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On Wave Breaking of Relativistically Intense Longitudinal Waves in plasma

Sudip Sengupta[1,2]

[1] Institute For Plasma Research, Bhat, Gandhinagar 382428, India, [2] Homi Bhabha National Institute, Training School Complex, Anushakti Nagar, Mumbai 400085, India

Study of spatio-temporal evolution and the determination of maximum possible amplitude of a coherent longitudinal plasma oscillation/wave is a topic of fundamental importance in non-linear plasma physics. The amplitude of these large amplitude plasma waves is limited by a phenomenon called wave breaking, which may be induced by several non-linear processes. In this paper, we briefly review our work on the space-time evolution and breaking of large amplitude relativistically intense electron plasma waves, for both - zero and nonzero electron temperature. Using Dawson Sheet Model [1] it is shown, that in a cold plasma relativistically intense oscillations/waves break when adjacent electrons start to cross each other (phase mixing) due to relativistic mass variation effects. A general expression for phase mixing time (wave breaking time) for an arbitrary longitudinal wave packet is derived [2]. This includes the breaking of both – relativistic oscillation and traveling wave solution – Akhiezer - Polovin Wave [3,4,5]. All these theoretical results are verified by using a code based on Dawson Sheet Model. We have further extended our studies on wave breaking to include finite temperature effects using Jüttner - Synge distribution for electrons. Existing theoretical results [5,6] in the literature are compared with the numerical results obtained using a, in-house developed, 1-D Particle-in-Cell simulation code. Furthermore, using numerical simulations, parameter regimes exhibiting the phenomena of relativistic Landau damping [7] and wave breaking has been clearly delineated.

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