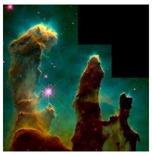

Dust Charge Measurement and Wave Excitation in a RF Discharge Dusty Plasma

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Abstract

The axial plasma potential and electric field profile in front of a grounded plate in a rf discharge plasma have been measured by using an emissive probe in order to determine the charge of dust particles levitating just above the plate. The dust charge is calculated from the force balance equation between the gravitational and the sheath electrostatic force at the levitation height for different Ar gas pressure and compared with the values obtained from OML theory. The average dust charge is found to be of the order of 10^4e. Shock/solitary wave propagating in a 2D dust crystal lattice have also been excited.

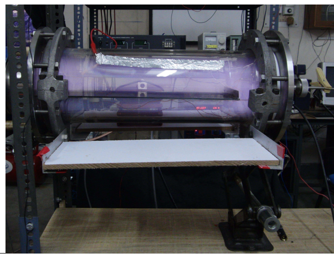
Introduction

- Dusty plasma consisting of electrons, positive ions and charged microparticles occur in various space environments as well as in laboratory discharges [1].
- Dust particles usually attain high negative charges (10^3 – $10^4 e$) in laboratory discharges [2] and exhibits several remarkable features like strong coupling effects, plasma crystal formation etc. The relevant time scales of dust dynamics ~ milliseconds to seconds which allows direct observations using video cameras [3].
- Charging of dust grain in a plasma is an important phenomena which significantly influences the formation of ordered crystal structure, dust levitation and many collective phenomena. In the present work dust charge is determined in a plasma sheath by measuring the axial plasma potential and electric field profile above a grounded plate using an emissive probe.
- The formation of 2D dust crystal lattice and propagation of shock and solitary waves through lattice have also been observed.

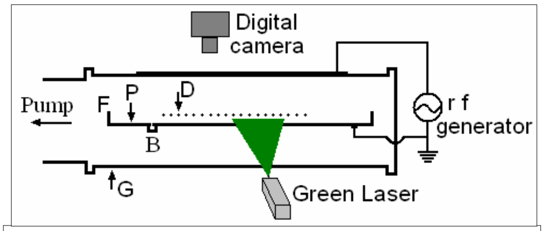
Experimental setup and procedure

- Cylindrical glass chamber, 50 cm in length & 15 cm in diameter
- Rf power (13.56 MHz) ~ 2-20W for producing Argon discharge
- Argon working pressure ~ (10^{-3} to 10^{-2}) mbar
- Silica particles: 5μm in diameter
- Diagnostic tools….

→ Cylindrical Langmuir Probe & emissive probe (for determination of plasma parameters)
→ Green Laser sheet (532 nm) for illuminating particles
→ High speed digital camera for recording particle movement.



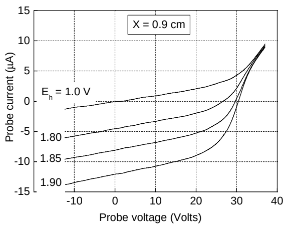
Photograph of the chamber with discharge

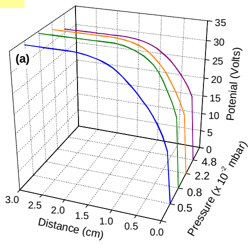


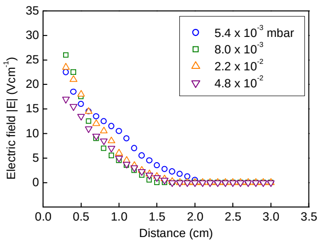
Schematic diagram of the setup. G: glass chamber, P: conducting plate, B: Buzzer, F: Fence, D: dust Particles.

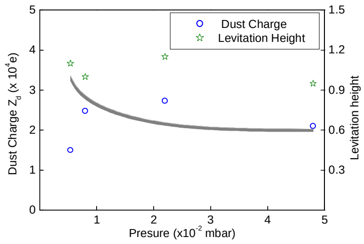
Experimental results

Dust charge measurement









At the levitation height

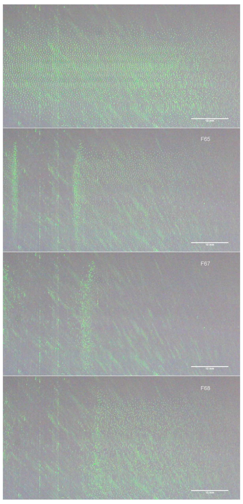
$$Z_d e E(X_0) = M_d g$$

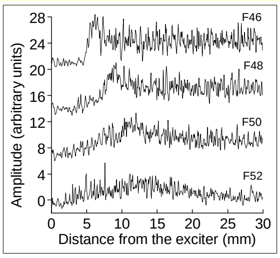
Orbit motion limited theory

$$\exp\left(-\frac{e\phi}{T_e}\right) = \left(\frac{m_e T_i}{m_i T_e}\right)^{1/2} \left(1 + |Z_d| \frac{n_d}{n_e}\right)(1 + e\phi / T_i)$$

$$Q_d = 4\pi\varepsilon_0 a\phi$$

Shock wave excitation



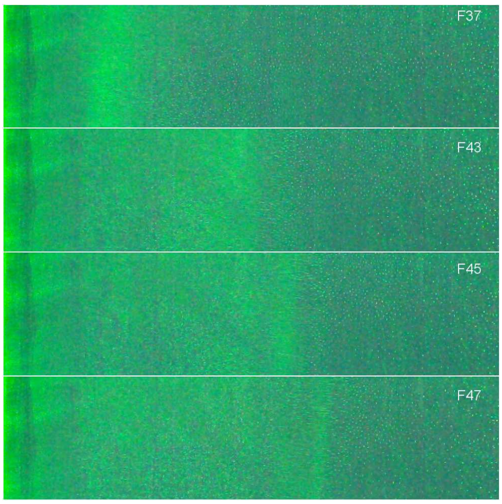


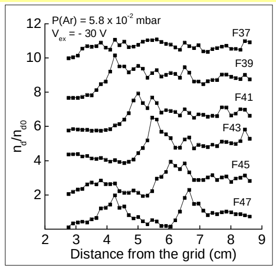
Measured wave velocity is ~ 4.5cms^{-1} corresponding to -20V excitation.

$$C_{DL} = \left(\frac{Q^2 e^{-k}(k^2 + 2k + 2)}{4\pi\varepsilon_0 m_d k \lambda_d}\right)^{1/2}$$

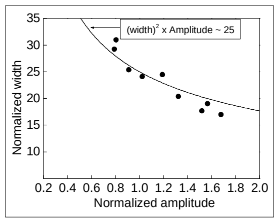
The dust lattice speed in this case is 3.19 cms^{-1}. The Mach no. of the observed lattice shock wave is 1.4 [3,4].

Solitary wave excitation





Measured wave velocity ~ 5.45 cms^{-1}



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