§39. Theoretical Studies on Environments 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 fuel.

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 40 km/s. To estimate number density and velocity is very important for analysis of collisions between plumes at the center of the chamber.

Fig. 2 shows diameters of clusters and condensation rate at the same time in Fig. 1. The regime x < 0.5m, clusters are created.

Collisions between plumes produced by ablation at the center of the liquid wall chamber are estimated. Collisions between plumes strongly affect a design of laser fusion reactor. Fig. 3 shows the time development of pressure distribution. Note that in Fig. 3, times from a collision starts are described. As shown in Fig. 3, at the time = 2.0 ms, near by the center of the chamber, pressure is roughly 2000 Torr, and after time=2.0ms, pressure near by the center are slightly decreasing.

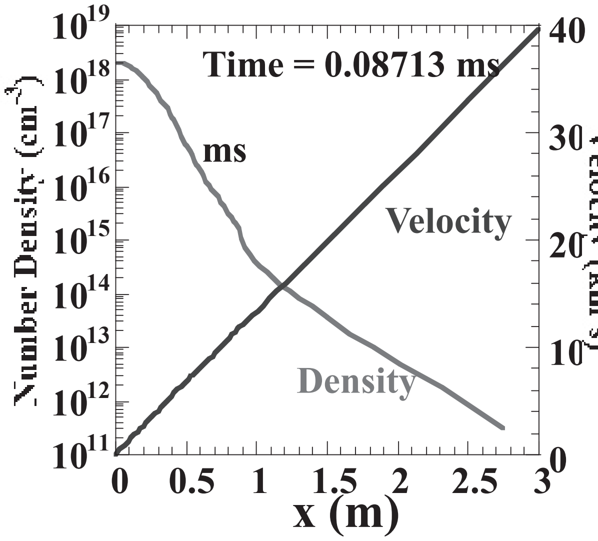

Fig. 1 Number density and velocity profiles of lead.

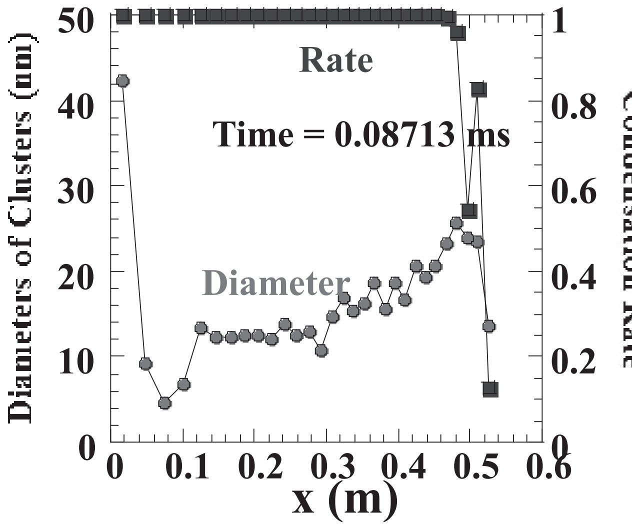

Fig. 2 Diameters of clusters and condensation rate.

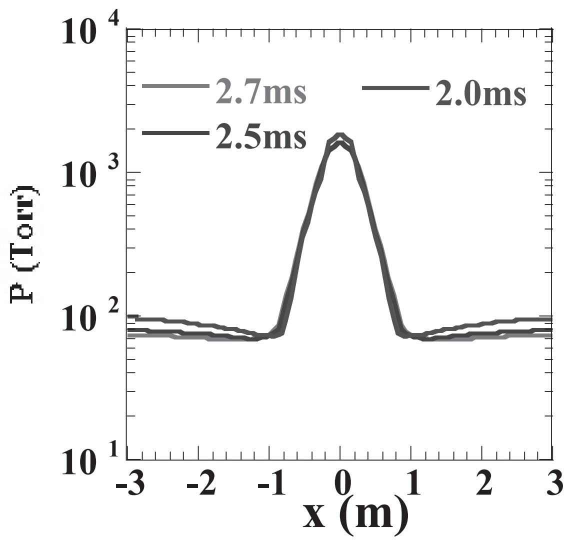

Fig. 3 Time development of velocity profiles.