Dust as Fine Electrostatic Probes for Plasma Diagnostic

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Here we present a novel use of small dust for plasma diagnostic in the Inertial Electrostatic Confinement (IEC) plasma and sheath of a planar rf-discharge. Because the dust charge is a function of multiple plasma parameters, and the dust charge adjusts itself upon changes in plasma conditions instantaneously, dust particles are an ideal diagnostic tool. The main advantage of such diagnostic system is its simplicity. This is because the key measurements in such diagnostic system are the position of the dust particle or its motion following a perturbation. This technique only requires access to the discharge chamber, dust particles, a laser to illuminate them and a camera to capture the motion of the dust.

The use of electrostatic fields to confine fusion plasma was invented by Farnsworth in the 1960's [1]. Nuclear fusion in such case can be achieved by injecting ions into a spherically or cylindrically symmetric electrostatic potential well where ions converge to the centre, resulting in a core of increased ion density. The technique where particles are ensnared in an electrostatic well is called IEC and is being used for fusion with large neutron counts readily being achieved. The profile of electrostatic potential well is a key factor for the whole process, but the electrical potential in the plasma in such devices has not been mapped properly. Analyzing the trajectories of charged dust particles has given useful quantitative information about the shape of the potential well in the ion beam and in the future promises to be able to give qualitative measurements of the electric field as theories of the IEC and the dust charge develop.

When plasma comes into contact with material surface, a layer of net space charge called *plasma sheath* establishes itself between the surface and the bulk plasma. Despite decades of investigation in dc and rf sheaths, there are still uncertainties about aspects of sheath structure which remains a topic of contemporary theoretical and experimental interest. We report here simultaneous measurements of sheath electric field and dust charge using various sizes of dust particle.

It is well known that dust of different sizes is levitated in positions within the sheath corresponding to their values of non-uniform sheath electric field [2]. By measuring the equilibrium position and resonant oscillation frequencies of particles of various sizes, the values of E and ZE` were obtained as a function of position within the sheath from which Z can also be determined as a function of position within the sheath. The E profiles obtained have been compared with sheath models. It was found that electric field is indeed linear in the middle of the sheath for a wide range of pressure. A non-linear dependence for E in the region near sheath boundary was found for the pressures under 50 mTorr.

References

1. T. Farnsworth, U.S. Patent No. 3 258 402 (1966).
2. A.A. Samarian, S.V. Vladimirov, Phys. Rev. E **67**, 66404 (2003)