Seminar

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Institute for Plasma Research

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Title: Complex Plasma: Studies of Microparticle Charge, Drag Force and Associated Non-Linear Phenomena

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Date: 27th July 2023 (Thursday)

Time: 3.30 PM

Venue: Seminar Hall, IPR

Abstract

Complex plasma or dusty plasma is a plasma, consisting of small solid particles of typical size from a few nm to mm scale in diameter in plasma environment. Some of the known dusty plasma phenomena observed are planetary rings of planets (e.g., Saturn rings), comet tails, interstellar clouds, fusion reactors (Tokamak and Stellarator), and contamination in semiconductor industry. The presence of even a tiny number of dust particles in the microelectronics industry or in fusion reactors has become an urgent issue. Dust charge and Debye screening length are two important parameters of dusty/complex plasmas because they influence not only the Coulomb coupling parameter, but also the transport of dust grains in electric and magnetic fields, and interaction with nearby dust grains.

Current research involves specific contributions in dusty plasma mainly focused on magnetized dusty plasma. Firstly, one of the primary objectives is plasma characterization of novel asymmetrical design of Dusty Plasma Experimental (DPEx-II) setup, which is used for observation and study of dust crystal formation. Three different probe diagnostics such as Langmuir Probe, Emissive Probe and double Langmuir Probe is used to find the plasma parameters under varying experimental parameters like DC voltage, vacuum pressure, temporal and spatial resolutions etc. Secondly, sheath structure near emissive wall/probe is studied in presence of dust particles through numerically. The plasma-electrode/wall interactions are studied by the potential of the sheath structure, which influences the electron and ion interactions with the boundary as well as electrode/wall effects on ambient plasma properties. Virtual cathode is one of the phenomena that occurs near the emissive wall/electrode in the sheath structure. To observe and explain the behaviour of virtual cathode in the presence of dust particles, a novel mathematical model has been devised. Virtual cathode is observed in dusty plasma at critical wall temperature (2494 °K), which is significantly higher than in a plasma system.

Lastly, the charged dust particles collective effects result in the production of a dust crystal-like structure, which is of importance in physics, chemistry, and materials science. Experiments have shown that dust crystals grow in plasma with and without the application of an external magnetic field. However, there is a limitation of theoretical study on the production of dust crystals in plasma. Hence, a new mathematical model is proposed with magnetic field and validated with COMSOL simulation. The behaviour of charge dust particles in the presence of a magnetic field (***B***) up to 6 T has been studied using numerical and computational methods. Simulating charged dust particles in the presence of ***B*** is done using the COMSOL Multiphysics software. Interaction of charged dust particles are measured from the scattering cross-section parameter derived from the mathematical modelling and plotted with varying ***B***. In both numerical and computational analyses of charged dust particles, it is proven that the scattering cross-section reduces as ***B*** increases. Furthermore, crystal like structure formation is observed at higher ***B*** and the results are backed up by previous experiments.