Hot plasma effect on the impedance probe measurement

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Impedance-probe technique developed by Oya [1966] is a unique method to obtain the absolute value of the total electron density with measuring the equivalent capacitance of an electrode immersed in plasma. This method enables us to detect the UHR frequency to deduce the absolute electron density with high accuracy as the standard observation technique on-board the spacecraft and sounding rocket. However, frequency variation of probe capacitance also includes much more information, such as electron temperature and ion sheath thickness (e.g. Oya and Aso [1969], Takahashi et al. [1985], Wakabayashi and Ono [2006]). The NEI (Number density of Electrons by Impedance probe) data obtained from the PPS system on board the Ohzora (EXOS-C) satellite suggest that equivalent capacitance variation is affected by the electron electrostatic wave. We analyzed the NEI data observed by the Ohzora satellite to examine the effect of hot plasma on the characteristics of antenna impedance.

Based on Balmain's cold plasma model, probe capacitance shows a maximum value at the electron cyclotron frequency (Balmain [1964]). In Crawford et al. [1966] model, which took into account the equivalent plasma permittivity component perpendicular to magnetic field, the maximums of probe capacitance variation could appear at the harmonics of the electron cyclotron frequency. The present data analysis results also showed the maximums of probe capacitance at the cyclotron harmonic frequencies. We also found the minimums of equivalent capacitance at cyclotron frequency and its second harmonics. It seemed to depend on the angle between the probe and the direction of the magnetic field. These results can not be explained by previous models based on the cold plasma or warm plasma model for the calculation of the plasma mobility tensor. The results of present study suggest that there is the effect of hot electrons on the measurement of impedance probe exciting through the electrostatic electron cyclotron harmonic waves (e.g. Nakatani and Kuehl [1976]).