MEASUREMENT OF ELECTRIC FIELDS IN THE H-1NF HELIAC

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There are a number of laser induced fluorescence techniques which can be used to measure internal plasma electric fields. It is planned to use a technique based on Stark mixing of energy levels in a supersonic beam containing metastable helium atoms to measure radial electric fields in H-1NF. Enhanced values of radial electric field are associated with improved confinement modes in H-1NF and other magnetically confined plasmas.

Electric fields play an important role in many plasma processes. In low temperature processing plasmas strong electric fields are present in the sheaths where ions are accelerated for use in semiconductor etching and plasma assisted thin film deposition. In magnetically confined high temperature plasmas enhanced values of radial electric field are associated with improved energy confinement.

Probe techniques are unsuitable for measuring electric fields in both sheath regions of low temperature plasmas and high temperature plasmas. There are, however, several techniques using laser induced fluorescence (LIF) which are suitable in these circumstances.

One technique involves laser excitation of atoms, for example helium, to Rydberg states which, being hydrogen-like, exhibit the linear Stark effect in the presence of an electric field. The Stark splitting of the Rydberg state can be detected by monitoring a fluorescence transition or by the optogalvanic effect. The latter has been used to measure the electric field distribution in the cathode sheath of a dc glow discharge [1].

Another technique exploits the fact that the transition probability of a forbidden transition is increased due to Stark mixing of the wave functions of closely-spaced energy levels. In helium for example (see Figure 1), laser radiation tuned to the 2^1S-n^1D forbidden transition is used to excite helium atoms in the 2^1S metastable state and fluorescence is observed on the allowed n^1D-2^1P transition. Since the 2^1S-n^1P transition is allowed, Stark mixing between the closely spaced n^1P and n^1D levels causes the excitation transition probability, and as a consequence also the fluorescence signal, to be functions of electric field. The technique is sensitive to smaller values of electric field for larger values of n.

The fluorescence signal is, however, proportional to the density of atoms in the n^1D state. The fluorescence observed when the allowed 2^1S-n^1P transition is excited provides a signal proportional to the n^1D density as a result of collisional transfer between the n^1P and n^1D levels. Thus the ratio of the former fluorescence signal to the latter yields a quantity which depends upon electric field only; for sufficiently small perturbations it is proportional to E^2. This technique has been used to measure the electric field in the cathode sheath of a glow discharge [2]. A similar technique using transitions in the molecule BCl, has been used to measure electric fields in an rf sheath [3], and in the cathode fall of a magnetron discharge [4].

In order to use these techniques to measure electric fields in magnetically confined plasmas, a beam of suitable particles is needed to provide a sufficient particle density. Motional Stark effect diagnostics designed for measuring the q profile in tokamaks have been used to measure the

radial electric field distribution [5,6]. In this case an energetic deuterium or hydrogen beam traverses the plasma resulting in Hα emission which is split into polarised components by the electric field experienced by the moving atoms, which is the combined motional emf field and laboratory frame electric field. By measuring the polarisation of the emitted light in two different directions it is possible to deduce both the *q* profile and the radial electric field profile.

To measure radial electric fields in H-1NF it is intended to use the method of Figure 1. The helium atoms will be in the form of a supersonic beam in order to minimise the motional Stark effect contribution to the perturbing electric field. Nozzle designs for the production of supersonic beams are available in the literature, including ones which incorporate discharges to enhance the metastable content [7].

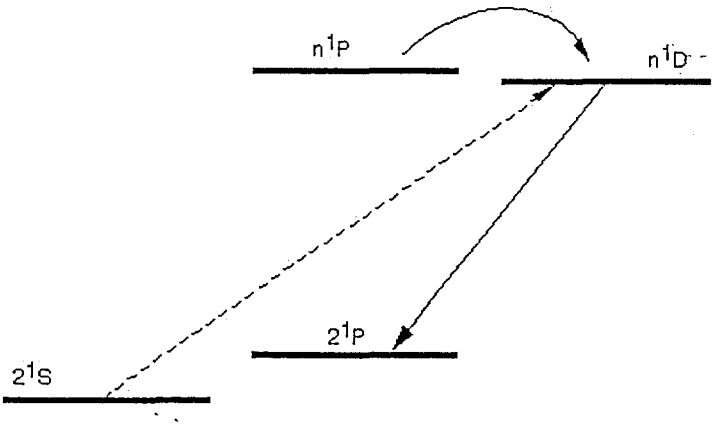

Figure 1 Energy levels and transitions of the helium atom used for the measurement of electric fields by LIF

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