Influence of the solid-to-plasma transition on the laser energy deposition in targets and subsequent hydrodynamics for direct drive inertial confinement fusion

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Inertial Confinement Fusion (ICF) is a method of achieving nuclear fusion reactions by bringing a small mass of combustible material at high densities with the desired thermodynamic properties. To achieve this goal, direct drive ICF uses high power laser beams to implode a spherical target which consists of gaseous DT fuel surrounded by a thin shell of DT ice and an outermost layer of plastic ablator. The laser ionizes the plastic which is ablated and the target implodes due to the rocket effect. In radiation hydrodynamics codes, the plastic ablator is approximated as opaque to the laser radiation, i.e. an initial plasma state is assumed. The solid-to-plasma transition of the ablator is not modeled in the aforementioned codes, whereas it may have an important role in implosion symmetry, target compressibility, shock timing, and hydrodynamic instability.

This work focuses on the experimental validation of a solid-to-plasma transition model and its introduction in a 3D radiation hydrodynamics code, in order to study its influence on direct-drive implosions. It is based on a recent physical model developed in Ref. [1, 2] which describes the solid-to-plasma transition of polystyrene (most ICF ablators are composed of polystyrene). This model has been experimentally benchmarked for photoionization in Ref. [3].

I will present results from an experiment carried at CEA-DIF on the GCLT laser, in order to validate the collisional ionization within the model. This model for photoionisation has been introduced in a numerical tool coupling the 3D laser propagation code IFRIIT [4] and 3D Eulerian hydrodynamic code ASTER [5]. I will also present simulations used to investigate impact of transition on experiments undertaken at the OMEGA laser facility. They show that transition have an effect on shock velocity for low adiabat simulations, and a reduction of low mode of hydrodynamic instabilities.

References

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