STIMULATED RAMAN AND BRILLOUIN SCATTERING IN THE ELECTRON-POSITRON PLASMA LIMIT

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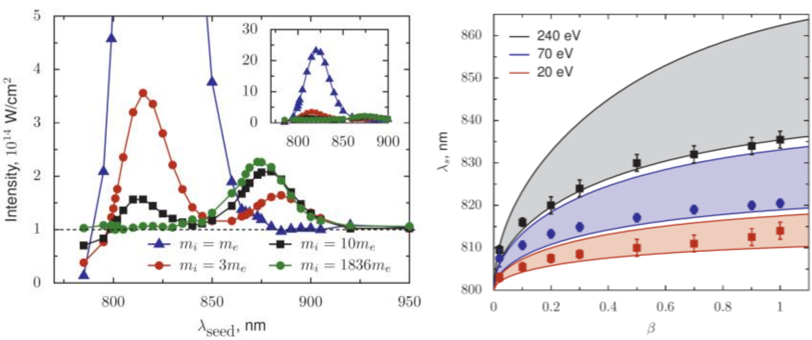
Stimulated Raman [1,2] and Brillouin [3] backscattering in plasmas have been studied extensively as methods for amplification of short-pulse lasers to extraordinarily high intensities. Here, we use stimulated backscattering to examine the behavior of wave-coupling and electrostatic modes as the ion mass is reduced to the electron-positron limit. We present a series of particle-in-cell simulations of wave-coupling in light-ion plasmas, providing a benchmark limit for standard-ion-mass Brillouin and Raman amplification, a demonstration of the suppression of Raman backscattering in electron-positron plasmas [4], and an analysis of the behavior of the acoustic mode when the electron and positron temperatures are equal.

We derive unified dispersion relations for the Langmuir and acoustic modes in a plasma with $\beta = m_e/m_i$ between 0 and 1. For an electron-positron plasma with equal species temperatures, the acoustic mode is heavily damped and not generally observed [5]. With counter-propagating high intensity fields we demonstrate amplification mediated by the acoustic mode, showing that the acoustic mode phase speed approaches $C_e^2 = \gamma_e T_e/m_e$ with $\gamma_e = 1$ rather than 3. We also find suppression of Raman amplification as $\beta \to 1$.



Wave-coupling resonance can be characterized by varying the seed laser wavelength for different ion to electron mass ratios (left), showing the suppression of the Langmuir mode and enhancement of the acoustic mode in the electron-positron case. Comparison of the acoustic mode resonance wavelength with calculated dispersion relations (right) reveals better agreement with the $\gamma_e = 1$ (isothermal) prediction (lower lines) than the $\gamma_e = 3$ (adiabatic) value, particularly at higher temperatures, an unexpected result likely due to the thermalization of the particle distributions on the wave fluctuation timescale.

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