Computer Simulation of Electric Field Sensor in Space Plasma

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A dipole antenna has been commonly used for electric-field sensors in plasma wave observations via scientific satellites in space.

Electric field sensors in plasmas are characterized by their effective lengths and antenna impedances.

The effective lengths and antenna impedances depend on target waves and plasma parameters around a satellite.

We have been using approximation values under the assumption that wavelengths are much longer than antenna lengths.

However, it is not true, because wavelengths of electrostatic waves are much shorter than those of electromagnetic waves and their wavelengths can be in the same order of antenna lengths.

Hence knowing the characteristics of electric field sensors over plasma waves with shorter wavelengths is significant in evaluating intensities and phases of targeted electrostatic waves.

In this research, we simulated the antenna impedances of electric field sensors in magnetized plasmas over electromagnetic waves with short wavelengths.

We conducted Particle-In-Cell simulations with electric field sensors as inner boundaries.

The results were evaluated considering the linear dispersion relations in magnetized plasmas.

According to the calculation results, when the wave number of the antenna resonance is large enough, it is estimated that the resonances are seen at the frequencies of the electron cyclotron harmonics, which are frequently observed in the magnetized plasmas.

When the wave number is small enough, the resonances frequencies are shifted to slightly high.

As results of the PIC simulations, the resonances were seen at harmonics of the electron cyclotron frequency when their wave numbers were large.

When the wave number was small, no resonance was observed.

We also performed simulations to examine effects of a satellite body to characteristics of electric field sensors.

When the length of the satellite parallel to the antenna was about the same as the sensor length, the resonance of the antenna impedance at the second harmonic disappeared, and the resonance at the third harmonic became prominent.

In the present paper, we discuss the characteristics of electric field sensors in plasmas over plasma waves with short wavelengths that are comparable with lengths of electric field sensors.

Keywords: antenna impedance, computer simulation, electric field measurement, Particle-in-cell

