Seminar

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Institute for Plasma Research

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Title: Nonlinear waves and chaos in different plasma systems

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Date: 03rd January 2025 (Friday)

Time: 10.30 AM

Venue: Seminar Hall, IPR

Abstract

Nonlinear ion acoustic waves excited by charged space debris objects in the ionospheric plasma have been studied using a forced KdV equation where effects of the debris are interpreted in the forcing function. Different accelerated solitary wave solutions of the forced KdV equation have been derived for various forcing functions. As an extension to (2+1) spatiotemporal dimensions with inclusion of static dust cloud in the ionosphere, we have derived a forced KPII equation that governs the dynamics of dust-ion acoustic waves excited by the charged debris. Exact accelerated and novel curved solitary wave solutions of the forced KPII equation have been derived. Next, we have considered the presence of ambient magnetic field in the ionosphere giving rise to excitations of magnetosonic waves by the space debris. The nonlinear evolution of slow and fast magnetosonic waves has been studied within the framework of a Hall MHD model to derive a forced KPI equation and its accelerated lump wave solutions. In order to interpret electron inertial effects in our formulation, we have, further, implemented an extended MHD model which yields a forced KPI equation for slow magnetosonic waves in the entire parameter space and a large region in the parameter space for the fast magnetosonic waves. A forced KPII equation governs the dynamics in the remaining small region of the parameter space for fast magnetosonic waves. The electron inertial effects are found to be crucial only for nearly perpendicular propagation of fast magnetosonic waves. All the nonlinear solitary wave solutions are pinned in nature, i.e. they move with the same velocity as the space debris objects, and can be detected using various ground-based sensors providing indirect signatures of the debris.

In addition, we have modeled the excitations of high frequency electrostatic drift waves with the derivation of a novel third order nonlinear equation. This is accompanied with a detailed study of the linearized dispersion relation. Different exotic solutions of the nonlinear equation are explored using certain techniques. Finally, chaotic evolution of nonlinear magnetic fields in flowing MHD plasmas has been studied with help of second order coupled nonlinear equations. A quasi-periodic route to chaotic oscillations of the nonlinear magnetic fields has been observed numerically as the electron-to-ion mass ratio is varied. Some signatures of self-organized criticality have also been witnessed.

References

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