Thermo-mechanical-optical Study Of Diode Pumped High Energy Laser Amplifiers For Laser Fusion

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Abstract

High average power lasers with increased efficiency are a crucial development required for achieving inertial confinement fusion as a viable energy source. For high average power, the thermal management and its influence on laser beam quality strongly effect the final focusability on the target of fusible material. Incorporating new high power diode technology for fusion-class lasers and understanding performance impacts, namely efficiency is critical to success. A thermo-mechanical-optical model of such a diode-driven laser amplifier in COMSOL is presented. A holistic model tracks inputs from illumination-driven heat to ion energy storage dynamics to a customized optical propagation model yielding final output optical maps of phase and polarization as influenced by local thermal and stress. The mapping of stress tensors to anisotropic elasto-optical material models of crystalline gain media is evaluated, to capture birefringence effects. Cross-validation efforts from in-house code bases and published empirical results have been evaluated for canonical test cases. Additionally, mesh sensitivity studies provide minimum resolution requirements for calculating the true optical path of rays within the thermally stressed optics stack. The final model outputs enable studies of the influence of architecture and design choices on optical metrics that indicate how to best manage the laser beam lines in a future fusion power plant.