Plasma Characterisation for Microwave-plasma Interaction Experiments

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Non-linear effects can occur when an electromagnetic (EM) wave propagates through a plasma. This can cause the formation of plasma oscillations and secondary EM waves transferring energy into the plasma, especially at plasma resonances. Raman and Brillouin scattering are parametric processes where two EM waves are coupled to Langmuir and ion-acoustic electrostatic oscillations respectively, and are relevant to intense laser plasma interactions [1-4]. Brillouin interactions can occur in any plasma below the critical density but are expected to be dominated in plasma below quarter critical density by the faster growing Raman interaction. These interactions can be studied using microwave beams which can reach normalised intensities comparable to those relevant to important laser plasma interactions in tenuous, cool and accessible plasmas, potentially enhancing diagnostic access and hence insight into the non-linear plasma dynamics. Similar dynamics are known to arise in ionospheric experiments using powerful radio waves [5].

Magnetised plasma waves such as the upper and lower hybrid and cyclotron resonances could also be coupled to beat waves. This may be useful in delivering energy in over-dense magnetically confined fusion plasma. For example, in spherical aspect tokamaks, the high plasma density achieved for a given magnetic field means it is difficult to couple energy into the plasma at the lower harmonics of the electron cyclotron frequency where current drive is reasonably efficient. Coupling of two high frequency waves to such magnetised oscillations offer a route to mitigate this difficulty [6,7]. This can also address problems in fusion plasma where the evanescent gap between the antenna and the plasma makes it difficult to introduce lower frequency signals to directly modulate the ions.

To investigate these multi-frequency microwave-plasma interactions a new cylindrical plasma experiment has been constructed at the University of Strathclyde. Two of the planned