Target implosion uniformity in heavy ion fusion

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It is well known that heavy ion beams (HIBs) have a high controllability, a high driver energy conversion efficiency and a high repetition rate. Wobbling HIBs are easily available as the energy driver in inertial fusion.

Previous studies have shown that spiral wobbling HIBs mitigate the illumination non-uniformity [1]. Figure 1 shows a schematic diagram for the spiral wobbling beam. For the spiral wobbling beam the beam radius changes from 3.1mm to 3.0mm at $t = 1.3\tau_{\mathrm{wb}}$. Here τ_{wb} is the time for one rotation of the wobbling beam axis. The beam rotation radius becomes 2.0mm at $t = 2.0\tau_{\mathrm{wb}}$. After that, the beam rotation radius is 2.0mm.

If we actively impose the perturbation phase by the driving energy source wobbling or oscillation, and so if we know or define the phase of the perturbations imposed actively, the perturbation growth can be controlled in a similar way as the feedback control mechanism. The wobbling HIBs define the perturbation phase. This means that the perturbation phase is known, and so the perturbations successively imposed are superposed in the plasma. The HIBs accelerate the fusion target fuel with a large acceleration in inertial fusion. The wobbling HIBs would provide a small oscillating acceleration perturbation in the target implosion. So the Rayleigh-Taylor instability growth would be reduced by the phase-controlled superposition of the HIBs perturbations in heavy ion inertial fusion [2].

The purpose of this study is to evaluate the mitigation of the non-uniform implosion by the spiral wobbling HIBs.

Figure 2 shows a non-uniformity history of the target ion temperature. The non-uniformity is evaluated by the total relative root-mean-square (RMS). In Fig. 2, the target is a spherical aluminum shell having a thickness of 1 mm, and the intensity of the beam is constant at 100TW. The beam irradiation time duration is 40 ns. The Pb beam particle energy is 8 GeV. The total beam number is 32.

In conclusion, Fig. 2 demonstrates that the non-uniformity is reduced well by the spiral wobbling HIBs. By the HIBs wobbling motion, the non-uniform illumination is mitigated, and the Rayleigh-Taylor instability growth is mitigated by the oscillating acceleration perturbation induced [2].

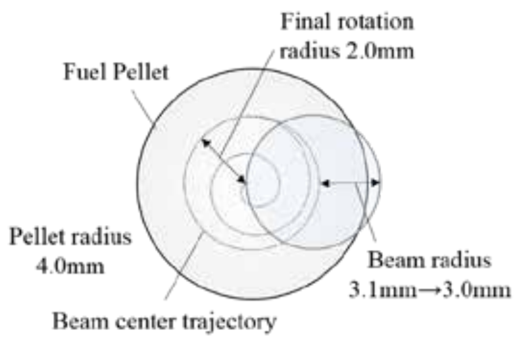

Fig. 1 Schematic diagram for the spiral wobbler.

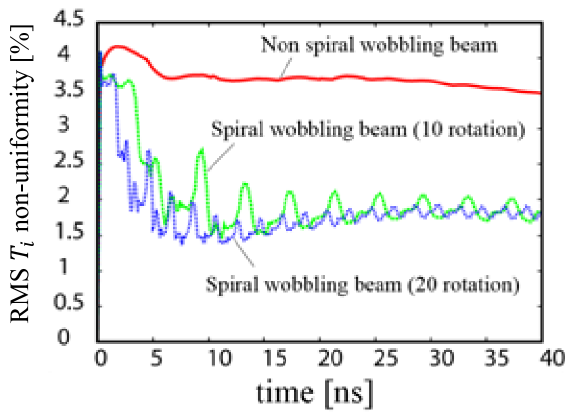

Fig. 2 Non-uniformity of ion temperature.

Acknowledgements: The work was partly supported by JSPS, MEXT, CORE (Center for Optical Research and Education, Utsunomiya University), ASHULA, ILE / Osaka University, and CDI (Creative Department for Innovation, Utsunomiya University).

References

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