Seminar

Institute for Plasma Research

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

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Date : 26th July 2018 (Thursday)

Time : 10:30 AM

Venue : Seminar Hall, IPR

Abstract :

The study of relativistically intense longitudinal waves in a plasma is a fascinating field of research in nonlinear plasma physics. The amplitude of these waves are limited by a phenomenon called wave breaking. Wave breaking serves as a useful paradigm to elucidate the underlying physics behind a wide range of physical phenomena and is occurred by several non-linear processes. In this talk, we present a thorough investigation on the excitation, space-time evolution and breaking of a variety of relativistically intense electron plasma waves that a homogeneous unmagnetized plasma 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 of the electrons. 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 derived 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. 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) 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. Using our simulation results, we have found that the phase mixing time scale in a warm plasma can be interpreted using Dawson's formula for phase mixing time for a non-relativistic cold inhomogeneous plasma, which is based on out of phase motion of neighbouring oscillators constituting the wave. Future scope of the above work has also been addressed.