Seminar

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Institute for Plasma Research

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Title: Experimental Study of a Quasi two-dimensional Complex Plasma

Speaker: Ms. Swarnima Singh

Institute for Plasma Research, Gandhinagar

Date: 04th August 2023 (Friday)

Time: 3:30 PM

Venue: Seminar Hall, IPR

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Abstract

Dusty plasma or Complex plasma is an extraordinary form of matter characterized by its composition primarily consisting of solid particles ranging in size from micron to submicron dimensions, commonly referred to as "dust", when present alongside other plasma constituents such as electrons, ions, and neutrals. Under laboratory conditions, these particles get highly charged and self-organize themselves, forming a strongly coupled system. The study of such dusty plasma systems offers an opportunity to explore phenomena found in two-dimensional (2D) solids and liquids at the kinetic level, using relatively straightforward optical diagnostic techniques on reasonable timescales. Due to their inherent versatility, dusty plasmas have emerged as a prominent model for atomic crystals, enabling in-depth investigations of various phenomena related to collective behavior, hydrodynamics, plasma physics, statistical mechanics, and condensed matter physics. In this talk, four such ubiquitous phenomena in 2D, namely structural phase transitions, existence of a triple point, dynamical rearrangement and self-sustained phase coexistence will be discussed. These have been studied in the past in other physical systems such as colloids but their experimental demonstration have remained elusive in a 2D complex plasma crystal. The experiments are performed in the Dusty Plasma Experimental-II device and the critical underlying factors responsible for formation of afore mentioned phenomena in dusty plasma are explored and identified. For the first set of experiments, a structural phase transition is demonstrated in a 2D monodisperse complex plasma by mitigating the effects of mode-coupling instability and the inherent particle-wake non-reciprocal interaction. The different geometric topology in a dust system is characterized using the local bond-order parameter and the static structure factor. Subsequently, the effect of the initial dust density on the transition sequence of a 2D dust crystal is studied and the emergence of a "Triple Point" state above a density threshold is identified. This state exhibits square, hexagonal, and liquid regions, each characterized by different types of oscillations. Additionally, a novel technique for adjusting the radial confinement of the dust without altering the discharge conditions will be explained, leading to the formation of buckled monolayers and square lattice structures. This state is further characterized by dynamical structural rearrangements resulting from the heterogeneous cooperative motion of dust particles. Finally, the formation of a self-sustained 2D solid-liquid coexistence state will be showcased, originating in the system due to the onset of the Schweigert instability. The experimental findings hold potential interest for a wide range of interdisciplinary fields where 2D systems and their structural and dynamic properties are of crucial importance.
