Unraveling Electrical Fields, Ion Densities and Dust Particle Charge in an RF Plasma Sheath by Single Particle Experiments under Hypergravity and Microgravity Conditions

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Abstract

The sheath of RF plasmas is studied intensively by many groups in the world. However, independent diagnostics that determine the electrical field and the ion density are scarce. When dust particles are inserted in the plasma, they will be suspended in the sheath by an equilibrium of the electrical force and gravity. The charge of these particles is unknown and very difficult to measure. In our experiments, we have exposed the plasma to hypergravity by implementing it in a centrifuge. Furthermore, we have applied microgravity by implementing the experiment in an airplane and conduct parabolic flights. In this way, the equilibrium position of the particle is determined as a function of apparent gravity, in the range 0-10 g. Also, the RF power was modulated, and the resonance frequency was recorded. By combining these experimental findings with the equation of motion of the particles, the Poisson equation, and the assumption that the sheath is collisional, the electrical field, the particle charge and the ion density can be calculated in a self-consistent way. It appears that the sheath is slightly non-linear.