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Optimum design of a cone-inserted target implosion for reactor scale Fast Ignition

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Abstract

In the fast ignition of laser fusion[1-3], a reliable target design is required for an ignition scale target. This paper shows the optimized target design of an implosion phase of the fast ignition, which is scalable to larger targets. The requirements from the heating process are taken account into the design[4-6]. Many two-dimensional radiation magneto-hydrodynamic simulations were conducted in order to maximize the areal density for fast ignition, where multi-step laser pulses, target structure including the optimization of the guiding-cone were optimized with the consideration of the heating laser specifications.

As in the conventional implosion method using a spherical shell target, implosion dynamic is more susceptible to the hydrodynamic instabilities, such as Rayleigh-Taylor and Richtmayer-Meshkov instabilities. Alternatively, a solid spherical target is effective for the fast ignition scheme. Here a spherical deuterated polystyrene (CD) shell filled with DT fuel is applied. In this case, the low isentropic compression of the fuel is essential. For that purpose, Kidder proposes a tailored pulse, which is obtained by analytical solution [7]. Because it is difficult to use the analytical solution directly, we optimize it as the multi-step pulse. At each step, the intensity is increased by 8 times, which is most efficient shock compression in the ideal gas assumption (γ =5/3) because the ablation pressure is proportional to the 2/3th power of the laser intensity, and the pressure jump is kept less than 4. The laser intensity is determined by the initial radius of the shell here.

Following one-dimensional optimization, two-dimensional optimization was performed using 2-D radiation hydrodynamic simulation code [8]. The mass density contours of the case are shown in fig 1. Multi-shock arrived at the implosion center at the same time.

In conclusion, a target can be highly compressed using multi-step laser pulse irradiation to a solid spherical target with an inserted gold cone. In an 8 kJ (laser wavelength=0.35 μm) scale implosion, the maximum areal density of DT fuel reaches 0.39-0.42 g/cm^2 according to the two-dimensional simulation results, which is 62-70 % of the case without the inserted-cone. Based on the similarity rule of hydrodynamic, we estimate that the requirement of the implosion laser energy for ignition scale target (ρR_{max} =1.0 g/cm^2) is 85-135 kJ. Further study of the optimization of the heating process [9-13] and some effects of the external magnetic field using a MHD simulation code are in execution.

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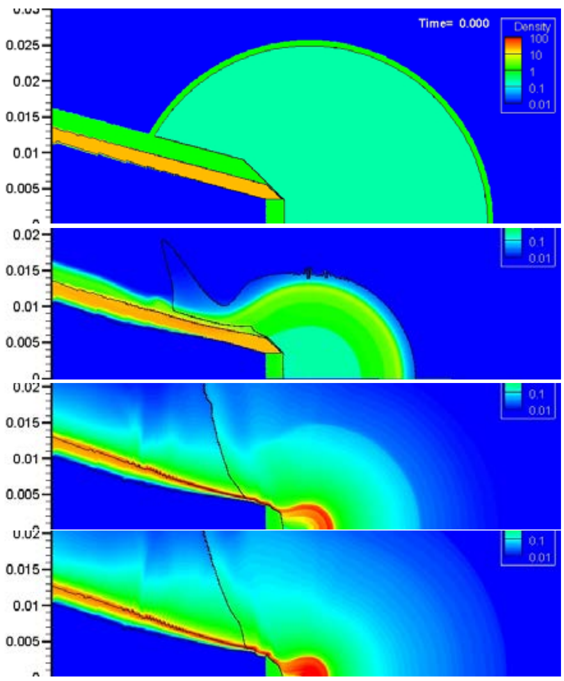

Figure 1. Mass density contours of the optimized implosion for *t*=0, 12.0, 14.05, and 14.15 ns.