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Experiments on Orbiting dust particles in Plasma Multi-rings

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Experiments on Orbiting dust particles in Plasma Multi-rings

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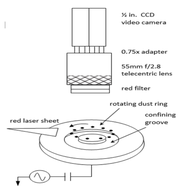
Abstract

A grooved rf electrode was used to generate an argon plasma. Dust particles were dropped into the plasma and settled in the plasma sheath several millimeters above the electrode. The dust particles formed various sized multi-rings (1-4 rings) and had a tendency to orbit about the center of the electrode through the rings. The angular velocity (ω) was calculated for particles in each section of the ring. It was found that as the number of rings in a section (therefore the mass) increased, ω decreased which agrees with the conservation of angular momentum. The pressure was also varied and it was found that as pressure increased, ω decreased.

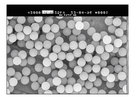
Experiment

- Dust is trapped in the ring shaped plasma sheath which forms above the electrode.
- A laser sheet illuminates the dust particles
- Overhead camera records the multi-ring dynamics

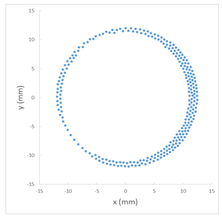


Experimental Parameters

- Neutral Pressure 17.5 mtorr Ar
- rf power ~4.5 W
- rf electrode diameter 89 mm
- Dust particles: microspheres
  diameter = 8.94 ± 0.09 μm
  mass = 5.65 x 10^{-13} kg
- Video: 2048 frames of data at 15 frames/second
  256 x 1024 pixels



Multi-Ring

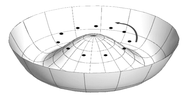


- Multi-ring system is shown
- Dust particles orbit with different angular velocities depending on the multi-ring section

Force diagram

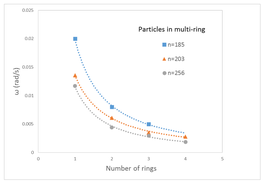
a) Forces acting on a dust particle

b) Plasma sheath with dust particles



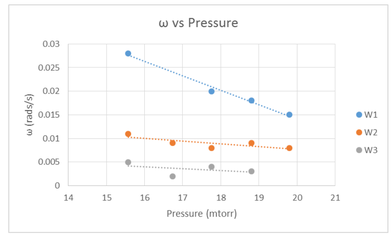
ω vs Ring Section

- Data from three different multi-ring systems is shown
- Data shows that as the number of particles in the ring section increases, angular velocity decreases.
- Data is consistent with conservation of angular momentum



ω vs Pressure

- Data from one multi-ring system is shown
- Increasing the pressure narrows the potential well which decreases the inter-particle spacing
- Data shows that as the pressure increases the angular velocity tends to decrease

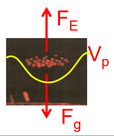


Plasma

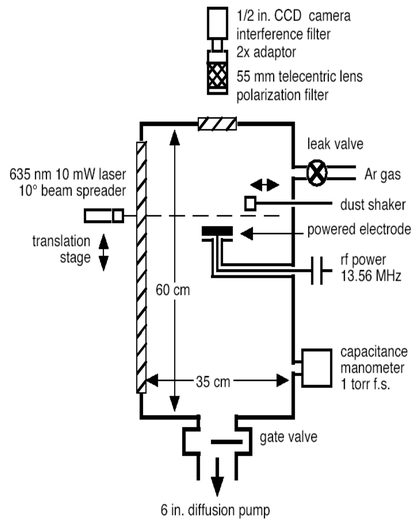
- Glowing gas composed of positively charged ions and electrons.
- Charged particles in the plasma interact with each other exhibiting collective effects.

Dusty Plasmas

- Dust particles are found in many types of plasmas.
- The particles carry a negative charge.
- The dust interacts with electric fields, magnetic fields, and gravity.

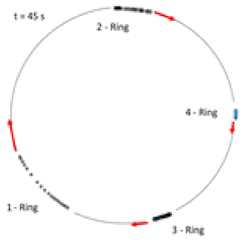


Schematic of Dusty Plasma Device



Dust Particle Rotation

- The time-lapse motion of a particle in each section of the ring is shown below for t = 45 s
- The diagram shows that the lower the number of particles in the section, the faster the rotation in the given time
- The particle angular velocity in each section of the ring is consistent with the conservation of angular momentum
- Arrows have been added to show the direction of rotation



Further Study

- Further analysis of individual particle motion in the sheath structure
- Analysis of the ion drag force generated by the flow of ions into the anode interacting with the dust particles