Particle simulation of non-uniform lunar surface charging associated with surface topography

*Jin Nakazono[1], Yohei Miyake[2]

1. Kobe university , 2. Education Center on Computational Science and Engineering, Kobe University

On the surface of the Moon, solar wind plasma falls directly on the surface and forms distinctive electrostatic environment, which is also affected by photoelectrons and accumulated surface charges. A number of on-orbit observations by lunar explorers have suggested that the lunar dayside surface has positive potentials. Since space plasmas generally have ability to charge solid surfaces negatively, it is acknowledged that photoelectron emission is essential to keep the lunar surface at a positive floating potential.

In this study, we use 3D PIC simulations to show that regardless of the ability of this photoelectron emission, a positive surface potential is also possible by considering a specific class of surface geometries. The lunar surface has uneven surfaces over a wide range of spatial scales, from topography such as craters, vertical holes, and boulders to surface rocks to regolith layers. Several numerical simulations have shown that topographic features such as craters and vertical holes create an electrostatic environment unique to these features. As well as these topography-scale surface features, microcavities formed by small rocks and regolith particles at smaller scales are also interesting targets in terms of mass transport by electrostatic energy. At such scales, the insufficient debye shielding capability results in stronger electrostatic fields, which are considered to be one of the key factors for the mobilization and lifting of charged regolith particles.

In this simulation, the solar wind plasma flow is set up from the sky to the surface using a plane with a sub-debye-scale open-topped cavity that is accessible to a certain fraction of the incoming plasma particles as a surface profile model. The simulations show that the solar wind plasma flow can create a positive potential on the cavity floor up to several hundred V, which is comparable to the kinetic energy of ion particles. The potential value shows an increasing trend with the depth-to-width ratio of the cavity. The simulation also indicates that the positive charging condition holds even without a photoelectron current from the cavity floor. Furthermore, it is shown by simplified numerical modeling that this charging process in sub-debye scale cavity can be mainly explained by the thermal and bulk velocities of the ambient plasma in addition to the cavity geometry. In this presentation, we report the dependence of the non-uniform charging by the geometry of lunar cavity surface and the ambient plasma conditions from both simulation and numerical modeling.

In this presentation, we will report two main progresses. First, we will report the dependence of the cavity surface charging on the cavity shape and ambient plasma parameters obtained in the present investigations. After that, we will report our recent effort in improving the numerical method to achieve both numerical stability and small computational cost, which will be necessary for simulating the cavity charging with smaller spatial scales.

Keywords: Solar wind plasma, Lunar, Surface charging, Particle simulation

