Application of CIP-Soroban method to implosion process of heavy-ion-beam driven inertial confinement fusion

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An implosion process of heavy-ion-beam (HIB) driven inertial confinement fusion (HIF) is key issue to achieve fusion energy release. The uniformity of HIB irradiation should be improved due to spherically symmetric implosion in a direct-drive fuel pellet. Modification of the fuel pellet structure was proved to be effective to reduce the irradiation nonuniformity in our previous study [1]. Figure 1(a) shows a typical fuel pellet for HIF, which consists of a tamper layer of lead (Pb), an ablator layer of Al (aluminum) and a fuel layer of Deuterium-Tritium (DT). The tamper layer is used to keep the hydrodynamic energy inside the fuel pellet to raise the implosion efficiency [2]. For this reason, the tamper layer is made of heavy element with high mass number, which has higher stopping power for more electrons that it possessed compared to the ablator material.

The derivatives of physical values grow dramatically especially after the void closure phase of the fuel pellet. As the results, the truncation errors grow fast and decrease the accuracy of the numerical simulation for the implosion process. Coarse arrangement of the calculation grid points (mesh) works bad in capturing the shape of tamper layer, and small errors of the shape of tamper layer can cause big shifts of the stopping range of the HIBs in ablator layer for the stronger stopping power of tamper layer than ablator layer.

CIP-Soroban method is a good adaptive mesh refinement method, which was developed for numerical simulations for hydrodynamics of incompressible fluids [3]. The mesh size of CIP-Soroban method varies inversely to the derivatives of physical values meantime capable solves the equations with CIP method, which has 3rd order accuracy. On the other hand, CIP-Soroban method works well in capturing object surface [4] which is good for capturing the shape of tamper layer of fuel pellet.

We have built a developed code with CIP-Soroban method for compressible fluid to simulate the implosion process of HIF [5]. Figure 1(b) shows one snapshot of velocity distribution during implosion simulated by the code. The dots in Fig. 1(b) were the grid points of CIP-Soroban, which distributed suitably dense in the areas with high derivatives of physical values and the shape of fuel pellet were well captured. We will report the detail during our presentation.

References

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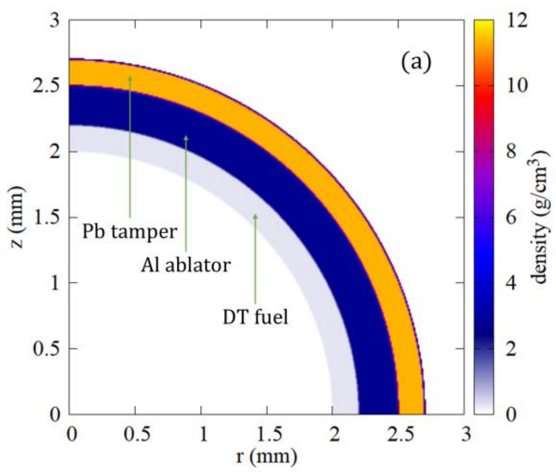

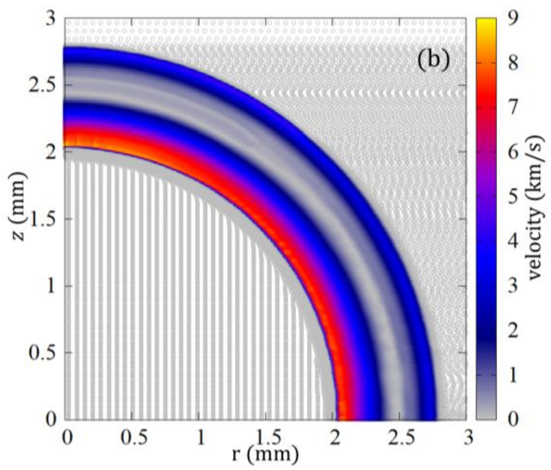

Figure 1. (a) The structure in *r-z* cylindrical coordinate of a typical fuel pellet for heavy-ion-beam driven inertial confinement fusion; (b) a snapshot of grid points and velocity distribution during implosion calculated with CIP-Soroban method.