Optimization of Polar Direct Drive Illumination for Mega-Joule Laser Facilities

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The National Ignition Facility (NIF) has achieved ignition [1] using an indirect drive approach to inertial confinement fusion (ICF) where a roughly 1mm radius spherical target was compressed to less than 0.1mm by x-rays. Stable compression requires highly uniform, spherical illumination, which is achieved for indirect drive with the use of a cylindrical hohlraum where laser light enters at the poles and is converted to thermal x-rays before driving the target. This helps to improve irradiation uniformity, but at the cost of laser-target coupling efficiency when compared to a direct-drive (DD) approach. Due to its efficiency, DD is a promising candidate when moving beyond ignition towards a future energy source. However, testing DD at ignition scales is challenging as the mega-joule laser facilities (National Ignition Facility, NIF and Laser Méga-joule, LMJ) are configured with beams entering the target chamber in the polar region for indirect-drive, and so require optimization to enable DD compatible illumination. The NIF features: 48 quads entering from different ports with independent pointing, power balance, wavelength tuning and defocusing; and the quads may be split to 192 beams with individual pointing offsets. A polar direct-drive (PDD) scheme has already been tested on the NIF [2], however there are a large number of possible beam configurations and evaluating them currently requires expensive experimental/computational methods, so it is likely not the optimal solution. In addition, the use of beam diagnostics or changes to the target/implosion dynamics requires manual re-optimisation and different configurations are required for solid targets, conventional hotspot ignition, and shock ignition.

This talk presents the use of Bayesian optimization and genetic algorithms for efficient evaluation within the PDD parameter space for the NIF. The procedure creates highly uniform illumination configurations in the presence of temporally varying plasma and laser plasma interactions (LPI), such as cross-beam energy transfer [3]. The automated process reduces the prerequisites for target and diagnostic changes. The process is currently being applied to aid in the design of experiments for both the NIF and LMJ.

References

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