere and no intrinsic magnetic field, solar wind plasma falls directly on the lunar surface and forms an electrostatic environment near the lunar surface. The formation of the electrostatic environment is known to be strongly dependent on the topology and sunlight conditions of the lunar surface. The Moon has a wide range of topographic features, from craters and boulders to surface rocks and regolith layers. In recent years, unique topographic features such as vertical holes have been also identified. The investigation of the unique surface charging characteristics caused by these irregularities and their dependence on spatial scales is very important to quantitatively understand the lunar surface environment, which will be a critical issue in future lunar explorations. In this study, we compare the plasma and electrical environments of lunar holes and hollows with different sizes and shapes using particle simulations to reveal the charging characteristics of lunar surfaces with complex shapes.
We set up a lunar surface with a cavity in the simulation space, and simulated the solar wind plasma flow, and the sunlight illumination and its associated photoelectron emission from the surface. The simulation results show that the surface charging within the cavity can be understood in terms of separate contributions of the solar wind plasma and the photoelectron currents. The solar wind electrons collide with the cavity wall at relatively shallow positions due to their greater thermal motions than ions. Therefore, the proportion of solar wind electrons that approach the bottom of the cavity is small, and the deepest part of the cavity surface will be charged positively. This effect will be moderated as the cavity aperture becomes greater, because it leads to the larger number of solar wind electrons approaching the bottom of the cavity. The photoelectron current basically contributes to the positive charging at the photoelectron release point, which is the well known behavior. On the cavity wall, however, the emitted and recollected photoelectrons behave as they transport negative charge to the deeper part of the cavity, which moderate the positive potential at the bottom of the cavity formed by the solar wind ions.

Keywords: the Moon, plasma, surface charging, hole and cavities, particle simulation

