Computer experiments on antenna characteristics in space plasma

Nobuyuki Nakamura[1], Hideyuki Usui[2], Hirotsugu Kojima[2], Hajime Kaishima[1], Hiroshi Matsumoto[2], Yoshiharu Omura[2]

[1] RASC, Kyoto Univ, [2] RASC, Kyoto Univ.

Antenna characteristics in a magnetized plasma such as input impedance, effective length and pickup factor are important in the plasma wave observation, partcularly for calibration of wave data obtained from spacecraft. However, it is difficult to evaluate antenna characteristics in space plasma accurately because of complex interaction among antenna itself, plasma waves, background plasma and

photoelectron sheath.

For last several decades, many studies on antenna characteristics have been done. In terms of antenna impedance, theoretical analyses were done with the assumption of the antenna surface current. Simultaneously analysis of antenna impedance was carried out

by real observation with spacecraft and antenna equivalent circuit which is parallel circuit of resistance and capacitance was used. However there are some discrepancy between the observational results and the analysis with antenna equivalent circuit, which may be caused by the effect of sheath and photoelectron.

In the present study, we focused on a dipole antenna and examined its characteristics in space plasma by performing three dimensional

electromagnetic PIC(Particle-In-Cell) simulation. In three dimensional PIC simulation as a antenna analysis we put a conducting dipole antenna immersed in a magnetized plasma and examine its impedance, effective length including plasma kinetic effects under a variety of plasma environments. Firstly, we performed simulations to obtain the antenna impedance. In these simulations impedance resonance at the plasma frequency was recognized and the resonance becomes duller as

thermal velocity of background plasma became larger. These results were consitent with theory qualitaively and we will proceed to the

quantitative analysis. Next, we performed simulations to obtain effective length. We investigated the effective length by using a

receiveing antenna and calculated effective length from antenna surface current under the circumstances an electrostatic wave was

excited by the beaminstability. When wave length was comparable to antenna length antenna surface current can be approximated as sine

wave. However, if load impedance is far higher compared to the antenna impedance it can be considered that the current flowing over the

antenna becomes very little and the voltage induced on antenna becomes dominant. We are investigating the association between effective

length and current distribution on antenna.

The above simulations are performed in only case that antenna length is larger than the local Debye length. Therefore we also focus on the situation where the local Debye length is larger than or comparable to the antenna length.