§65. Formation of High Areal Density Core Plasma Using Slow Velocity Implosion

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In fast ignition scheme, the high energy electron or ions is applied to achieve the ignition condition of the temperature, where a central hot spot (CHS) is not required [1]. That is, the implosion core required for fast ignition system is different from that of the CHS scheme. Only the main fuel of the low temperature and high density is required in fast ignition. Therefore, it is necessary to design targets, which is different from that of the CHS[2].

One of the realistic solution is "slow velocity implosion" scheme, where a hot spot is not formed. Another advantage of the scheme is the suppression of the Rayleigh-Taylor instability. In order to avoid the mass density reduction due to hydrodynamic instability, the acceleration of the imploding shell should be kept low. In addition, reducing the velocity of the inner shell is important to prevent stagnation, and the keeping the shell in low isentrope is ideal. After these theoretical study, it is necessary to verify the scheme experimentally in near future. A preliminary experiment for the scheme is planned to realize the concept of the slow velocity implosion. In this year we focus on the pulse shaping which is most important technical method.

Due to the delay of the installing the arbitrary laser pulse shaping system, our experiments were postponed in this financial year. The experimental data which was obtained last year was analysed. Also computational simulations were conducted to design next coming experiments.

Experiment design and preparation

Simulation conditions are based on the specification of the current direct drive implosion laser GXII[3]. The total energy and the wavelength of the laser are assumed as 3.3 kJ and 0.53 μm respectively. The tailored laser pulse is applied and its duration is limited to 4.5 ns due to the GXII limitation. An r-t diagram is shown in Fig.1 which is simulated using 1-D code (Fig.1). The implosion velocity reaches 1.6×10^7 cm/s which is half of conventional implosion. In this design work the laser pulse shaping is one of the most important factor, and the same pulse shape should be reproduced in experiment. The 2-D simulation is executed with the same conditions. Averaged density, radius, and averaged ion temperature of core are 126 g/cm^3, 24 μm and 30 eV respectively (Fig. 2). In addition, simulation with non-uniform laser irradiation are considered, where the robustness of the slow velocity implosion was confirmed. Though high density core is form successfully, there are some points to be noticed. The CD shell near the gold cone is not accelerated effectively, and stranded. In the 2-D target design, there are still room to study with the realistic laser pulse shape which will start operation next year.

Preparation of the experiment is in progress. For example, VISAR (Velocity Interferometry System for Any Reflector) was demonstrated under the severe pre-heat environment. Cu-coated target vanished the noise due to the pre-heat when shock breakout time was measured, as well as SOP (Streaked Optical Pyrometer)[4].

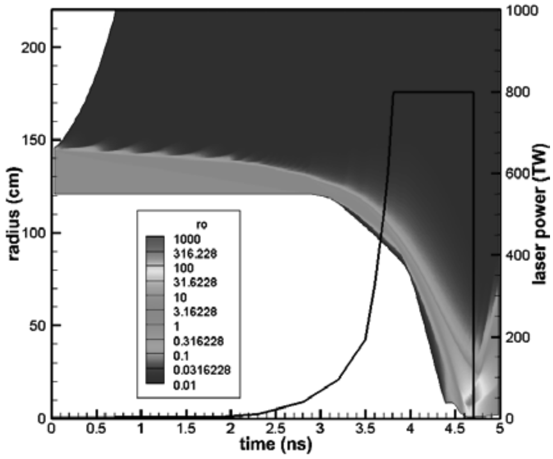

Figure 1. Optimized slow velocity implosion. r-t diagrams with filled colors and laser power. The implosion velocity reaches 1.6×10^7 cm/s which is half of conventional implosion.

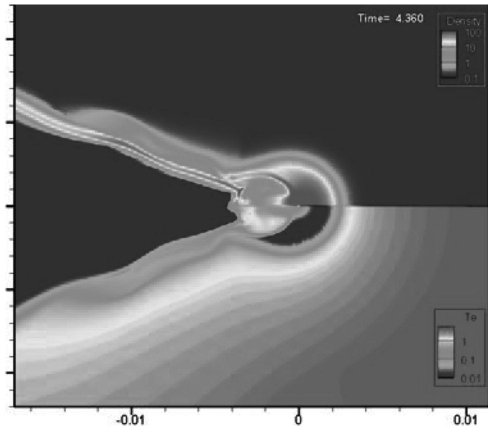

Figure 2. Mass density (above) and electron temperature (below) at maximum compression time.

Summary

Numerical simulations for experimental design using 1-D and 2-D simulation were conducted. In the result, we have confirmed that the slow velocity implosion has advantage in formation of high areal-density core plasma for fast ignition scheme. The arbitrary laser pulse shaping system which will be installed in GXII system enables this slow velocity implosion. Diagnostics system with VISAR and SOP for shockwave measurement were demonstrated in basic experiments.

1) R. Betti and C. Zhou, *Phys. Plasmas* **12**,110702, 2005.

2) M.H. Key, *Phys. Plasmas* **14**, 055502, 2007.

3) H. Nagatomo *et al.*, *EPJ Web of Conf.* **59** 03007, 2013.

4) K. Otani, K. Shigemori, *et al*, *Phys.Plasmas* **17**, 032702, 2010.