Seminar

Institute for Plasma Research

Title : Study of electrostatic instabilities in current carrying cold plasmas

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Time : 10.30 AM

Venue : Seminar Hall, IPR

Abstract :

Electrostatic instabilities in current carrying cold plasmas are of fundamental importance owing to their natural occurrence in both laboratory and astrophysical plasmas. For example, current driven electrostatic instabilities are seen in laser driven ion acceleration schemes, inertial confinement fusion, strong double layer formation, cosmic ray acceleration in astrophysical shocks etc. In this thesis talk, we present our studies on space-time evolution of electrostatic instabilities in current carrying cold plasmas, both in the non-relativistic and relativistic regime, and spanning a wide range of ion to electron mass ratios.

In a homogeneous plasma and in the limit of infinitely massive ions, we first present stationary non-trivial solutions of a current driven relativistic Fluid-Maxwell system, for a wide range of values of κR , which is ratio of maximum electrostatic field energy density to average beam kinetic energy density. In the limit of large κR , stationary structures with periodic electron sheets are seen. We next present the spatio-temporal evolution of a relativistic electron beam (REB), when it is perturbed by a relativistically intense wave. It is found that the current diminishes with time due to relativistic phase mixing effects. An exact analytical expression for the current is derived by transforming the governing equations in Lagrangian frame. These analytical results are further supplemented with numerical results using an in-house developed 1D particle-in-cell (PIC) code. This novel effect may be of relevance to the transport of energy carried by the REB in fast ignition scenarios.

Using PIC simulation, we have further extended our studies to finite ion to electron mass ratios, where we have observed the resonant excitation of the well-known Buneman instability (BI). An extensive comparative study between simulation results and well known fluid/kinetic models of BI is carried out from linear stage of the instability till its quenching and beyond. After quenching of the BI, a strong interaction between preheated electrons and cold ions leads to the excitation of a coupled state, known as coupled hole-soliton (CHS). The amplitude-speed relation of CHSs found in our simulations is in conformity with Saeki's model of CHSs. Study of BI is further extended to the weakly relativistic regime. In contrast to the non-relativistic case, at the point of quasi-linear saturation, the ratio of electrostatic field energy density to initial beam kinetic energy density, shows dependence on initial drift velocity of the beam as ~ 1/γ0 2 where γ0 is Lorentz factor associated with the initial electron beam velocity.