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NUMERICAL ANALYSIS OF CHARGED PARTICLE EFFECTS ON SOLAR SAILS FOR INTERPLANETARY FLIGHT

Abstract

Solar sail is considered to be a candidate spacecraft for interplanetary flight. It consists of a large membrane to convert the solar radiation pressure into the spacecraft thrust. The scales of the membrane are estimated from 10m x 10m to 100m x 100m to obtain sufficient thrust. During interplanetary flight, a solar sail is exposed into the solar wind plasma whose density and temperature vary depending on the distance between a spacecraft and the sun. Photoelectron current from the sunlit surface of the spacecraft also varies depending on the solar flux.

Because the Debye length of the solar wind plasma around the solar sail is smaller than the scale of the spacecraft, the current collection onto the spacecraft is affected local spatial distribution of plasmas including photoelectrons. Therefore, it is of importance to study the charged particle profiles in terms of spacecraft charging.

We performed computations to analyze charged particle profiles as well as spacecraft charging using the three-dimensional electrostatic Particle-In-Cell (PIC) code we had been developed. We tried these analyses under three plasma environments, near earth, inferior planet and superior planet environments. In each environment, we evaluated the spacecraft floating potential that was determined by the current balance onto the spacecraft and the space charge effect of the charged particles around the spacecraft. Spatial profiles of the charged particle were also obtained that would have been important to investigate the location of a payload of a solar sail.

In addition, we also performed charging analysis using MUSCAT, a spacecraft charging analysis software, as the reference result of the floating potential of the spacecraft. The differential voltage between the local insulator component and the body potential of the spacecraft was originally obtained by the MUSCAT computation.

In this paper, we will report the charged particle effects on solar sails in terms of spacecraft charging obtained by computational analysis.