Seminar

Institute for Plasma Research

Title : Breaking of Relativistically Intense Longitudinal Waves in a Homogeneous Plasma

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Date : 8th September 2017 (Friday)

Time : 10.00 AM

Venue : Seminar Hall, IPR

Abstract :

The space-time evolution and breaking of relativistically intense waves in a plasma is a fascinating field of study in nonlinear plasma physics. *Wave breaking*, which serves as a useful paradigm to elucidate the underlying physics behind a wide range of physical phenomena - ranging from particle acceleration in laser/beam plasma experiment to inertial confinement fusion, is induced by several non-linear processes. In this thesis talk, we present a thorough investigation of the formation, space-time evolution and breaking of a variety of relativistically intense electron plasma waves that a homogeneous unmagnetized plasma (cold as well as warm) can support.

It has been shown by using Sheet Model (proposed by Dawson, 1959) that in a *cold plasma*, relativistically intense oscillations/waves break when the trajectories of the adjacent electrons start to cross each other (phase mixing) due to temporal dependence of phase differences which arises because of relativistic mass variation effects. Analytical expressions for phase mixing time scales (wave breaking time) for an arbitrary longitudinal wave packet (specified by amplitude and spectral width) & longitudinal Akhiezer-Polovin mode (traveling wave in a relativistic cold plasma) have been given and verified by using a code based on Dawson Sheet Model. Another manifestation of breaking via phase mixing of relativistically intense nonlinear plasma oscillations in a cold plasma have been illustrated by changing the geometry of oscillations from planar to cylindrical and spherical oscillations.

Studies have been further extended to a *warm plasma* in both non-relativistic and relativistic regime by using an in-house developed, 1-D Particle-in-Cell (PIC) simulation code. In the non-relativistic case it has been shown that in a Maxwellian plasma, the maximum electric field amplitude sustained by a *self-consistent* electron plasma wave follows similar scaling with electron temperature as derived by Coffey in 1971 using a water bag distribution. In the relativistic case, electron temperature has been introduced by loading a Jüttner - Synge distribution along with a longitudinal Akhiezer-Polovin mode; it has been observed that in the low amplitude limit, the resultant structure follows the *relativistic warm plasma dispersion relation* given by Buti and Pegoraro. Further it has been demonstrated that, like a cold plasma, in a warm plasma also the wave breaks via phase mixing at arbitrarily small amplitude when perturbed by a small amplitude longitudinal perturbation. Variations of phase mixing time for a wide range of input parameters have been studied. Furthermore, for both non-relativistic and relativistic case, parameter regimes exhibiting the phenomena of Landau Damping & wave breaking in a warm plasma have been clearly delineated. Future scope of the above work has also been addressed.