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希薄なプラズマ環境における宇宙機表面からの光電子放出に関する数値シミュレーション研究

Numerical Study on Photoelectron Emission from Spacecraft Surface in Tenuous Plasma

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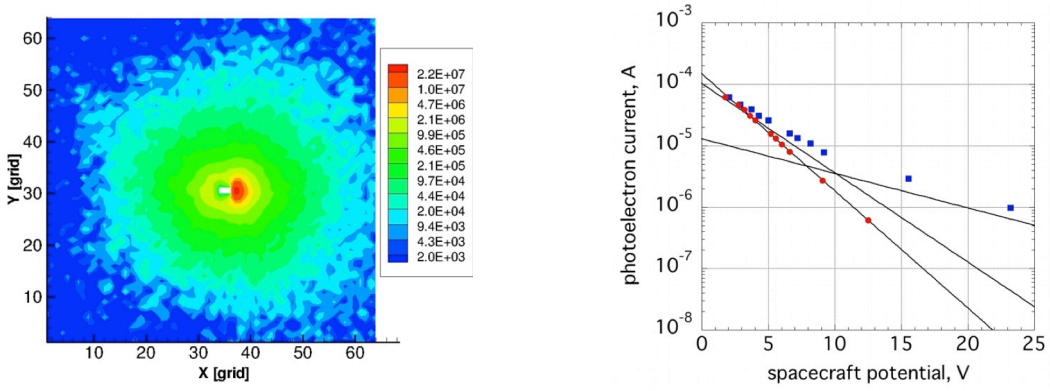
In a low-density space plasma, the electric potential of a sunlit spacecraft is strongly affected by photoelectron emission from its surface. The spacecraft has a positive potential due to the photoelectron current, and its equilibrium state is determined by the balance of current from the escaping photoelectrons and impinging ambient electrons. Hence, knowledge of the energy distribution of photoelectrons and the net photoelectron current is of importance for evaluation of measurements of electric field in space. Nakagawa et al. estimated the current density carried by photoelectrons from the GEOTAIL spacecraft from the spacecraft potential and the ambient plasma density and temperature observed by the sensors onboard the spacecraft assuming the balance of the currents carried by photoelectrons and the ambient electrons [1]. They had estimated that emitted photoelectrons consist of several components with different temperatures.

We had numerically evaluated the correlation between the photoelectron current and the spacecraft potential for the photoelectrons consists of several components using a conventional three-dimensional electrostatic full Particle-In-Cell (PIC) code we had developed [2]. In this simulation, a linear combination of two Maxwellian distribution functions was introduced as the energy distribution of photoelectrons. We confirmed the important role of the high-temperature component of the photoelectrons to explain the electric potential of the spacecraft observed by GEOTAL. The numerical results show the spatial distribution of photoelectrons in the vicinity of the spacecraft, and their space charge effect is clearly estimated. Heating of the low temperature component of the photoelectrons is newly recognized in the numerical simulation.

[1] Nakagawa, T. et al., “Net Current Density of Photoelectrons Emitted from the Surface of the GEOTAIL spacecraft,” Earth, Planets and Space, vol. 52, pp283-292, 2000.
[2] Muranaka, T., et al., “Research and Development of Plasma Simulation Tools in JEDI/JAXA,” Journal of Space Technology and Science, vol. 25, No. 2, pp. 1-18, 2011.



Figures: Numerical results of the spatial distribution of photoelectrons around the spacecraft (left), and the correlation of the photoelectron current and the spacecraft potential (right).