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 : 22nd January 2021 (Friday)

Time : 3:30 PM

Online link: https://meet.ipr.res.in/Hariprasad_synopsis

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 of 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 exhibits different phase states depending on the value of Γ - the ratio of the potential energy to the kinetic energy of the system. Conventional plasmas have Γ<1 and are in the weakly coupled gaseous state. As Γ increases beyond 1 the dust component of the complex plasma can evolve into a liquid state or eventually acquire a crystalline state. In the past, complex plasma crystals have been mainly explored in RF glow discharge plasmas since producing them in a DC glow discharge have 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. The plasma crystal is found to be stable over a range of discharge parameters for a long duration. I have characterized the plasma crystal using a host of diagnostic tools including pair correlation functions, Voronoi diagrams, Delaunay triangulation, Langevin dynamics, etc… The crystal is found to be sensitive to discharge parameters, dust particle size, and the number of dust particles. The stability and visco-elastic nature of the crystal structure have been further investigated under the perturbation of a single test particle. In another set of experiments, the formation of a complex plasma cluster and its thermodynamic nature has been explored as a function of the cluster configuration. Controlled experiments have also been carried out to examine the nature of phase transition in a DC produced complex plasma crystal. The crystalline structure is found to undergo a first-order phase transition when the neutral gas pressure is reduced infinitesimally. This is further confirmed by the existence of a hysteresis in the Coulomb coupling parameter as a function of the neutral gas pressure. In some of the other experiments, the complex plasma crystal is seen to melt into a cold-fluid state through an intermediate non-equilibrium crystal-fluid co-existing phase when the working pressure is reduced gradually. Our experimental findings may be of interest in a wide range of inter-disciplinary fields, where researchers are exploring two- dimensional structures, their phase behavior, and their non-equilibrium characteristics.