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NUMERICAL MODELING OF SPACECRAFT POTENTIAL MODULATIONS DUE TO TIME-VARYING PLASMA WAVE FIELDS

Abstract

Based on the particle-in-cell (PIC) method, we numerically model the modulation of a spacecraft potential in the presence of time-varying fields of plasma waves. Recent observations by Van Allen Probes showed apparent spacecraft potential fluctuations associated with chorus wave detection [e.g., *Malaspina et al.*, 2014], and a major physical factor of the effect was identified as photoelectron-escape current modulations due to wave electric field. Although its dependencies on wave frequency and magnetic field strength have been examined experimentally [e.g., *Wang et al.*, 2014], there are a number of remaining issues such as effects of wave polarization or spacecraft geometry. Also, in-space spacecraft potential measurements are conducted by seeing a potential difference between spacecraft chassis and electrostatic probes, and thus it is necessary to consider the difference of their responses to external wave electric fields.

In this paper, we perform plasma particle simulations to address such unresolved issues. Our original PIC simulation code EMSES has a capability of reproducing plasma wave excitation/propagation as well as spacecraft charging in a self-consistent manner [*Miyake and Usui*, 2009]. Meanwhile, such analysis with realistic physical parameters requires too large computational resources, because the typical spatial scale of plasma wave lengths is much greater than that of the spacecraft size. Thus, we propose another modeling of the phenomena by applying a spatially-uniform and time-varying electric field to the whole simulation domain as an external force term. We have confirmed that this model can reproduce the photoelectron-mediated spacecraft potential fluctuations in the presence of a circular-polarized wave electric field. We examine the case of multiple spacecraft bodies corresponding to the spacecraft chassis and the probes, and discuss the difference of potential fluctuations between the bodies, which will elucidate detailed mechanism of detecting spacecraft potential modulations in in-situ observations.