Seminar

Institute for Plasma Research

Title : Driven Phase Space Structures In A 1D Vlasov-Poisson Plasma

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Date : 31st January 2019 (Thursday)

Time : 11.00 AM

Venue : Seminar Hall, IPR

Abstract :

High temperature plasmas are characterized by charged particles undergoing several small angle Coulomb collisions leading to a rare large angle collision. Rarity of such large angle collisions renders these plasmas “collision-less” and such plasmas are well described by Vlasov models in the limit of weak correlations. Collision-less plasmas are often found in natural conditions such as space plasmas as well as in laboratory conditions such as Tokamaks, for example. Except for very special cases, even in its simplest form, Vlasov models are hard to solve analytically for specific initial and boundary conditions. Hence extensive efforts are underway world-wide to develop numerical Vlasov Solvers to understand collision-less plasma dynamics in natural and laboratory conditions.

In this work, considering an Eulerian grid in phase space, a fully nonlinear Vlasov-Poisson solver is developed for a 1D plasma where both electrons and ions are treated as fully kinetic species [VPPM 2.0]. This model is further generalized to include external drive and weak dissipation via specific models for collisions. Using this tool, in the first part of the work, using the fully kinetic model for both electrons and ions, it is shown that normal modes of electrons and ion kinetic branches, namely electron acoustic mode, electron Langmuir mode, ion acoustic mode and ion bulk mode - are excitable simultaneously using a external electric field of appropriate frequency and mode number. These results are corroborated using a simple dispersion analysis. In the second part, formation of phase space structures or phase space vortices (PSVs) and their stability to weak dissipation is addressed. PSVs are constructed in limits where electrons are kinetic and ions are immobile, followed by ions being fully kinetic and electrons are infinitely mobile (or Boltzmann-like). A frequency chirping (or sweeping) model is incorporated in an external drive to construct giant PSVs with multiple extrema, starting from Maxwellian plasmas. Role of trapped and untrapped particle dynamics in the formation of giant PSVs is elucidated by constructing excess density fraction as a measure of trapping in phase space. A simple free electron gas model subject to external drive is shown to qualitatively reproduce basic features of the PSVs. When weak dissipative effects/collisions are included, depending on the collision models used, it is shown that the giant PSVs smoothen out, yet retain large excess density fractions. In this presentation, several of the above said results will be discussed along with major unsolved problems and possible future directions.