Detection of RF Perturbations Using an Ion Beam Diagnostic

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Presently, experiments are underway at the Plasma Dynamics Laboratory at Rensselaer Polytechnic Institute to demonstrate that the techniques developed for heavy ion beam probe diagnostics (HIBP) can be used to measure radio frequency (RF) fluctuations in plasmas. We hope to measure fluctuations in plasma density and magnetic and electric fields. This will provide a direct measurement of the electric and magnetic fields in the plasma during ICRF heating and thereby improve understanding of heating deposition and wave physics. In addition, the field and the density measurements will be used to determine the plasma reaction to the heating experiments. It is expected that the density measurements will be easiest to interpret, while the electric field measurement will be the most difficult to interpret. The diagnostic issues that will be important in taking data at RF frequencies include faster electronics, signal levels, and path effects. We have used a current to voltage amplifier design to measure 0-500 kHz fluctuations in several previous experiments. By reducing the gain and changing some components, a very similar design is capable of operation at RF frequencies. The modified circuit has been tested up to 15 MHz and worked well. The number of beam ions striking the detector plate in one RF period will be too small to obtain good enough statistics for fluctuation measurements, and therefore, averages over many cycles will be required. We expect to be able to achieve millisecond time resolution in the experiments. The global nature of the modes will tend to make path effects important in the HIBP signals. On the other hand, since the beam will take more than one period to cross the plasma, phase shifts may cancel some of these effects. In addition, a path effect term due to $dA/dt$ will be much more important relative to the electric potential than in lower frequency experiments. The initial experimental plan is to do a series of measurements in which a Lithium ion beam passes through an Argon helicon plasma. The helicon plasma was chosen because its high density (of order $10^{19}$ m$^{-3}$) will produce a larger HIBP signal than can be obtained from other small plasmas. The helicon plasma is formed within a solenoidal magnetic field of 1 kG on axis. The plasma is excited by an RF antenna that is a modification of the type used in Boswell’s experiments [1]. The RF power source is presently a 500 Watt, 13.56 MHz generator. From calculation of final trajectories we have determined that 16 to 29 keV Li ions can be used to probe a plasma with 1 kG magnetic field on axis. If the signal levels with a lithium beam are too small, a molecular hydrogen source will be used. For testing the basic operation of the ion beam probe we will use a simple plate detector mounted on the output flange. These preliminary experiments will be used to determine the feasibility of measuring density and magnetic field fluctuations. A second set of experiments using a more traditional HIBP energy analyzer as a detector is also planned. This detector will also be able to measure electric field effects on the probing ions. It will also be less sensitive to UV noise from the plasma.