A WEDGED-PEAK-PULSE DESIGN WITH MEDIUM FUEL ADIABAT (ENTROPY) FOR INDIRECT-DRIVE FUSION

Z. F. Fan[1], X. T. He[1, 2], J. Liu[1, 2], G. L. Ren[1], B. Liu[1], J. F. Wu[1], L. F. Wang[1, 2], and W. H. Ye[1, 2]

[1]Institute of Applied Physics and Computational Mathematics, Beijing 100088, China
[2]Center for Applied Physics and Technology, Peking University, Beijing 100871, China

In central hot-spot ignition of inertial confinement fusion (ICF), a spherical capsule containing deuterium-tritium (DT) fusion fuel is imploded to a much smaller sphere so as to achieve high fuel density and high temperature in the central hot spot, triggering ignition and producing significant thermonuclear output.

Low-adiabat (entropy) implosions maximize the fuel compression. Unfortunately, experiments on the National Ignition Facility has demonstrated that the hydrodynamic instability, which leads to hot-spot deformation, main-fuel-layer distortion and ablator mixing into the hot spot, is much prominent than expected [1]. High-foot high-adiabat implosions, with higher ablation velocities and larger density gradient scale lengths, are designed to reduce ablation-front Rayleigh-Taylor instability induced mixing of ablator material into the DT hot spot [2]. Nevertheless, the laser energy required for ignition is approximately proportional to the square of the fuel adiabat, and it seems hard to design a high-adiabat ignition target for the current mega joule laser facilities.

In this report, we propose a design of a wedged-peak-pulse at late stage of the indirect drive, for a medium fuel adiabat. First, during the wedged-peak-pulse the radiation drive grows gradually creating a series of compression waves which compress the fusion fuel without significantly raising the fuel adiabat. Second, the compression waves merges as they travel into the hot spot forming a strong inward shock wave or compression wave, which prohibits the reflection of the outward rebounding shock (from the spherical center) at the interface of the hot spot and main fuel layer, thus stabilizing the deceleration stage hydrodynamic instability.

With the wedged-peak-pulse, the fuel adiabat is kept at reasonable value such that the one-dimensional (1D) performance of the capsule is better than that of the high-foot implosions and comparable to that of the low-foot implosions. Meanwhile, the hydrodynamic instability, at both the ablator/fuel interface and hot-spot/main-fuel interface, are significantly reduced as compared with low-foot implosions.

Simulations with the LARED-JC code indicate that the wedged-peak pulse is achievable with a (cylinder) hohlraum driven by a laser facility with energy of ~2.0MJ. Moreover, our scheme is also robust with respect to the maximum radiation temperature.

We expect that the new type of design would be a good way for indirect-drive ICF on mega-joule laser facilities.

[1] S. Regan et al 2012 Phys. Plasmas 19, 056307
[2] O. Hurricane et al 2014 Nature 13008