Particle-In-Cell simulations on the characteristics of electric field antenna in the spacecraft environment

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We study the characteristics of electric field antennas immersed in space plasma by performing computer experiments. The plasma environment near the spacecraft becomes non-uniform due to the sheath formation and photoelectron emission, and such a non-uniform environment affects the antenna characteristics. However, because the analysis of antenna near-field is generally complex in plasma, it is difficult to consider the realistic plasma density distribution near the spacecraft by theoretical approaches. In the present study, we apply the Particle-In-Cell simulation method to antenna analysis, which enables us to treat the antenna model including a spacecraft body and analyze the effects of photoelectron emission on antenna characteristics. The present antenna model consists of perfect conducting antennas and spacecraft body whose joints are assumed to be electrically insulated. Moreover, we assumed the arrival direction of sunlight and modeled the photoelectron emission from the sunlit surfaces. Using these models, we first performed the electrostatic simulations focused on photoelectron sheath formation around the spacecraft. It was confirmed that the plasma environment depended sensitively on the incident angle of sunlight which determined the location and amount of photoemission. Next, the antenna impedance under the obtained plasma environment was examined by the electromagnetic simulations. Obtained impedance results were much different from those in vacuum below the characteristic frequency corresponding to the local density in photoelectron sheath. It was also found that this effect had much dependence on the incident angle of sunlight. Now we start to consider the real plasma parameters of the Earth's magnetosphere and examine the antenna impedance. These analyses will contribute to the calibration of plasma wave data obtained by spacecraft observations.