【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Mathematical and Physical Sciences)

Title of Project : Proof of Fast Ignition Scheme Using Super-penetration of Laser Light

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Research Project Number : 15H05751 Researcher Number : 70171741
Research Area : Plasma Science
Keyword : Fast Ignition, Laser Self-focusing, Relativistic Electrons

【Purpose and Background of the Research】

Fast ignition scheme of laser fusion is addressed to be an attractive option relative to the central ignition. We have found "Super-penetration", which can bring an intense laser light to a high density plasma via. relativistic laser self-focusing. In fast ignition a spherical fuel shell should be imploded to a 1000 times solid density and then should be fast heated by injecting an ultra-short pulse, but with energy enough to ignite the fuel. We will first optimize the Super-penetration using planer plasma with a large scale, and then will apply this Super-penetration to an imploded shell with a deuterium-tritium fuel for proof of fast heating.

【Research Methods】

[First Year] Necessary diagnostics are developed that include multichannel electron spectrometer, Thomson parabola ion spectrometer, backscattered laser spectrometry system etc.
[Second Year] Single pulse laser is used for optimization of Super-penetration.
[Third Year] Double pulse laser is used for optimization of Super-penetration.
These optimization will focus on (1) if Super-penetration can self-focus as a straight single channel over critical density plasma density under a mm scale length plasma condition, (2) if fast electrons are emitted to a forward direction along the laser axis within a narrow (like 10^{o} of full width of half maximum) solid angle, and (3) if fast electron energy spectrum can fit well to heat a high density core.

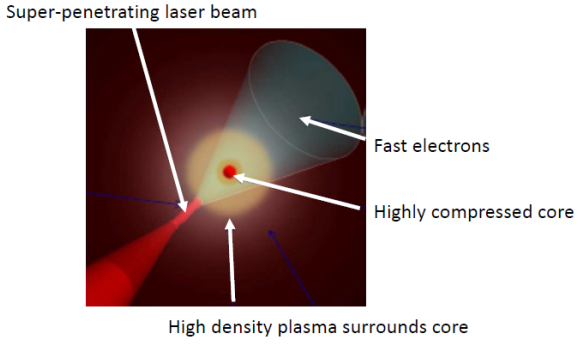

Figure 1 Fast heating scheme using Super-penetration of laser light

[Fourth Year] Optimized super-penetration is applied to a high density CD shell implosion.
[Fifth Year] Optimized Super-penetration is applied to a high density of DT shell implosion.
Typical experimental lay out is shown in Fig. 1.
These experiments are only possible at the Laboratory for Laser Energetics, University of Rochester, N.Y., U.S.A. Collaboration has been established between Osaka U. and U. of Rochester for more than 10 years.

【Expected Research Achievements and Scientific Significance】

Since a high density fuel core has been already established at LLE, Univ. Rochester using DT fuel, we can utilize this core and the experimental platform at LLE. Super-penetration laser energy is about 1 kJ in 1 to 10 psec pulse width while the imploded core energy is of the order of 300 J. If 50 % heating efficiency is obtained for the core, the core internal energy may be doubled. This corresponds to more than 10 times the neutron increase in the experiment. If this fast heating is achieved, it is possible to estimate the energy required for fast ignition for the real ignition experiment. At the same time, this physics related to Super-penetration will be utilized to Non-linear plasma physics, particle acceleration, laboratory astrophycis, equation of state, new material production under extreme condition.

【Publications Relevant to the Project】

Efficient propagation of ultra-intense laser beam in dense plasma, H Habara, S Ivancic, K Anderson, D Haberberger, T Iwawaki, C Stoeckl, KA Tanaka, Y Uematsu, and W Theobald, Plasma Phys. Contr. Fus., 57, 064005 (2015).
Collimated fast electron beam generation in critical density plasma, T Iwawaki, H Habara, S Baton K Morita, J Fuchs, S Chen, M Nakatsusumi, C Rosseaux, F Flippi, W Nazarov and KA Tanaka, Phys. Plasmas 21, (2014).

【Term of Project】 FY2015-2019

【Budget Allocation】 145,000 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.eie.eng.osaka-u.ac.jp/le/en/