

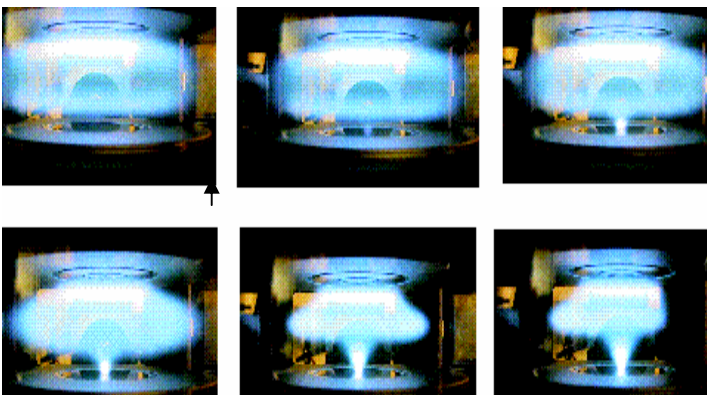


The adaptive electrode: complex-plasma manipulation (how to move particles using RF)

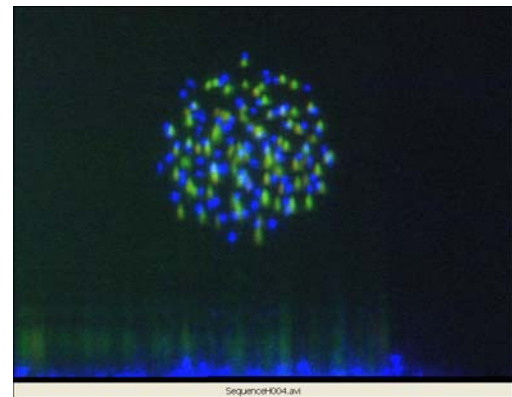


This project is an experimental study on the nature, the dimensions and the time scale of the perturbation introduced by RF biasing of areas adjacent the plasma. The theoretical analysis of the RF sheath, and of the charging of particles in it, has disclosed a levitation force on particles, which is substantially different from the DC one often used in complex plasmas modeling. Experimentally the RF heavily-loaded sheath presents characteristics completely different from the normal case $V_{RF}=V_{DC}$. Regions of extra ionisation and complex electrostatic structures arise in which it is possible to find uniform gravity compensation in 3-D. This allows for the first time the formation of 3-D clusters under gravity condition.

This work presents a new plasma configuration with localised RF on the boundary, useful for particle manipulation. The electrostatic structure have been visualised by nano-particles grown in the plasma and by injected microparticles.



The glow emitted above a pixel kept at $V_{DC}=0V$ and RF driven ($V_{RFpp}=0, 47, 47, 60, 100, 140V$ respectively). Upper electrode voltage $V_{RFpp}=250V$ $P=81Pa$. PKE chamber.



A cluster of 70 particles. The green-red picture shows $2.3 \times 1.7 mm^2$. The same cluster, observed at 90° , is shown by the blue dots.

We have theoretically proved, and experimentally demonstrated, that, without applied DC, particles of a large range of diameters, can be collected, transported and stored in a flexible and reversible manner. Although anode-like effects are clearly visible the particles do not fall on the electrode. An obvious application is the cleaning of the plasma. The effects here described are independent of the plasma chemistry, they have been achieved in electropositive and electronegative plasmas. They are also independent of the nature of the return pattern of the RF current as they were observed in experiments with metal and floating electrodes/chambers.

The particle can find equilibrium positions in volumes where three dimensional clusters form. By a fine adjustment of the RF applied to a DC-grounded pixel we were able to control the number of particles in the cluster and also its shape. At low pressure a poloidal motion sets up. A three-dimensional simultaneous visualization technique has been used for recording vibrations and structure transitions.

In the equilibrium positions the vertical confinement is provided by the electric field of double layers/striations combined with the suitable conditions for the charging. The analysis of the structures will clarify whether the horizontal confinement is due to plasma pressure or by internal forces among the cluster component (Leonard-Jones like potential) or by ion drag.

References: 'Complex-plasma manipulation by radiofrequency' B. M. Annaratone, T. Antonova, D. D. Goldbeck, H. M. Thomas and G. E. Morfill, Plasma Physics and Controlled Fusion, EPS invited papers 2004