High-resolution laser-induced fluorescence in the pre-sheath of a positively biased probe

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We address the general problem of precision measurements of ion distribution functions in the presheath region of a probe. The goal is to obtain sub-millimeter (Debye length) spatial resolution and bandwidth comparable to the ion-plasma frequency. Even with the large scattering cross section of laser-induced fluorescence (LIF) this resolution is not possible directly because of the limited photon count rate. We report measurements of high-resolution ion flow and density profiles and explore the implementation of auto and cross-correlation functions techniques involving both LIF and small electric field probes to measure the fluctuations and ultimately the transport in the presheath region of a positively biased probe in an unmagnetized DC Argon plasma discharge.

1. Introduction

The detailed nature of the plasma sheath continues to be a topic of intense research, being important both for understanding the plasma boundary as well as the currents collected by electric probes. In particular, the importance of instabilities that may occur in the plasma presheath is now recognized. Direct observation of these instabilities is complicated by the fact that they occur in non-uniform regions of the plasma where the relevant spatial and temporal scales are small. The goal of this work is to develop techniques for making in-situ measurements of ion distribution functions with sufficient spatial and temporal resolution to enable measurement of unstable waves and their effects.

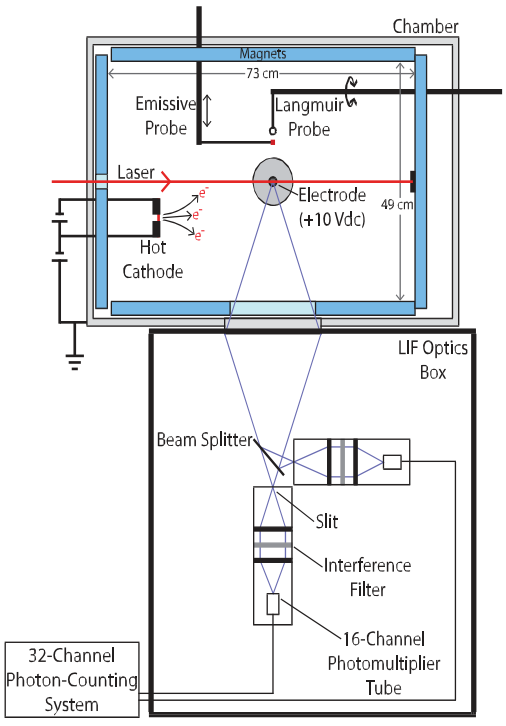

Figure 1 Experiemmental set-up.

2. Experimental set-up

A DC Argon gas discharge in a cylindrical multi-dipole chamber of radius 30 cm and length of 1m is outfitted with a high efficiency imaging light-collection system capable of simultaneously imaging the light from two independent LIF systems onto identical 16 element PMTs connected to a 32 channel photon counting system or to an 120 MHz acquisition system that can time-stamp the arrival of photons in each channel. A schematic of the set-up is shown in figure 1.

By computing auto and cross-correlation functions it is possible to measure power spectra with a photon statistics noise floor that can be improved by obtaining large ensemble averages. Stationary conditions are obtained by feedback control of plasma parameters.

Initial results demonstrating high spatial resolution LIF of the ion distribution functions in the vicinity of a positively biased probe have already been obtained [1]. Preliminary results of high time resolution measurements will be presented and discussed.

3. Acknowlegements

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3.1 References

[1] R. Hood, B. Scheiner, S. D. Baalrud, M. M. Hopkins, E. V. Barnat, B. T. Yee, R. L. Merlino, and F. Skiff, Physics of Plasmas 23, 113503 (2016).