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Control of Imploded Core Plasma by Using 12 beams of Gekko XII
12ビーム爆縮による爆縮コア制御

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The new laser arrangement to implode a fast ignition target, 12 beams implosion, is tested by using Gekko XII laser in Osaka university. The 3 laser beams near a cone are shifted not to irradiate a cone. Long gold cone is used to prevent the irradiation of 3 beams with fundamental frequency. It is found that the spherical symmetry of the imploded core plasma is improved and the motion of the imploded core plasma towards the cone is suppressed by using 12 laser beams. These results suggest that 12 beams implosion is a powerful concept to control the imploded core plasma.

1. Introduction

Fast ignition [1-4] is one of the proposed ways to achieve high fusion energy gain in inertial fusion research. It has the potential to achieve ignition and burn with significantly less energy than is required for the central ignition scheme. The fast ignition realization experiment (FIREX-I) project is going on at Osaka University. The goal of FIREX-I is to achieve heating of the compressed core to above 5 keV. For effective heating of imploded core, it is necessarily to control the implosion hydrodynamics. Usually, 3 laser beams near the cone are not used for implosion because they irradiate a cone. However, it was found that this laser unbalance caused an ununiform implosion and made the imploded core plasma move toward the cone. The imploded core plasma may collide with the cone tip and break it. This may become a serious problem of disturbing the effective generation of fast electrons from the cone tip. Therefore, we proposed the new concept of implosion, 12 beams implosion, and tried it in the fast ignition integration experiment.

2. Concept of 12 beam implosion

Figure 1 shows the schematic diagram of a cone-shell target and configurations of the 3 laser beams near the cone. The dotted line shows an original configuration of 3 laser beams. In 12 beams implosion experiment, these 3 laser beams are shifted not to irradiate a cone as shown in Fig. 1 with the solid line. Long cone is used to prevent the irradiation of 3 laser beams with fundamental frequency inside a cone. (The conventional cone size is shown as broken line in Fig. 1.)

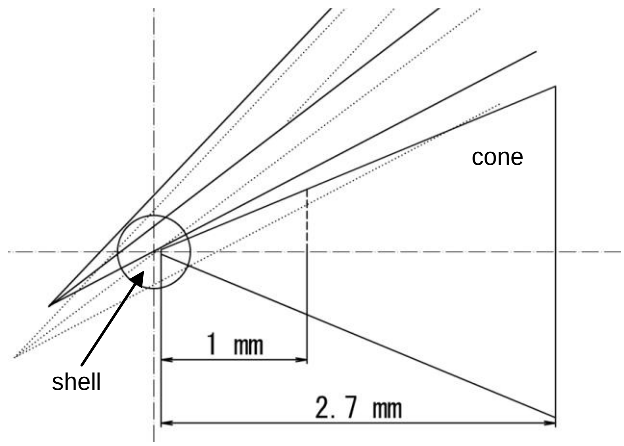

Fig.1. Schematic diagram of a target and configurations of 3 laser beams near the cone.

3. Experiment

The experiments were performed using Gekko XII and LFEX laser system [5] at the Institute of Laser Engineering, Osaka University. The wavelength of the GXII laser is 0.53 micron and the pulse duration is 1.5ns. The total energy of the GXII implosion laser was about 2 kJ. The wavelength of the LFEX laser is 1.05 micron and the pulse duration is set to 2 ps. The targets were deuterated plastic shells with long gold cones. The diameter of the shells was about 500 micron. A distance between the cone tip and the center of its shell was about 50 micron.

X-ray framing camera (XFC) [6-8] was used to obtain the time-resolved 2 dimensional X-ray images of the imploded core. XFC can record images in every 80 ps with a high spacial resolution (17.3 micron). In the fast ignition experiment, hot electrons are generated and emit sub-MeV to MeV energy X-rays through bremsstrahlung. These high energy X-rays cause high background noises and make measurements difficult. X-ray reflectors made of platinum X-ray mirrors were used to discriminate high energy X-rays and thermal X-rays. Shields made of lead are introduced to XFC in order to block direct incidence of high energy X-rays which make noises.

4. Results and Discussions

Figure 2 (a) and 2 (b) show X-ray images of imploded core obtained in 9 beams implosion and 12 beams implosion, respectively. The position of the chamber center is shown as a white cross. It is clearly seen that the imploded core plasma shows more spherical form in 12 beams implosion than that in 9 beams implosion. In 9 beams implosion, the imploded core is generated near the cone tip and moves toward the cone. On the other hand, in 12 beams implosion, the imploded core plasma is generated away from the cone tip and moves toward the cone slowly. Figure 3 shows the velocity of the imploded core estimated from X-ray images. It is shown that the velocity of the imploded core plasma in 12 beams implosion is suppressed by about half of that in 9 beams implosion. These results show that 12 beams implosion is effective way to generate spherical and stable imploded core plasma. We are trying to estimate the motion of the imploded core plasma by using computer simulation. The details of the imploded core plasma generated in 12 beams implosion experiment, such as the density and the temperature, will be measured in the next experiment.

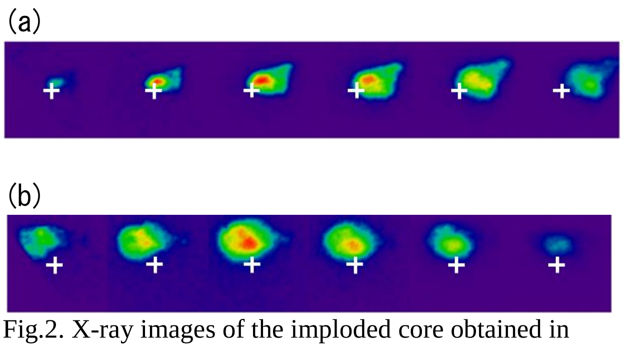

Fig.2. X-ray images of the imploded core obtained in (a) 9 beams implosion and (b) 12 beams implosion.

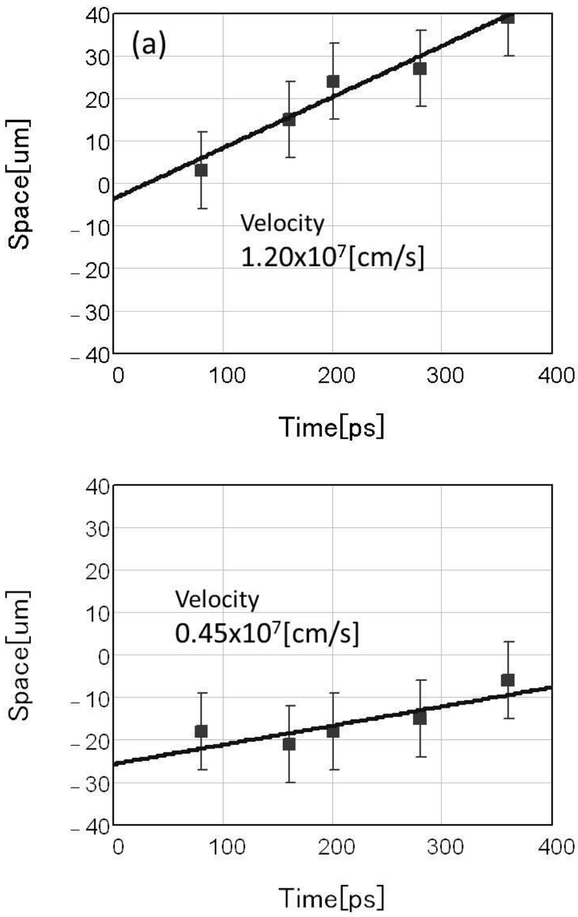

Fig.3. The velocity of the imploded core estimated form the X-ray images obtained in (a) 9 beams implosion and (b) 12 beams implosion.

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