Comparison of Spectroscopic and Probe data in a Magnetic Mirror Helium Plasma

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Langmuir probe and spectroscopic diagnostics are used to routinely measure electron temperature and density over a wide operating range in a reconfigured Double Plasma device at University College Cork, Ireland \(^1\). The helium plasma is generated through thermionic emission from a negatively biased tungsten filament confined by an axisymmetric magnetic mirror configuration consisting of two 20 cm long x 3 cm diameter cylindrical stacks of NdFeB permanent magnets that are coaxially positioned on opposite sides of the cylindrical vessel of diameter 25 cm, mounted flush with the vessel walls.

Langmuir probe data fitted with a bi-Maxwellian distribution show temperatures up to several tens of electron volts and densities of order \(10^{16} \text{ m}^{-3}\) to \(10^{18} \text{ m}^{-3}\) can be achieved. The data is consistent with the formation of a confined population of primary electrons which are generated from the thermionic emission of the tungsten filament located within the mirror and a secondary population generated through the ionisation of the working helium gas.

The emission of the plasma is analysed using a Fourier Transform-based Bruker spectrometer with a highest achievable resolution of 0.08 \(\text{cm}^{-1}\). In the present work, the helium emission in the visible range is analysed using the Bruker spectrometer as well as an Ocean Optics USB2000+ dispersive grating spectrometer to investigate the dependence of the spectral intensity data on the density and temperature of the electrons (determined from Langmuir probe data analysis) via the manipulation of the Engineering parameters (plasma current, pressure and bias voltage).

In contrast to previous studies the emission from all strong visible lines ranging from 300 nm to 750 nm are being examined as opposed to the standard lines (667, 706, 728 nm). This allows us multiple combinations of singlet-singlet\(^2\) line ratios that can be used as a density diagnostic as well as multiple singlet-triplet\(^3\) lines that are used as a temperature diagnostic.

This approach of determining plasma parameters is beneficial due to the passive and non-intrusive nature of spectroscopic measurements and is being developed for application as a temperature and density diagnostic on the MAST Upgrade Super-X configuration divertor leg.

\(^1\) PJ McCarthy et al., 30\(^{th}\) ICPIG (2011) Topic B6
\(^2\) Singlet lines in the visible that are being used include 396, 492, 501, 667 and 728 nm
\(^3\) Triplet lines in the visible include 318, 388, 402, 447, 471, 587, 706 nm