Particle-In-Cell Simulation on the Characteristics of a Receiving Antenna in Space Plasma Environment

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For the precise calibration of electric field data obtained by scientific spacecraft, we have to investigate the characteristics of a receiving antenna in space plasma environment. We applied the electromagnetic Particle-In-Cell (PIC) plasma simulation to the antenna analysis in space plasma [1][2]. By using the PIC modeling, we can self-consistently consider the plasma kinetic effects. This enables us to naturally include the effects of the inhomogeneous plasma environment such as a sheath created around the antenna. We particularly modeled situations of electrostatic/electromagnetic-wave reception by an antenna aboard scientific spacecraft and examined the effective length of the antenna.

Fig. 1 shows the model of the current analysis. In the model, we initially set up external waves that propagate in the simulation region. We also placed a wire antenna made of a perfect conductor, in which the electric field values are set to zero. In the simulation, we observed the value of the wave electric field E and the input voltage V_i induced at a gap between two antenna-body elements as shown in Fig. 2. The effective length is obtained as the ratio of V_i / E. In the current study, we examined the effective lengths in receiving the Langmuir and Whistler waves as electrostatic (ES) and electromagnetic (EM) modes, respectively. As a preliminary result, we confirmed that the effective length of the dipole antenna coincides with the half of the dipole physical length in absence of sheath and photoelectron effects. We next started the analysis of a "puck" antenna, which is an electric field instrument for the future satellite mission: BepiColombo. By using a simplified model shown in the bottom panel in Fig. 3, we analyzed the effective length. As a result, the effective length of the "puck" antenna is approximately 80 % of the total length for the simplified model, which is larger than that of a simple dipole antenna [3]. The dependence on the ratio of the sensor length to the boom length and the photoelectron and sheath effects on the effective length should be investigated as a future work.

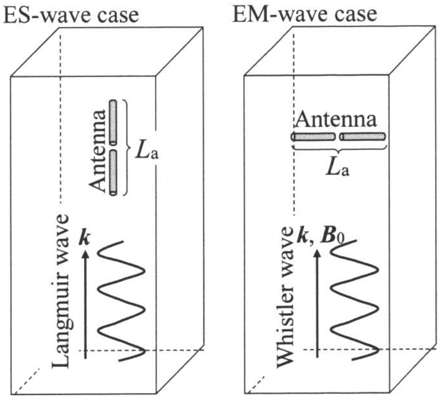

Figure 1. Simulation model for the analysis of receiving antenna characteristics.

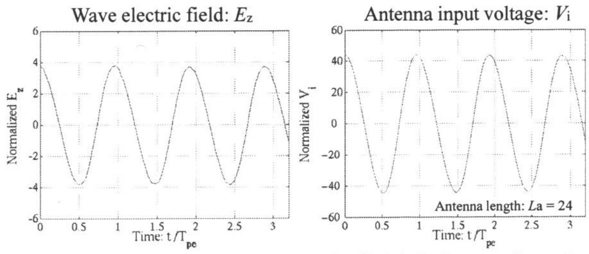

Figure 2. Plasma wave electric field (left panel) and waveform received by a dipole antenna (right panel).

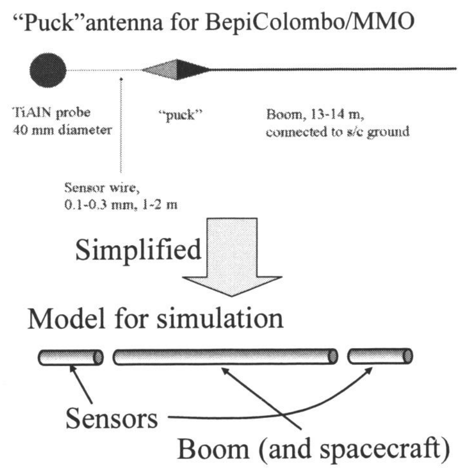

Figure 3. "Puck" antenna (one side, upper panel) and its simplified model for simulation (bottom panel). We set the ratio of the sensor length to the boom length as 1/6.

REFERENCES

[1] Miyake, Y., H. Usui, H. Kojima, Y. Omura, and H. Matsumoto (2008), *Radio Sci.*, 43, RS3004, doi:10.1029/2007RS003707.

[2] Miyake, Y., and H. Usui (2008), *Radio Sci.*, in press.

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