Characteristics of the sheath capacitance measured by the impedance probe on-board sounding rockets

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The impedance probe developed by Oya [1966] is a determination method of the electron number density by measuring the equivalent capacitance of a conductor probe immersed in plasma. This method enables us to determine the UHR frequency to deduce the absolute electron density accurately. The impedance probe has been applied to many sounding rockets and satellite observations of the electron density. However, frequency variations of the probe capacitance also include much more information, such as the electron temperature and the probe potential (e.g., Oya and Aso, 1969; Watanabe, 2000; Wakabayashi and Ono, 2006). We will show analysis results of the sheath capacitance response due to the change of the Debye length and the probe surface potential.

Due to the difference of thermal velocities between electrons and ions, the ion sheath is formed around the probe. The probe capacitance at much lower frequency than the characteristic frequencies (such as the sheath resonance frequency) is recognized as the sheath capacitance. In this study, the sheath capacitance is calculated based on Oya and Aso [1969] and compared with the measured values obtained by the impedance probe on-board sounding rockets, S310-35 and S520-23.

The sounding rocket S520-23 was launched from Uchinoura Space Center on 2nd September 2007. The measured values of the sheath capacitance are well fitted with the calculated ones. On the other hand, the sheath capacitance measured by the impedance probe on-board S310-35 shows lower values than the calculated. The rocket experiment using S310-35 was carried out in the auroral ionosphere. It is concluded that a charge-up effect of the probe caused by the auroral particle precipitation has to be taken into account.

It is confirmed that the electron temperature is able to be estimated from the sheath capacitance, under the condition that the probe potential is equal to the floating potential in Maxwellian plasma. Furthermore, the charge-up effect of the probe can be discussed quantitatively by using the electron temperature data obtained by the Langmuir probe.