Seminar

Institute for Plasma Research

Title : Collective plasma structures with kinetic nonlinearity: their coherence, interaction and stability

Speaker : Mr. Debraj Mandal
Institute for Plasma Research, Gandhinagar

Date : 9th January, 2018 (Tuesday)

Time : 03.30 PM

Venue : Seminar Hall, IPR

Abstract :

A large part of the universe that exists in the plasma state satisfies the collisionless conditions and evolves by means of strong kinetic nonlinear activity. The elegant collisional linear description, and its nonlinear counterparts, lose their applicability in this regime and plasmas begin to show strong departure from these conventional results. Finding a general nonlinear kinetic description of collective structures defines the central idea of the modern plasma theory of collective waves and instability. In this regime, the non-thermal phase-space distributions with particle trapping represent collective structures, essentially corresponding to a possible infinity of valid nonlinear solutions of the collisionless Vlasov equation. These coherent structures are observed in a variety of plasmas from hot fusion plasmas to space plasmas. The computer simulations are strongest means of exploring this interesting physics and validating few existing analytic approaches to stable nonlinear kinetic coherent structures. The high resolution, multiscale, multispecies, fully kinetic simulations of essentially nonlinear, collective kinetic plasma response to phase-space perturbations are done describing mechanism, mutual interaction and unstable evolution of coherent phase-space structures in the present study.

In the first part, the current driven ion acoustic instability is explored in phase-space where resulting solitary waves coexist with an electron plasma wave capable of perturbing the trapping potential. The results of multiscale simulations are analyzed following the kinetic prescription of phase-space vortex solutions that account for a stronger nonlinearity originating from the electron trapping. The coherent structures in electron acoustic regime are explored in the next part where the nonlinear interaction between multiple solitary electron phase-space holes is studied. Evolution of the analytic trapped particle solitary solutions prescribed by H. Schamel are examined, observing them propagate stably, preserve their identity across strong mutual interactions in adiabatic processes and display close correspondence with observable processes in nature. In the subcritical electron drift regime, where no perturbation must grow according to the linear theory, the small phase-space perturbations grow and propagate at arbitrary velocity in the simulations. These results support that the kinetic nonlinearity begins to act well below the linear instability threshold and follow a nonlinear dispersion relation (NDR). This questions the validity of plasma stability criterion based on linear approaches of Landau and Van-Kampen that prescribe discrete and continuum collective mode spectra, respectively. The final part of the simulation work addresses consistency of the existing analytic models of this class of structures in the light of formation and evolution of electron phase-space holes from an initial perturbation. The existing theories are critically compared from the view points of their underlying approach to equilibrium.