§6. Coefficient of Ion Sensitive Probe for Ion Temperature Measurement

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Electrostatic probes have been intensively used to measure plasma properties since the early study of plasma physics. Langmuir probes are the most widely used probes among them; they evaluate electron temperature, T_e, by fitting a simple function, analytically given by $I \sim \exp(eV/k_BT_e)$ to measured V-I characteristics of the probes.[1] Most electrostatic probes evaluate electron properties because the electron mass is much smaller than ion masses, and because the current to an electrode immersed in plasma is mainly dominated by electrons that reach the electrode.

To evaluate ion temperature, some modifications to electrostatic probes are required. An ion--sensitive probe that consists of a central electrode and a guard electrode, as shown in Fig. 1, is one of the examples.[2] The central electrode is placed parallel to the magnetic field and the cylindrical guard electrode surrounds the central electrode to block electrons from reaching the central electrode, because the gyroradii of electrons are much smaller than those of ions. Thus, ion current flowing into the central electrode is measured with the bias voltage, V, applied to the central and guard electrodes against the ambient plasma. Ion temperature, T_i, is evaluated with the assumption that the measured V-I characteristics obey a simple function given by

$I \sim \exp(-eV/k_BT_i)$.

However, a numerical study of the ion current of such ion--sensitive probes with various radii and heights of electron guard shows the need of a calibration coefficient, c, of each ion sensitive probe to evaluate ion temperature for a fitting function with the form:[3]

$$I \sim \exp(- c\, eV/k_B T_i) .$$

The coefficient, c, depends on the radius, R, and height, H, of an ion sensitive probe and Fig. 2 shows how the coefficient, c, depends of the normalized radius, R/ρ, and height, H/ρ, where, ρ is a characteristic ion gyroradius and given by

$\rho = [2mk_BT_i/(eB)]^{1/2}$.

In the HYPER-1 device, ion temperatures estimated from the measured V-I characteristics of ion sensitive probes with the numerically obtained coefficient, c, will be compared with those estimated from Doppler broadening of the line of laser induced fluorescence scattered by moving ions will be made.

References

1) H. M. Mott-Smith and I. Langmuir: Phys. Rev. **28** (1926) 727 -763.
2) I. Katsumata and M. Okazaki: Jpn. J. Appl. Phys. **6** (1967) 123-124.
3) A. Tsushima and Y. Tayama: Jpn. J. Appl. Phys., **44** (2005) 4128 - 4132.

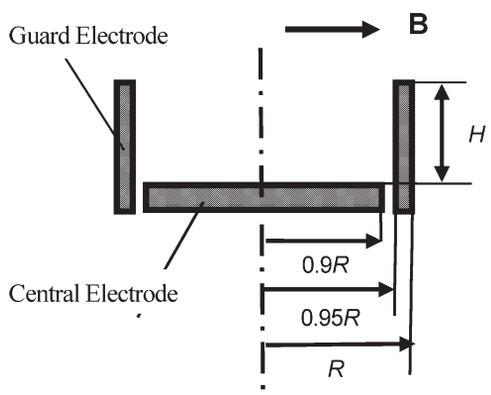

Fig. 1 Schematic drawing of ion sensitive probe.

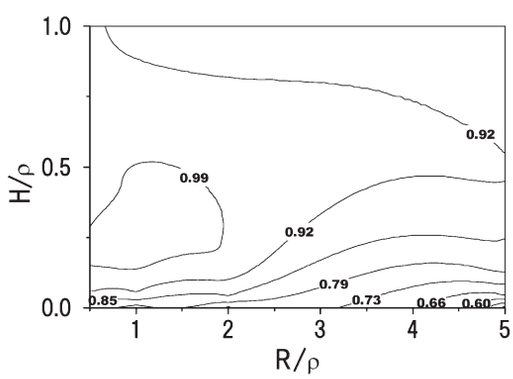

Fig. 2 Contour map of coefficient, c.