Computer experiments on the characteristics of electric field antenna in the spacecraft environment

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The characteristics of electric field antenna immersed in space plasma are affected by complex interactions among antenna, plasma waves, and plasma particles. Such effects have to be investigated quantitatively for the calibration of wave data obtained by spacecraft observations. However, the antenna analysis in space plasma is generally complicated because it is basically a dispersive and anisotropic medium. In the previous theories, antenna analysis has been done for a dipole antenna immersed in a uniform cold or hot plasma with the assumed antenna current distribution. In the present study, the electric field antenna characteristics were studied by means of the Particle-In-Cell simulations. The PIC simulation method to enables us to treat the realistic antenna model and analyze the plasma kinetic effects such as photoelectron emission and sheath formation on the antenna characteristics.

The present antenna model consists of perfect conducting antennas and spacecraft body whose joints are assumed to be electrically insulated. Moreover, the authors assumed the arrival direction of sunlight and modeled the photoelectron emission from the sunlit surfaces. In the present study, the emitted electrons are assumed to have a Maxwellian spectrum.

Using these models, the authors 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.

Finally, the antenna impedance under the obtained plasma environment was examined by the electromagnetic simulations. Both real and imaginary parts of impedance were changed from those in vacuum below the characteristic frequency corresponding to the local density in photoelectron sheath. It was found that this effect had much dependence on the incident angle of sunlight. This suggests that the impedance characteristics vary with the spin or attitude change of spacecraft. Now the authors started to include the realistic parameters of background plasma and photoelectron to evaluate the plasma environment and antenna characteristics. These analyses will contribute to the calibration of plasma wave data obtained by spacecraft observations and the design of electric field antennas aboard the future mission.