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Seminar

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Institute for Plasma Research

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Title: Excitation of non-linear waves and instabilities in a flowing dusty plasmas

Speaker: Mr. Krishan Kumar
Institute for Plasma Research, Gandhinagar

Date: 12th December 2023 (Tuesday)

Time: 03:30 PM

Venue: Seminar Hall, IPR

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Abstract

Plasma flow is a common condition in astrophysical [1] as well as laboratory plasmas [2]. The presence of stationary objects in the path of flowing plasmas results in the excitation of various fascinating structures like bow shocks, solitons, wakes, and more. Flow-induced instabilities like Kelvin-Helmholtz instability and Rayleigh-Taylor instability *etc.* also arise in flowing plasmas. In order to examine some of these spectacular phenomena, laboratory experiments are conducted using flowing dusty plasmas. Dusty plasma consists of micron or sub-micron-sized charged particles, electrons, ions and neutrals and has rich collective dynamics. The experiments are performed in the Dusty Plasma Experimental (DPEx) device in which a DC glow discharge Argon plasma is formed in between a circular anode and a grounded tray-shaped cathode. A dusty plasma is created using kaolin particles and flow is made in the dust fluid ranging from subsonic to supersonic using different techniques. When the dust fluid flow is generated over a charged object with a subsonic speed, it produces typical wake patterns, whereas a slightly supersonic flow triggers the formation of different structures in the fore-wake region known as precursor solitons [3]. Excitation of this fore-wake phenomenon using two charged objects leads to the interaction of precursor soliton with wake structure in between two charged objects. After the interaction soliton continues to propagate with higher amplitude and velocity in the same direction whereas the width of the soliton decreases. The decrement of distance between two charged objects results in the trapping of wave between them. The experimental findings of the interaction of precursor soliton with wake structure and trapping of wave are qualitatively compared with the numerical model of the forced-KdV equation with two sources. The cylindrical (or spherical) precursor solitons get excited when the dust fluid flows over a cylindrical (or spherical) charged object with a supersonic speed and study the propagation characteristics of these solitons with dust fluid velocity and strength of the charged object. A molecular dynamics simulation is performed to provide theoretical support for experimental findings. The study of the interaction of a dust acoustic soliton with a potential barrier is carried out and found that the soliton reflects after interacting with the potential barrier. The modified-KdV equation is derived and numerical results obtained from the equation are found to be in good agreement with experimental observations. The study of Kelvin-Helmholtz instability in flowing dusty plasma is also carried out in which a shear is generated in the dust fluid flow and a vortex is formed at the interface of two layers of the fluid. Molecular dynamics simulation is also carried out to support experimental observations.

1. Meyer, Eileen T., *et al.*, Nature 521.7553 (2015): 495.
2. Drake, Glendinning, *et al.*, Phy. Rev. Letters 81, 2068 (1998)
3. Jaiswal *et al.*, Phy. Rev. E 93, 041201 (2016)
4. Krishan Kumar *et al.* phy. Plasmas 29, 123703 (2022)
5. Krishan Kumar *et al.* phy. Plasmas 28, 103701 (2021)
6. Krishan Kumar *et al.* Scientific Reports 13:3979 (2023)