Kinetic Simulations of laser plasma interaction at high intensities

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Due to their extremely high damage threshold, plasmas can sustain much higher light intensities than conventional solid state optical materials. Because of this, lately much attention has been devoted to the possibility of using parametric instabilities in plasmas to generate very intense light pulses in a low-cost way. Crossing of a long pulse of relatively low intensity (pump) with a short laser pulse (seed) in a plasma provides energy transfer from the pump to the seed that can reach intensity many times higher than the pump. If the seed carrier frequency is frequency downshifted with respect to the pump, in order to match the plasma frequency, the short-pulse amplification is based on the Stimulated Raman Scattering Instability, if the seed carrier frequency is of the same order of the pump, it is based on Stimulated Brillouin Instability in the so called strong-coupling regime (sc-SBS). The quality of the pump propagating in the plasma before the coupling, and in particular the possibility of filamentation, affects the energy transfer. We present here recent multi-dimensional kinetic simulations that show the feasibility of achieving amplified light pulses with high efficiency. Shaping the plasma and extending the laser beams diameter allows for effective energy transfer from the pump to the seed while minimizing other unwanted plasma processes. In order to obtain amplification to of up to $10^{18}$W/cm$^2$, we reduced the pulse duration of the initial seed to the order of ten femtoseconds. As the seed is amplified, the spectrum of the seed evolves and changes considerably so that it cannot be explained anymore by sc-SBS only. A mixing between SRS- and SBS-aspects (mixed mode regime) takes place.