§ 5. Stimulated Scattering of Relativistic Laser Light in Subcritical Plasmas

Ishiguro, S.,
Škorić, M.M. (Vinča Inst., Yugoslavia)
Li, B.W., Nikolić, Lj. (The Grad. Univ. for Advanced Studies)
Sato, T. (Earth Simulator Center)

Relativistic laser-plasma interaction is a source of various electronic instabilities. In particular, a large effort has been put into studies of backward and forward stimulated Raman scattering (SRS) and relativistic modulational instability (RMI) for varying laser-plasma parameters. The theory of electron parametric instabilities predicts the relativistic broadening and merging of unstable regions for SRS and RMI at high laser intensities.

We study by one-dimensional relativistic particle-in-cell simulations, a linearly polarized relativistic laser (10^{17} W/cm^2 $<$ I $<$ 10^{19} W/cm^2) interacting with a plasma layer ($T_e \sim 1$keV) at a subcritical density range ($n_c/4 < n/\gamma < n_c$); where γ is the relativistic factor. In regions which are overdense for standard SRS, intense coherent reflectivity pulsations at frequencies below the electron plasma frequency (ω_p) are typically observed in our simulations. In early stage, the spectrum is well explained by a resonant 3-wave parametric decay of the relativistic laser pump into the slowed ($\sim$ "critical") Stokes light sideband ($\omega_s \sim \omega_p$) and the trapped electron-acoustic wave (TEAW, with $\omega_a < \omega_p$). This appears a relativistic version of stimulated electron-acoustic scattering (R-SEAS), recently studied by a number of authors. In nonlinear saturation, there is a rapid growth and strong localization of the Stokes wave by forming narrow intense EM soliton-like structures with (downshifted) laser light trapped inside. The train of relativistic EM solitons gets irradiated through the front vacuum-plasma boundary in a form of intense coherent reflection of the downshifted laser light (Fig. 1, 2). Large TEAW excited in the plasma quickly heats up electrons to relativistic energies (Fig. 3) which eventually suppresses the instability in our simulations. For example, 1 psec pulse of the fundamental light at 10^{18} W/cm^2 transmits about 70 % of laser energy while propagating through the 20 microns thick uniform subcritical plasma at $n = 0.7n_c$, placed in vacuum. However, in a similar case, a shorter 0.5 psec pulse experiences just 40 % transmission due to large transient backscatter and absorption. This novel behavior which alters the distribution of relativistic laser energy between transmission, scattering losses and generation of energetic electrons has escaped earlier attention while being possibly relevant to future fast ignition and hohlraum target experiments. We plan to further address this problem by two-dimensional (2D) and 3D simulations.

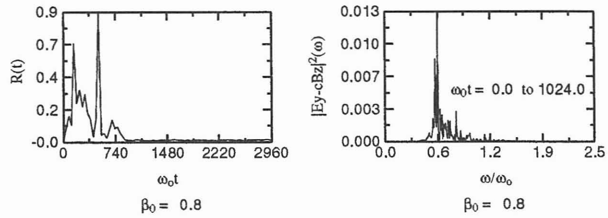

Fig. 1. Time evolution of reflectivity (left) and spectrum of scatterd electromagnetic field (right).

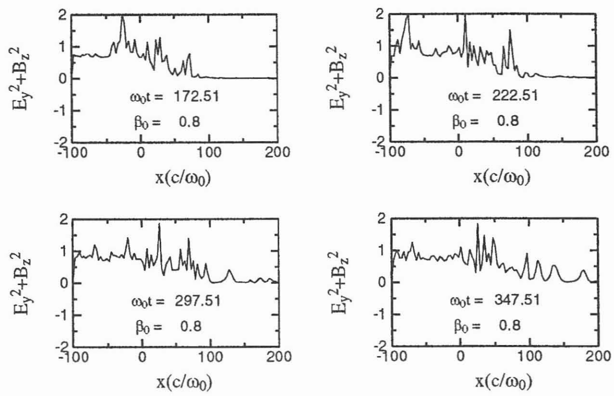

Fig. 2. Time evolution of electromagnetic field.

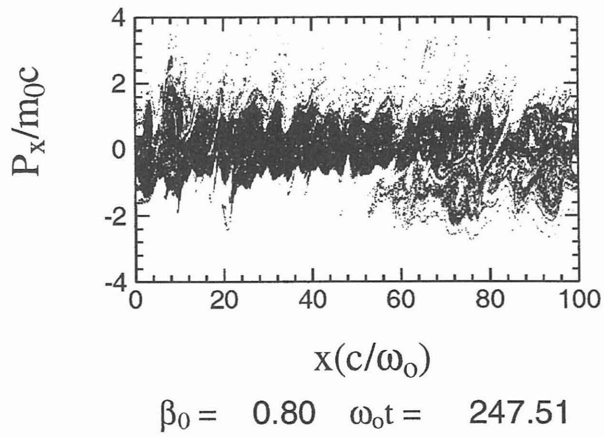

Fig. 3. $x - p_x$ phase space plot of electrons.