Measurement of the Electron Energy Distribution Function by Langmuir Probe in an ITER like Hydrogen Negative Ion Source

[1]B. Crowley, [1]D. Homfray, [1]S.J. Cox, [2]D. Boilson, [3]H P L de Esch and [3]R.S. Hemsworth

1.Euratom/UKAEA Fusion Association, Culham Science Centre, Abingdon,. OX14 3DB, UK.
2. Association Euratom/DCU, Dublin City University, Dublin 9, Ireland
3. Association Euratom-CEA, CEA Cadarache, F-13108, St. Paul lez Durance, France

Abstract

The development of a high yield H^- (or D^-) ion source capable of long pulse operation is an essential step towards the realisation of a neutral beam heating system for ITER. In Cadarache, development on negative ion sources is being carried out on the KAMABOKO III ion source (an ITER like source, i.e. a caesiated, filamented, multi-pole arc discharge source). A key feature of the ion source is the separation of the driver region from the extraction region by means of the magnetic filter field. The filter field keeps the electron temperature at the extraction grid is low in order to minimise the destruction of H^- ions through the process of electron detachment ($e+H^-\rightarrow e+H+e$). The cross section for this process increases by 3 orders of magnitude in the electron energy range from 1 to 10 eV. Hence for optimisation of the source it is important to know the electron temperature. To this end a Langmuir probe is used to measure the plasma parameters (T_e, n_e and V_p) in front of the extraction grid. But, the EEDF in low pressure plasmas is generally non-Maxwellian even at the low electron energy range and application of conventional theory can lead to significant errors. In non-Maxwellian plasmas, the electron temperature can be thought of as an effective electron temperature corresponding to a mean electron energy determined from the integrals of the electron energy distribution function (EEDF). Druyvesteyn [1] shows that the EEDF is proportional to $\sqrt{V}\frac{d^2i}{dV^2}$, where d^2i/dV^2 is the second derivative of the probe current-voltage characteristic. However determining d^2i/dV^2 from a traditional Langmuir probe trace using numerical techniques is inherently noisy and generally yields poor results. We have developed a Langmuir probe system based on a method first used 1950's by Boyd and Twiddy [2]. The system measures the second derivative directly.

This paper presents a detailed account of the experimental method, apparatus and software used along with some preliminary results from the KAMABOKO III source including a comparison with conventional probe methods.

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[1] Druyvesteyn, M.J. Z. Phys. 64, p790, 1930

[2] Boyd and Twiddy Proc.Roy.Soc p250 53 part A 1959