Operation of a Microwave Hairpin Probe in a Helicon Plasma Source

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A simple hairpin structure on the end of a transmission line acts as a quarter wavelength resonator. The resonant frequency depends on the permittivity of the surrounding matter. This has been previously used in a variety of low temperature plasmas [1-4] to determine the electron density. In this work we report the use of the probe in a helicon plasma source that has been primarily configured for investigations of performance as a thruster for space applications. The source envelope is a quartz tube 170 mm long and 45 mm inner diameter and is fitted with a saddle coil arrangement for coupling to the helicon modes. It was operated at around 0.1 Pa in argon (16.5 sccm) with absorbed power in the range 200 - 400 W dm\textsuperscript{-3}.

Within the source region the plasma is strongly magnetised (B \sim 50 mT) but several centimetres downstream the field is negligible and the plasma density falls below 10\textsuperscript{14} m\textsuperscript{-3}. The effect of the magnetic field on the permittivity of the plasma must therefore be taken into consideration, at least within in the source [5].

The hairpin method gives effective measurements of the plasma density profile with a positional accuracy of \pm 5 mm. Under the given conditions, at maximum power and field the plasma density in the source reaches 10\textsuperscript{17} m\textsuperscript{-3} at 40 mm inside the quartz tube. The density falls off rapidly outside the source, being 6 \times 10\textsuperscript{15} m\textsuperscript{-3} at 40 mm downstream.


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