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Numerical analysis on the photoelectron environment around space-based electric field sensors

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In low-density plasmas typically encountered in space, photoelectrons emitted by solar illumination form a high-density photoelectron cloud in the vicinity of a spacecraft body and an electric field sensor. The photoelectron current emitted from the sensor body has also received considerable attention because it is a primary factor in determining floating potentials of the sunlit spacecraft and sensor bodies. Considering the fact that photoelectron distribution can cause spurious electric field and unexpected change of sensor properties, we require quantitative evaluation of the photoelectron environment around the spacecraft and its influence on sensor characteristics. Particularly, it is necessary to develop a numerical approach so that it is applicable to a wide range of presumable situations of photoelectron environment around spacecraft.

In the current study, we applied the Particle-In-Cell plasma simulation to the analysis of the photoelectron environment around spacecraft and its influence on sensor characteristics. By using the PIC modeling, we can self-consistently consider the plasma kinetics. This enables us to simulate the formation of the photoelectron cloud as well as the spacecraft and sensor charging in a self-consistent manner. Meanwhile, since the computational cost to reproduce the photoelectron environment is generally significant in a three-dimensional model, there are still remaining issues toward the establishment of a practical numerical antenna-analysis tool, such as the inclusion of the realistic scale size of the sensor and plasma/photoelectron parameters in the simulation.

We report the progress of an analysis on photoelectron environment around MEFISTO, which is an electric field instrument for the BepiColombo/MMO spacecraft. In considering photoelectron environment, the photoelectron guard electrode is a key technology of MEFISTO for producing an optimum condition of the photoelectron distribution. We show some simulation results regarding the photoelectron guard effect on the photoelectron distribution in the vicinity of the instrument. We also report the latest status of our numerical antenna analysis tool toward the inclusion of more practical sensor model and plasma parameters.

Keywords: Electric antenna, Photoelectron, PIC simulation