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The Deleterious Effects of Multibeam Laser–Plasma Interactions on Inertial Confinement Fusion and Their Mitigation

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Recent experiments on the National Ignition Facility (NIF) (using x-ray drive) and on OMEGA (using direct drive) have shown reduced drive relative to predictions; multibeam parametric instabilities are implicated. This talk will review the experimental evidence for multibeam instabilities, describe current theoretical understanding, and present mitigation schemes. Drive in both indirect- and direct-drive inertial confinement fusion (ICF) schemes is generated by the overlapping of many laser beams. In both cases, multiple beams interact cooperatively in the plasma to drive instability. This is undesirable because instability is present even when individual laser beams are below single-beam thresholds. This talk will describe advances in the modeling of collective two-plasmon decay (important for direct drive because of its effect on drive and target preheat) together with recent experimental scalings obtained in near-NIF conditions. These results suggest a combination of beam-geometry optimization and the use of mid-Z ablator material will mitigate the risk. Another example that has been identified on both OMEGA and in indirect-drive (ID) targets on the NIF is cross-beam energy transfer (CBET). In CBET, laser power is transferred between crossing laser beams caused by low-frequency nonlinearities. On OMEGA, it was first observed through analysis of unabsorbed light and confirmed when CBET models were coupled with hydrodynamic codes. This talk will show that wavelength separation between the NIF cones, that is effective for ID, may be effective for NIF polar drive (PD) designs. Other mitigation schemes for PD including zooming and the use of mid-Z ablators will be described.
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