§37. Theoretical Studies on Collisions between Ablated Plumes in Laser Fusion Liquid Wall Chamber

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One of the critical issues of a laser fusion reactor with a liquid wall is the chamber clearance. After micro explosion with 100 MJ nuclear yield, about 10 kg of liquid metal evaporates from the surface due to heating by α particles, ions and debris from the target. The evaporated plume makes, then, mist and clusters after expansion cooling. Such clusters would attach on the injected target surface and degrade the target performance through RT instabilities and preheat of the cryogenic fuel. Collisions between plumes produced by ablation at the center of the liquid wall chamber are estimated.

To experimentally simulate the ablation process, laser irradiation is often used. We, however, found that ablation process by ions is quite different from that by lasers. The range of α particles in liquid Pb is about 10 μm. As the result, superficial liquid Pb evaporates as a high density, low temperature, plasma with low ionization rate.

In this study, we have developed an integrated ablation simulation code DECORE (Design Code for Reactor) to clarify the ability of the chamber clearance. In this integrated simulation code, effects of condensation of a plume, the formation of clusters in the ablated plume, phase transition from liquid to neutral gas to partially ionized plasma, absorption of energies of charged particles, equation of state, hydrodynamics, and radiation transport are included.

Fig. 1 shows number density and velocity profiles of lead at the time a plume reaches to the center of the chamber.. As shown in Fig. 1, ablated lead moves with velocities of roughly 10 km/s. To estimate this velocity is very important for analysis of collisions between plumes at the center of the chamber.

Fig. 2 shows the time development of number densities. Note that in Fig. 2, times from a collision starts are described. As shown in Fig. 2, until time = 2.95 ms, near by the center of the chamber, number densities are increasing and after time=2.95ms, number densities near by the center are decreasing.

Fig. 3 shows the time development of velocity profiles. As shown in Fig. 3, velocities are reversed after the collision at the center.

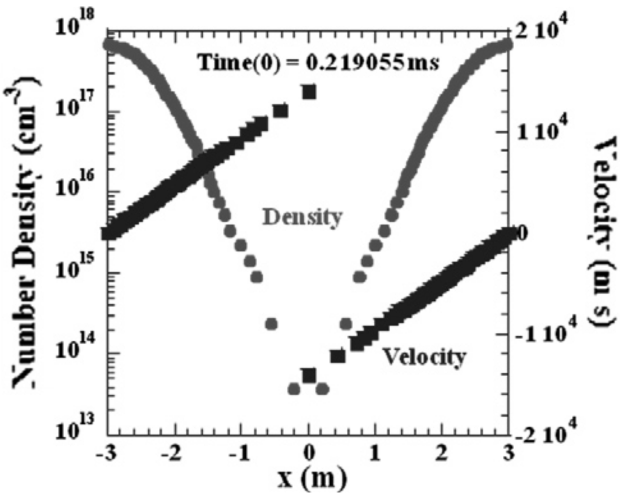

Fig. 1 Number density and velocity profiles of lead.

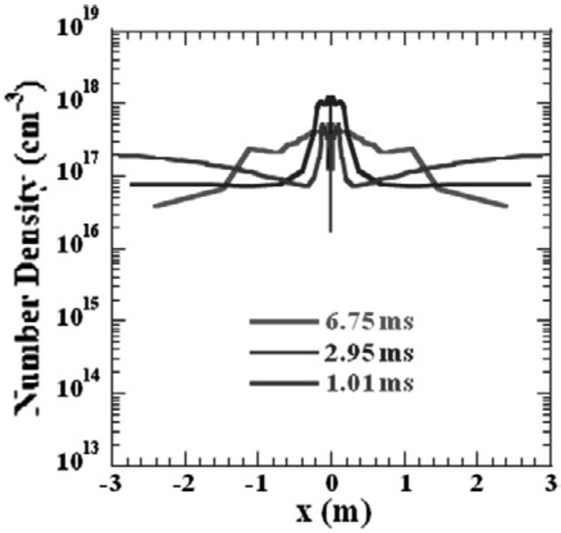

Fig. 2 Time development of number densities.

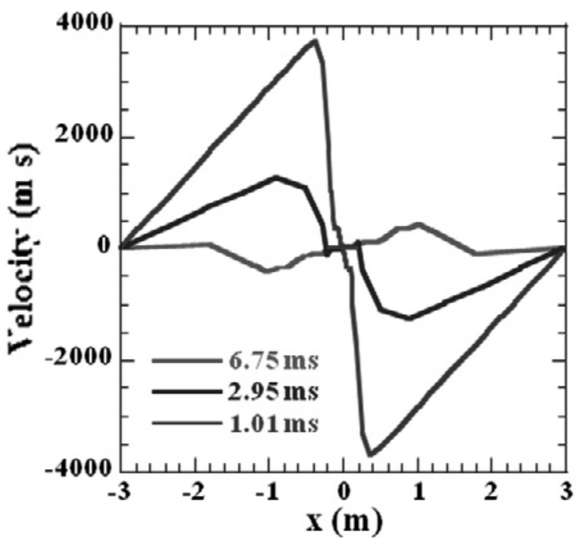

Fig. 3 Time development of velocity profiles.