Seminar

Institute for Plasma Research

Title : Experimental Investigation of Complex Plasma Crystals in a DC Glow Discharge Plasma

Speaker: Mr. Hariprasad MG
Institute for Plasma Research, Gandhinagar

Date : 26th April 2022 (Tuesday)

Time : 03.30 PM

Venue : Online - Join the talk:
https://meet.google.com/chx-gewx-hri
(Preferably open the link using "Microsoft-Edge" or "Mozilla-Firefox)

Abstract :

In this talk, I will report on my experimental investigations of the dynamics of finite two- dimensional strongly coupled complex plasma crystals in an electrostatic trap. A complex (dusty) plasma comprises highly charged dust grains embedded in a pool of electrons, ions, and neutral atoms/molecules and is a versatile model system to explore various fundamental collective and non-equilibrium phenomena. A complex plasma system exhibits different phases depending on the value of the coupling parameter (□) - the ratio of the potential energy to the kinetic energy of the system. Conventional plasmas have □<1 and are in the weakly coupled gaseous state. As □□increases beyond 1, the dust component of the complex plasma can evolve into a liquid phase or eventually acquire a crystalline phase. In the past, complex plasma crystals were explored in RF glow discharge plasmas, since producing them in a DC glow discharge has proved to be experimentally challenging. I will report on our successful attempt at creating the first-ever complex plasma crystal in the Dusty Plasma Experimental (DPEx) device in the background of a DC glow discharge plasma [1]. The plasma crystal remains stable over a range of discharge parameters for a long duration. Plasma crystal is characterized by a host of diagnostic tools such as pair correlation function, Voronoi diagram, Delaunay triangulation, Langevin dynamics, etc. The crystal parameters are sensitive to discharge parameters, dust particle size, and the number of dust particles. The stability and viscoelastic nature of the crystal structure have been further investigated under the perturbation of a single test particle [2]. In another set of experiments, the formation of a complex plasma cluster and its thermodynamic nature have been explored as a function of the cluster configuration [3]. Controlled experiments have also been carried out to examine the nature of phase transition in a DC-produced complex plasma crystal. The crystalline structure has undergone a first-order phase transition when the neutral gas pressure is reduced infinitesimally [4]. In some other experiments, the complex plasma crystal melted into a cold-fluid state through an intermediate non-equilibrium crystal-fluid co-existing phase when the working pressure reduced gradually [5,6]. These experimental findings may be of interest in a wide range of inter-disciplinary fields, where researchers are exploring strongly coupled systems, their phase behavior, and non-equilibrium characteristics.

References:

1. “Experimental observation of a dusty plasma crystal in the cathode sheath of a DC glow discharge plasma”, Hariprasad et al., Phys. Plasmas, 25, 123704 (2018).
2. “Experimental investigation of test particle induced micro-structural changes in a finite two-dimensional complex plasma crystal”, Hariprasad et al., Phys. Plasmas 26, 103701 (2019).
3. “Experimental observation of a first-order phase transition in a complex plasma monolayer crystal”, Hariprasad et al., Physical Review E 101, 043209 (2020).
4. “Thermodynamics and self-organization of strongly coupled Coulomb clusters: An experimental study”, Hariprasad et al. Phys.Plasmas 28, 073702 (2021)
5. “DPEx-II: a new dusty plasma device capable of producing large sized DC coulomb crystals”, Saravanan Arumugam, et al., Plasma Sources Sci. Technol.30 085003 (2021).
6. “Non-equilibrium Crystal-Fluid Phase coexistence in Strongly Coupled complex Plasma”, Hariprasad et al., under communication in Nature Sci. Reports.