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Trapping induced nonlinear behavior of backward stimulated Raman scattering in multi-speckled laser beams[1]

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In inertial confinement fusion experiments, Stimulated Raman Scattering (SRS) occurs when electron density fluctuations amplify resonantly by the incident laser beams. These beams comprise several thousands of individual laser speckles. We have found in single-speckle studies that electron trapping lowers the threshold intensity for SRS onset to a value below that from linear theory and enhances scattering. The trapping-induced plasma-wave frequency shift leads to wave-front bowing and self-focusing, processes that saturate SRS and limit scattering within a speckle. With Petaflop-class supercomputers, we have now examined how laser speckles interact with one another through 3D particle-in-cell (PIC) simulations of two interacting speckles and 2D PIC simulations of ensembles of laser speckles (100s of speckles). Our work shows that an intense speckle can destabilize its neighbors, resulting in enhanced emission of particles and waves back to the original speckle, thus affecting its behavior in a manner that is nonlinear and nonlocal. Ensembles of speckles are thus found to collectively lower the SRS onset threshold. Simulations of the hohlraum interior where laser beams overlap show that multi-speckled laser beams at low average intensity (a few times 10^{14} W/cm^2) have correspondingly lower thresholds for enhanced SRS and that SRS saturates through trapping induced nonlinearities (other potential saturation mechanisms are also examined). Results from VPIC simulations and comparison with pF3d results will be discussed that employ inhomogeneous plasma profile taken from rad-hydro modeling of NIF ignition experiments. Implications for experiments at higher laser power will also be discussed.

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