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Characteristics of cyclotron harmonic resonances detected by an impedance probe experiment

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The impedance probe developed by Oya [1966] is a unique method to obtain the absolute values of the 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 accurately as the standard observation technique on-board spacecrafts. However, frequency variations of the probe equivalent capacitance (the probe impedance) reflect much more physical property of plasma, such as the electron temperature, the velocity distribution function and the dispersion relation. In this study, characteristics of the resonance phenomena in thermal magneto-plasma are ascertained.

It is theoretically confirmed that the antenna impedance in thermal magneto-plasma has series resonance frequencies at the electron cyclotron harmonic frequencies (e.g., Crawford et al., 1967). These resonances are reported to affect the impedance probe experiment (e.g., Ejiri and Obayashi, 1970; Oya et al., 1979). However, there has been little study that tried to examine the characteristics of cyclotron harmonic resonance, such as the occurrence characteristics and variations of the Q values. In this study, characteristics of cyclotron harmonic resonances are examined observationally and experimentally.

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 variations are affected by the electrostatic electron cyclotron harmonic wave. Moreover, the probe equivalent capacitance data obtained by a laboratory experiment using the impedance probe reveals two features which have not been reported in previous studies.

One is the existence of a parallel resonance near the electron cyclotron frequency. Frequency variations of the probe capacitance data obtained by both the Ohzora satellite and the laboratory experiment showed minimum values at slightly higher frequency than cyclotron frequency. It can be recognized as the effect of the Bernstein mode wave.

The other is that the Q values of the series resonances at cyclotron harmonics showed drastic increase near the sheath resonance frequency. This result indicates that the energy absorption of plasma at the resonance frequency becomes more efficient near the sheath resonance frequency.

These results may lead to an establishment of a new technique measuring the electron temperature and the understanding of the interactions between the RF probe and the ambient plasma.