Uniform implosion of fuel target in heavy ion fusion

R. Sato¹, K. Uchibori¹, H. Katoh¹, T. Karino¹, S. Kawata¹, A. I. Ogoyski²
¹ Graduate School of Engineering, Utsunomiya University
² Department of Physics, Technical University of Varna

In inertial fusion, the fusion fuel compression is essentially important to reduce an input driver energy [1]. In order to realize inertial confinement fusion (ICF), a sufficient energy gain is required. A uniform fuel implosion is essentially required to release the fusion energy. In order to realize the uniform implosion, the non-uniformity of the implosion acceleration should be less than a few % [2, 3]. In this research, we propose to employ wobbling heavy ion beams (HIBs) to reduce the HIB illumination non-uniformity and the Rayleigh-Taylor instability (RTI) growth.

The wobbling HIBs would provide a small oscillating acceleration perturbation in an inertial fusion fuel target during the target implosion. Therefore, the RTI growth is reduced by the phase-controlled superposition of perturbations in heavy ion inertial fusion (HIF) [4, 5].

Figure 1 shows a schematic diagram for the spiral wobbling beam. When we employ the spiral motion of each HIB axis, the initial imprint of the HIBs irradiation non-uniformity is significantly reduced. Figure 2 presents a successful non-uniformity smoothing effect on the fuel target temperatures for the case with the spiral wobbling HIBs at 29ns before the void closure. Figure 2 confirms the mitigation of implosion non-uniformity by the wobbling HIBs. Figure 3 shows non-uniformity histories of the target ion temperature. The non-uniformity is evaluated by the total relative root-mean-square. Figure 3 demonstrates that the implosion non-uniformity of the DT fuel target is reduced well by the spiral wobbling HIBs. Figure 4 demonstrates that the fusion energy gain increases in high rotation frequency.

In conclusion, we have confirmed that the implosion non-uniformity is successfully mitigated by using the spiral wobbling HIBs for the HIBs irradiation system.

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References