

## Quasi-one-dimensional Target by using Intense Ion Beams toward High Energy Density Astrophysics

大強度イオンビームを利用した高エネルギー密度宇宙物理実験のための  
準1次元標的の実現

Toru Sasaki, Takashi Kikuchi, Nob. Harada, Kazuhiko Horioka<sup>1)</sup>, and Nagatomo Hideo<sup>2)</sup>  
佐々木徹, 菊池崇志, 原田信弘, 堀岡一彦<sup>1)</sup>, 長友英夫<sup>2)</sup>

*Department of Electrical Engineering, Nagaoka University of Technology*  
*Kamitomioka 1603-1, Nagaoka, Niigata 940-2188, Japan*  
長岡技術科学大学 〒940-2188 新潟県長岡市上富岡町1603-1

<sup>1)</sup> *Department of Energy Sciences, Tokyo Institute of Technology*  
*Nagatsuta 4259, Midori-ku, Yokohama, 226-8502, Japan*

1) 東京工業大学 〒226-8502 神奈川県横浜市緑区長津田町4259

<sup>1)</sup> *Institute for Laser Engineering, Osaka University*  
*Yamadaoka 2-6, Suita, Osaka, 565-0871, Japan*

2) 大阪大学レーザーエネルギー学研究センター 〒565-0871 大阪府吹田市山田丘2-6

We proposed HED experiment based on intense ion beams as possible parameters of KEK digital accelerator. New target plasma, which was point-spot like spherical radiation source, was generated by the programed intense ion beams. We also investigated the radiation hydrodynamics based on the intense ion beams. To generate the well-defined plasma, we calculated the spherical target using intense ion beams with 1 mm in radius. The results indicated that the spherical target plasma could be point-spot like temperature distribution and the target size was about 0.4 mm full width of half maximum.

### 1. Introduction

High energy density physics (HEDP) is of interest in the efficient implosion of the inertial confinement fusion, the originating Solar Systems evaluated by the interior of giant planets as the Jupiter and the Saturn, and the generating process of highly energetic particles in astrophysical phenomena as the Gamma-ray burst, and so on [1]. Understanding these behavior and/or structure, we should have exact data on the equation of state (EOS) and the transport properties of electron and radiation in high energy density (HED) state. HED state of matter, which is categorized as a warm dense matter (WDM), a hot dense matter (HDM), and a radiation dominated matter (RDM), has a potential of abundant scientific discovery including the properties of plasma [2].

Intense ion beams, which are provided by the induction systems, are opening up an attractive branch for HEDP [3-10]. Accelerators producing opportunely tailored energies of intense ion beams are promising energy drivers for inertial fusion energy and are also expected to be able to provide a useful tool for creating HED matters. Compared to the high power devices, the intense ion beams using induction technology [11] have many advantages;

in uniformity of energy deposition, in large volume of the samples compared to diagnostic resolution, in virtue of the long stopping range, in an advantageous environment for diagnostics, in an ability to heat a variety of target materials in a condition with high repetition rate and multiple beam lines.

For the HEDP study based on the ion beams irradiation, the target should be in equilibrium and as well-defined as possible to accurately diagnose the physical parameters. In this study, we propose a method to make a HED state of matter based on available beam parameters in KEK digital accelerator. In this paper, a spherical point-spot like radiator is discussed using intense ion beams.

### 2. Quasi-spherical plasma for radiation hydrodynamics experiments based on intense ion beams

The hydrodynamics dominated by radiative energy flux and pressure plays a crucial role in not only for exploring astrophysical phenomena but also for evaluating the efficiency of hohlraum target for ICF driven by HIBs or lasers [1,12]. Especially, the explosion process in supernova is strongly affected by the radiation transfer in a wide range of parameters from optical thick to thin condition.

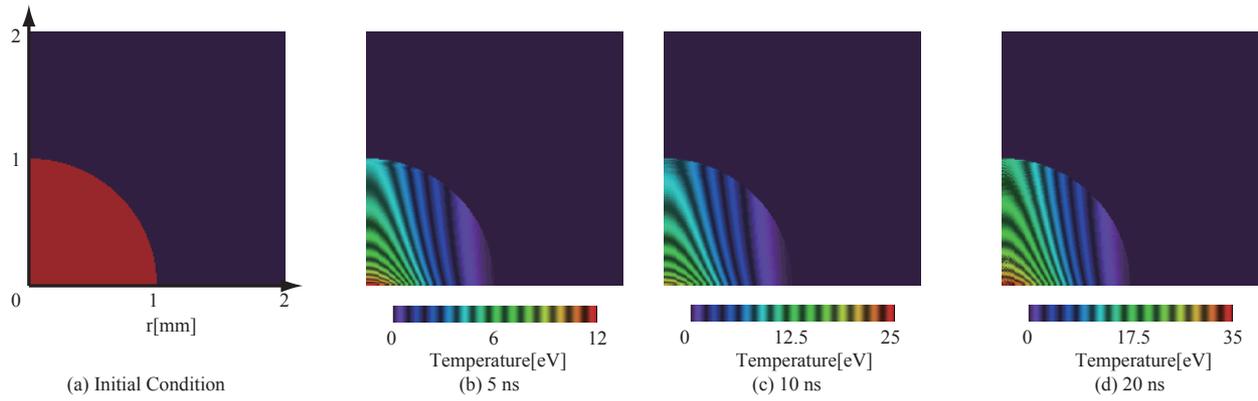


Fig. 1 Time evolution of spherical target irradiated by Argon ion beams with  $2 \times 10^{13}$  per bunch.

Then, we cannot determine directly the origin of radiation from the astronomical observation due to the unclarified effects. In order to study such processes, we should evaluate the energy transfer in dense high temperature matter. In a region from HDM to RDM, we should consider both the hydrodynamic energy flux and the radiation flux. The focusing beams as KEK Digital Accelerator with PS-ring are able to produced both HDM and RDM conditions [2].

We calculated the hydrodynamics of target with two-dimensional spherical geometry, which is assumed aluminum solid target with 1 mm in radius. The detail of calculation is shown in Ref. [10]. In this calculation, the beam radius is set to be 1~mm with a Gaussian distribution. The beam duration is 100 ns, and the beam particle number is  $2 \times 10^{13}$  argon ions with monotonic particle energy (1.67 GeV), which is considered to the stopping range in the target.

Figure 1 shows preliminary results of the evolutions of temperature at each time. As shown in Fig. 1, the point-spot like temperature distribution can be generated by the light ion beams. The radius of generated point-spot plasma is 0.4 mm full width of half maximum at center of target. It might indicated that the more smaller spherical plasma is created by irradiation of smaller beam radius.

### 3. Summary

We proposed HED experiment based on intense ion beams as possible parameters of KEK digital accelerator. New target plasma, which was point-spot like spherical radiation source, was generated by the prograded intense ion beams. We also investigated the radiation hydrodynamics based on the intense ion beams. To generate the well-defined plasma, we calculated the spherical target using intense ion beams with 1 mm in radius. The results indicated that the spherical target plasma could be point-spot like temperature

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