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Particle simulations on the photoelectron environment around an electric field sensor

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For more sophisticated electric field measurement planned in future magnetospheric missions, a strong demand arises regarding better understanding of the behavior of an electric field sensor in space plasma environment. In low-density space plasmas, photoelectron emission due to solar illumination creates a high-density electron cloud around a sensor aboard scientific spacecraft. Considering the fact that such a photoelectron cloud occasionally causes spurious electric field and unexpected change of sensor properties, we require quantitative evaluation of the photoelectron environment around the sensor and its influence on the sensor properties. Particularly, it is necessary to develop a numerical approach, which is applicable to a wide range of presumable situations of photoelectron environment around spacecraft.

In the current study, we applied the particle-in-cell (PIC) plasma simulation to the analysis of the photoelectron environment around spacecraft and its influence on sensor characteristics. The PIC approach enables us to reproduce the formation of the photoelectron cloud as well as the spacecraft and sensor charging in a self-consistent manner. Based on the PIC approach, we have developed a numerical model of a modern electric field sensor MEFISTO for the BepiColombo/MMO spacecraft. The model includes the photoelectron guard electrode and current biasing, both of which are realized in the simulation as a potential control of the instrument surfaces.

We report the progress of our analysis on photoelectron environment around MEFISTO and its influence on the sensor behavior. 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 sensor. We also report the recent progress of our numerical tool toward the inclusion of more practical sensor model and plasma parameters.

Keywords: Electric field sensor, Photoelectron, PIC simulation