Spatially autoresonant stimulated Raman scattering in inhomogeneous plasmas the kinetic regime

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The impact of spatial autoresonance on backward stimulated Raman scattering in inhomogeneous plasmas in the kinetic regime is investigated. Starting from the system of three coupled wave equations, the inclusion of a nonlinear frequency shift due to kinetic effects in the equation of the electron plasma wave is found to lead to a cancellation of the wave-number shift due to the density gradient that would normally detune the resonance between the three waves. Through the amplitude of the electron plasma wave, the kinetic nonlinear frequency shift is observed to self-adjust to maintain this cancellation over a region in space, giving rise to phase-locked solutions to the electron plasma wave equation. This process may extend resonance in inhomogeneous plasmas beyond a single point in space, increasing the observed gain significantly above the level predicted by Rosenbluth [M. N. Rosenbluth, Phys. Rev. Lett. **29**, 565 (1972)]. Under appropriate fusion-relevant conditions, the amplitude of the electron plasma wave is observed to grow as the square of the distance propagated from a point of resonance until reaching a plateau. A reduced model is employed to provide analytic insight to the autoresonant wave coupling solutions. This model is used to explain the conditions under which autoresonance occurs and what causes the eventual plateau in the electron plasma wave amplitude.
1D particle-in-cell (PIC) simulations are performed in the weakly kinetic regime. The amplitude of the electron plasma wave is observed to follow the predictions of the reduced model and 3-wave coupling simulations. Phase locking between the three waves is clearly observed in PIC simulations over lengths up to $\sim 40\ \mu$m, leading to a significant autoresonant electron plasma wave amplitude (corresponding to an electron density perturbation $|\delta n_e/n_e| \sim 0.2$) reached via autoresonance.
Using 2D PIC simulations, autoresoance is investigated under conditions relevant to the interior of a hohlraum fusion target, where laser might may overlap with counter-propagating scattered light in an inhomogeneous plasma...