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Effect of spectral bandwidth on the stimulated scattering of spatially smoothed laser beams in direct drive experiments

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Stimulated laser scattering on plasma waves in a corona is the major obstacle to efficient laser energy deposition in direct drive inertial fusion. Optical laser beam smoothing techniques such as random phase plate (RPP), crossed polarizations, induced spatial incoherence (ISI), and smoothing by spectral dispersion (SSD) proved not sufficient for mitigation of parametric instabilities, and attention is shifted to the assessment of the potential of large spectral bandwidth of a few percent or more. Experimental data are limited, and the theory and simulations are of prime importance. However, numerical simulations deliver contradicting results in clear disagreement with established theories.

Here, we report the results of studies of spatial amplification of the forward and backward scattering of a broadband spatially smoothed laser beam in plasmas relevant to ICF. A recently developed statistical theory of parametric instabilities [1] is applied to the stimulated Brillouin scattering (SBS), and criteria for the mitigation of forward and backward scattering are obtained for laser beams smoothed with RPP, ISI, and SSD. The analytical results are confirmed with dedicated numerical simulations using a paraxial electromagnetic code and agree with the experiment [2]. By contrast, numerical simulations using a particle-in-cell code demonstrate that increasing laser bandwidth has little effect on stimulated Raman scattering (SRS), but increases the reflectivity and hot electron generation [3]. This effect is attributed to the electron trapping in the SRS-driven plasma wave and the broadening of the plasma resonance beyond the laser bandwidth. Theoretical analysis and relation to experiments will also be discussed.

References

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