Levitation of Dust in a Magnetised RF Plasma

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Dust contamination in plasmas remains a significant problem in fusion machines. Obtaining the plasma parameters, in order to understand dust transport, in a magnetised plasma is a challenging problem. Preliminary results of dust levitation in a magnetised RF plasma show a variation of dust height with increasing magnetic field strength. Emissive probe measurements exhibit a rapid increase in plasma potential followed by a plateau region with increasing magnetic field. Further work, using optical imaging and dust oscillations to provide the plasma parameters and dust charge, will be presented at ICPIG.

1. Introduction

Magnetised dusty plasmas naturally occur in space, fusion and industrial plasmas. Whether in planetary rings, tokamaks, or magnetrons, basic information about dust continues to be elusive. In ITER an estimated 1 ton of dust will be produced per year [1], reducing energy production and initiating disruptive instabilities.

2. Experimental Setup

2.1. Plasma Reactor

Ar plasma is generated at 13.56 MHz in a parallel plate capacitively coupled cell. The Al chamber, 14 cm sq by 7.5 cm deep, is placed inside a uniform magnetic field (to within 0.3 %) by a Helmholtz coil. The 4 cm diameter lower driven electrode is located 4.5 cm from the upper transparent ITO grounded electrode. RF plasma is generated by a Dressler Cesar 136 supply coupled through a matching unit to the powered electrode. Melamine Formaldehyde particles (10 µm diameter) were then levitated, in the plasma, balanced by the sheath electric field and gravity.

2.2. Diagnostics

The dust is illuminated by a laser system that generates a vertically scanning laser sheet. A 300 mW beam, 1 mm diameter at 532 nm, is enlarged to 4 mm by a beam expander. This is transformed into a laser sheet by cylindrical lenses. A system of two rotating mirrors [2] allows vertical adjustment of the laser sheet within the chamber. The light scattered by the dust particles is recorded by a Photron FASTCAM ultima APX camera. An emissive probe, with 50 µm diameter thoriated tungsten wire, was used to measure the plasma potential using the floating potential method in strong emission [3].

3. Results and Conclusions

As shown in Figure 1 at lower pressures (2 Pa) the dust falls with increasing magnetic field. At higher pressures (6 - 10 Pa), the dust falls and then rises with increasing magnetic field. At field strengths greater than 0.04 T, the dust levitation height does not change. This seems to coincide with the plasma potential measurements, which increase up to 0.08 T and then varies weakly with magnetic field. Recently, theoretical studies have shown that a magnetic field changes the dust surface charge [4]. Furthermore, the plasma parameters and electric field are expected to change with increasing magnetic field. This will also alter the dust charge and levitation height. Further experiments using a novel line ratio imaging technique to obtain electron density and temperature maps, at different field strengths, are planned. Also, dust oscillation observations, combined with emissive probe plasma potential measurements, will be used to obtain the dust charge and electric field at different field strengths. These will be presented at ICPIG.

4. References

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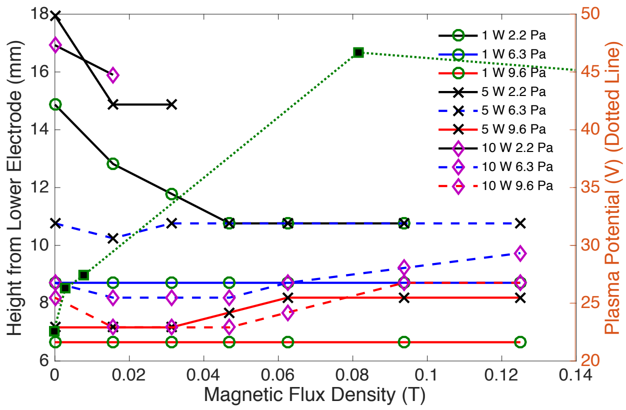

Figure 1 - Change in dust levitation height with magnetic field. The plasma potential measurement at 0.25 T is not shown on the figure.