Comparison of Thomson scattering and Langmuir probes for electron property measurements in magnetised plasma

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Langmuir probes are routinely used to measure fundamental electron properties, such as, temperature and density in low temperature technological and fusion edge plasmas, by monitoring the current drawn from the plasma as the probe tip is biased. They have a straightforward setup and are simple to operate, however the measurement is inherently perturbing, and interpretation of the data often requires a complicated model [1]. A complete theory for ion and electron collection covering all parameter space does not exist, but there are several parameterised theories for the case of unmagnetised plasma [1,2]. The presence of a magnetic field complicates probe theory [3] by introducing anisotropic current collection, increasing the probe disturbance length and reducing the return electrode area of the circuit. It is difficult to incorporate these effects into a model because cross-magnetic-field transport mechanisms are poorly understood.

The aim of this research is to assess the reliability of unmagnetised probe theories [1,2] in the weak magnetic field regime, where electrons are the only magnetised species. Probes were employed in a magnetron discharge (~5-35 mT) and several probe theories (OML, ABR, Laframboise, Boltzmann electron retardation [1,2]) were implemented to extract electron properties from the probe data. Results were compared with Thomson scattering measurements performed under identical discharge operating conditions, with and without the probe inserted. Thomson scattering has uncomplicated data interpretation, which is independent of the magnetic field, so can reliably measure bulk electron properties. Typical magnetron operating conditions has density $\sim 10^{17}$ m^{-3} and electron temperature < 1 eV for argon plasma measured by the Thomson diagnostic.

[1] P. M. Chung et al, "Electric Probes in Stationary and Flowing Plasmas", Springer-Verlag, Berlin (1975).

[2] F. F. Chen, "Langmuir probe analysis for high density plasmas", Physics of Plasmas 8, 3029 (2001).

[3] P.C. Stangeby, "Determination of Te from a Langmuir probe in a magnetic field by directly measuring the probe's sheath drop using a pin-plate probe", Plasma Physics and Controlled Fusion 37, 1337 (1995).