直接照射重イオン慣性核融合のための非球状燃料標的の爆縮過程の数値解析

Numerical analysis on implosion dynamics for non-spherical fuel target in direct drive heavy-ion inertial fusion

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An inertial confinement fusion (ICF) method is an important issue in a solution for the increase in world energy consumption. The ICF scheme by heavy-ion beam irradiation is expected to solve this issue. When performing a fuel pellet implosion by heavy-ion beam irradiation, it is technically challenging to irradiate a target with a heavy-ion beam in a higher symmetry from beam handling. To solve this problem, we have proposed a massive-ion beam driver system [1] and a barrel-shaped target design. In this study, we investigate the implosion dynamics with the non-spherical target to research the beam irradiation pattern using numerical simulations.

We used the CIP method [2] with the MmB correction [3] as the numerical scheme for the implosion dynamics analysis. The simulation model was assumed by one fluid, two temperature, and ideal gas.

Figure 1 and table 1 shows the initial conditions; (a) and (b) are the structures of spherical and non-spherical targets, and (c) is the initial temperature distribution. The layers are Pb of 11.3g/cm^3, Al of 2.69 g/cm^3, and DT ice of 0.2564 g/cm^3.

Figures 2 and 3 show the time evolution in the implosion phase for the spherical and the non-spherical targets, respectively. The color indicated the normalized values by the maximum one in the whole calculation process. It is found that the implosion dynamics are basically the same, because the void-closed velocity far exceeds the velocity of the shell structure influence.

We have confirmed that the shell structure does not affect the implosion before the shell collapse. Therefore, the shell structure of a properly designed target will not affect the implosion dynamics.

[1] K. Takayama, et al., Phys. Lett. A 384 (2020) 126692
[2] T. Yabe, *et al.*, J. Comp. Phys. 169 (2001) 556–593
[3] W. Huamo, *et al.*, IMPACT of Computing in Science and Engineering, Vol.1, Issue 3, September 1989, pp.217-259

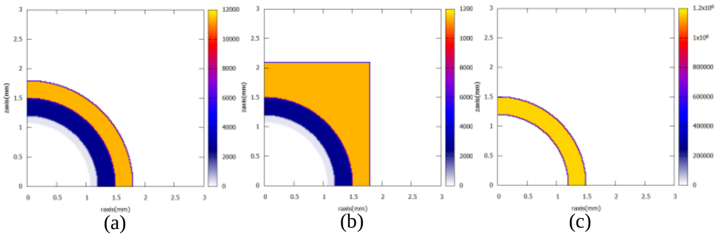

Figure 1 Target structure
(a) is the structure of spherical target, (b) is the structure of non-spherical target, (c) is the initial temperature distribution.

Table 1 Calculation Conditions

Spherical target	Non-spherical target
$1.5mm \le radial < 1.8mm\ Pb\ shell$; $1.2mm \le radial < 1.5mm\ \ Al\ ablator$; $1.08mm \le radial < 1.2mm\ \ DT\ ice\ fuel$; $others:\ void$	$1.5mm \le radial, raxis < 1.8mm,$ $zaxis < 2.1mm\ Pb\ shell$; $1.2mm \le radial < 1.5mm\ Al\ ablator$; $1.08mm \le radial < 1.2mm\ \ DT\ ice\ fuel$; $others:\ void$
Initial temperature	
$T_{ablator} = 100eV\ (1.16045 \times 10^6 k); T_{others} = 300k$	

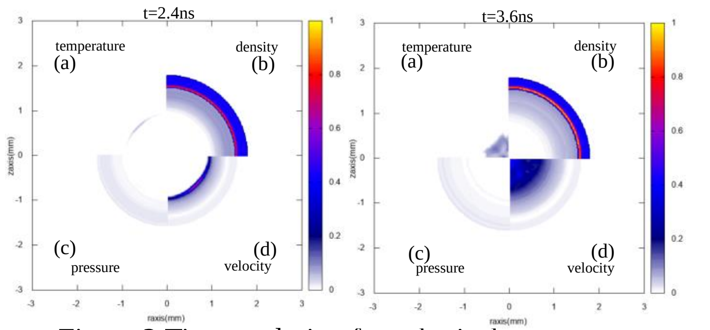

Figure 2 Time evolution for spherical target
Orthant (a) is temperature, orthant (b) is density, orthant (c) is pressure, orthant (d) is velocity.

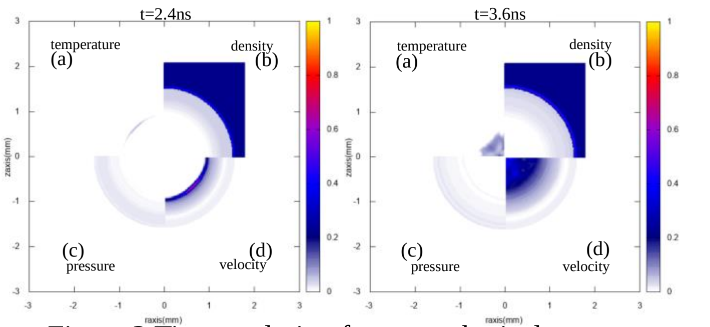

Figure 3 Time evolution for non-spherical target
Orthant (a) is temperature, orthant (b) is density, orthant (c) is pressure, orthant (d) is velocity.