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Target Design Study of Fast Ignition for Ignition and Burning Experiments

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In the fast ignition of laser fusion, a reliable target design is required for an ignition scale target. This paper shows the first optimized target design of an implosion phase of the fast ignition, which is scalable to larger targets.

The fast ignition scheme can be divided into three processes mainly; the formation of highly compressed fuel core plasma, the generation of high-energy electrons by an intense short pulse laser, and the heating fuel core by the high energy electrons. In the first process, a high areal density fuel core should be formed to stop the high-energy electrons. For the demonstration of a self-ignition the areal density should be more than 1.1 g/cm^2. For the self-ignition and high gain target designs it is necessary to carry out many implosion simulations for the large targets which require large amount of computer resources. We conducted 2-D implosion simulation of DT solid spherical target with gold cone target using the optimized laser pulse shape. Finally, we estimated the requirement of the implosion laser energy on the basis of the hydro-dynamic similarity rule. In conclusion, a target can be highly compressed using multi-step laser pulse irradiation to a solid spherical target. In the FIREX-I scale implosion (6.25 kJ/0.35 μm), the maximum areal density of DT fuel (ρR_{max}) reaches 0.28 g/cm^2 with a gold guiding-cone according to two-dimensional simulation. Based on the hydrodynamic similarity, we estimate that the requirement of implosion laser energy for ignition scale target (ρR_{max} =1.1 g/cm^2) is 380 kJ.

In order to optimize the whole process of fast ignition, heating simulation is necessary in the next step. This highly compressed fuel core profiles at the maximum ρR time will be the initial conditions of kinetic simulations for the next processes, where generation of energetic electrons due to the nonlinear relativistic laser plasma interaction, transport and absorption of the energetic electrons processes will be simulated. External magnetic field [5] is effective for improving the heating efficiency because it reduce the divergence angle of the energetic electrons. It will be taken account in next design study.

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