Experimental Observation of Coulomb Screening and Coulomb Acoustic Wave in Nanodusty Plasmas

Bidyut Chutia[1*], K. Avinash[2], S. K. Sharma[1] and H. Bailung[1]

Affiliation: [1]Institute of Advanced Study in Science and Technology (IASST), Paschim Boragaon, Guwahati-781035, Assam, India
[2]Sikkim University, Tadong-737102, Gangtok, Sikkim, India
**Present address: Centre of Plasma Physics-Institute for Plasma Research (CPP-IPR), Nazirakhat, Sonapur-782402, Kamrup (M), Assam, India*

E-mail: bidyut.chutia.jist@gmail.com

Abstract

A nanodusty plasma is composed of electrons, ions and nanometer sized dust grains. A large volume nanodusty plasma medium is achieved in laboratory using reactive discharge of argon and acetylene gas mixture. Such type of plasmas can result in a highly dense dusty plasma where the ratio of dust density to ion density i.e., Havnes parameter becomes very large, $P \gg 1$. Due to high dust density, the nanodust particles float at a small potential resulting in a reduced average dust charge. In nanodusty plasmas, self-excited dust density waves dominate the cloud dynamics in most of the experimental scenarios. The measured wave properties are used to estimate spatially resolved plasma parameters and dust charge in such an exotic environment up to great accuracy. It has been shown theoretically by Avinash et al. [1],[2] that in high dust density regime, dust particles screen each other not by usual Debye screening but by a new screening mechanism called "Coulomb Screening". This is shown to cause dust charge reduction. A characteristic scale length for "Coulomb screening" is obtained. It is shown that "Coulomb Screening" gives rise to a new acoustic mode called "Coulomb acoustic mode" in high density nanodusty plasma. In this particular work, the observations and results of an experiment [3] on the propagation of a self-excited dust density wave under strong Havnes effect will be presented based on these theoretical predictions. The experiment is performed in a vertically extended, highly dense nanodust cloud which is produced by using rf discharge of argon-acetylene gas mixture. The dust density wave appears spontaneously in the medium at a suitable set of discharge parameters. For the parameters of the experiment, the Coulomb screening dominates over the Debye screening. The dispersion relation is experimentally measured and compared with a theoretical dispersion which includes Debye as well as Coulomb screening. Based on this comparison the experimentally observed mode is identified as the "Coulomb Acoustic mode". Average dust charge and other plasma parameters are also estimated.

References:

[1] A new acoustic-like mode in an unmagnetized dusty plasma, Phys. Plasmas **7**, 2763 (2000).
[2] Effect of charge reduction on shielding in dusty plasmas, Phys. Plasmas **10**, 2663 (2003).
[3] Spatiotemporal evolution of a self-excited dust density wave in a nanodusty plasma under strong Havnes effect, Phys. Plasmas **28**, 123702 (2021).

Paper Code:

Paper Code	EP (Exotic Plasma (Includes Dusty Plasma))
Oral/Poster	Oral