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# 重イオン慣性核融合燃料標的の爆縮過程における希薄波の伝搬の影響
# Numerical analysis on influence of propagation of rarefaction wave in implosion process for heavy-ion-beam driven inertial confinement fusion target

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Heavy-ion inertial fusion (HIF) is an expected way to achieve thermonuclear fusion. Most of the energy of the heavy-ion beam is deposited inside the fuel target. The fuel pellet structure consists of fuel, ablator, and tamper layers for a direct-drive irradiation scheme [1].

The heated ablator expands outward and inward simultaneously after the heavy-ion beam irradiation. The inward expansion of the ablator causes the compression of the fuel and propagates the outward rarefaction wave. The rarefaction wave overtakes the outward expansion of the ablator, and the outward expansion is suppressed. As the result, the implosion efficiency of the fuel is improved. Tamper works as the "rigid wall" that holds back the outward flow of mass and energy. After the tamper collapse, the "overtaken" effect on outward flow from outward rarefaction wave decreases due to the velocity increase of outward flow after the transition of the outward shockwave through the inward rarefaction wave from the outer edge of the tamper layer. In this study, we numerically investigated the influence of rarefaction wave propagation in the implosion process for the HIF target.

We used the CIP method [2] with the MmB correction [3] as the numerical scheme for the implosion dynamics analysis. In a two-dimensional cylindrical coordinate system, the simulation model was assumed by one fluid, two-temperature, and ideal gas. Figure 1 and Table 1 show the initial density and temperature distributions. The target layers are Pb of 11.3 g/cm$^3$, Al of 2.69 g/cm$^3$, and DT ice of 0.2564 g/cm$^3$, respectively.

Due to the initial material and temperature distributions, the 1D initial pressure distribution is shown in Fig.2, and waves are generated inside the target. Figure 3 shows the 1D pressure distribution of the target at 3.0 ns. The propagation of the rarefaction wave can be treated as a sonic wave. During the "overtaken" period, the outward rarefaction wave propagates through the inward rarefaction wave [4], then the rarefaction wave propagates outward through the steady area behind the outward shockwave. The outward rarefaction wave catches the outward shockwave, and the rarefaction wave suppresses the shockwave. After that, the after-shock pressure decreases.

## Reference

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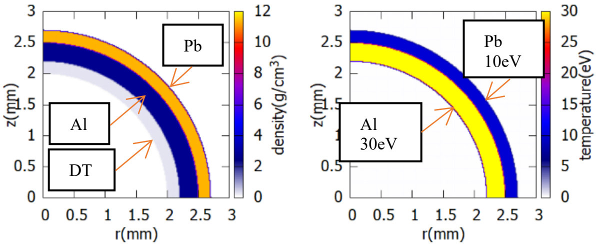

(a) density (b) temperature

Figure 1. Initial density and temperature distribution.

Table 1: Initial conditions

| Radius [mm] | Material | Density | Temperature |
|---|---|---|---|
| $r < 2$ | DT | 0.0002 g/cc | 300 K |
| $2 < r < 2.2$ | DT | 0.2564 g/cc | 300 K |
| $2.2 < r < 2.5$ | Al | 2.69 g/cc | 30 eV |
| $2.5 < r < 2.5+d_t$ | Pb | 11.3 g/cc | 10 eV |
| others | DT | 0.0001 g/cc | 300 K |

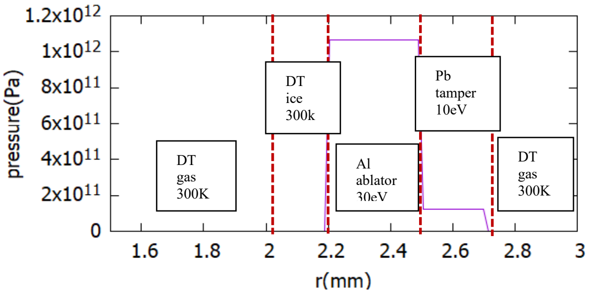

Figure 2. 1D pressure distribution

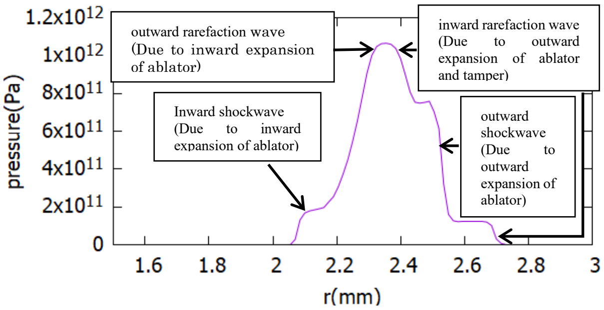

Figure 3. 1D pressure distribution at 3.0 ns: the heated ablator expands outward and inward simultaneously in the form of shockwave.