UNIFORM FUEL TARGET IMPLOSION IN HEAVY ION INERTIAL FUSION

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In inertial confinement fusion the target implosion non-uniformity is introduced by a driver beams' illumination non-uniformity, a fuel target alignment error in a fusion reactor, the target fabrication defect, et al. For a steady operation of a fusion power plant the target implosion should be robust against the implosion non-uniformities. In this paper the requirement for the implosion uniformity and the hotspot dynamics are first discussed. It is reconfirmed that the implosion uniformity should be less than a few percent [1]. Then non-uniformity mitigation mechanisms in the heavy ion beam (HIB) illumination are discussed in heavy ion inertial fusion (HIF) [2-5]. A density valley appears in the energy absorber, and the large-scale density valley also works as a radiation energy confinement layer, which contributes to a radiation energy smoothing [5]. In HIF the wobbling HIBs illumination also contribute to reduce the Rayleigh-Taylor instability (RTI) growth and to realize a uniform implosion [2-4].

In HIF there are several smoothing mechanisms for the target implosion non-uniformity introduced: the large-scale density-gradient smoothing effect on the RTI [5], the radiation smoothing effect in a direct drive target [2] and the RTI growth mitigation by the HIBs wobbling illumination [2-5]. The density gradient scale length L in a HIF target is the order of ~500 micron m or so. The large scale L of the density gradient comes from the long scale length of the HIBs energy deposition in a material.

By the expression of the RTI growth rate of $\gamma \approx \sqrt{gk/(1+kL)}$ [6, 7], the RTI modes with the long wavelength $2\pi/k$ become dominant in the HIF targets. On the other hand, the large density gradient scale L also produces the large-scale density valley in the HIBs energy deposition layer in the target radial direction. Inside the density valley the radiation energy could be confined, and the radiation energy is transported in the lateral direction along with the density valley to smooth the HIBs energy deposition non-uniformity.

The HIB accelerator has a capability to control and rotate the HIB's axis precisely with a high frequency. The wobbling HIBs would induce the dynamic mitigation of the RTI in HIF. Normally the perturbation phase is unknown so that the instability growth rate is discussed. However, if the perturbation phase is known, the instability growth can be controlled by a superposition of perturbations imposed actively: if the perturbation is induced by, for example, a driving beam axis oscillation or wobbling, the perturbation phase could be controlled and the instability growth is mitigated by the superposition of the growing perturbations [2-5].

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