Experimental investigation of laser ablated hydrodynamic instability at late driving period

Yu Dai[1,2], Haochen Gu[1,2], Yufeng Dong[1,2], Peng Zhou[3,4], Dawei Yuan[4,5], Zhe Zhang[1,3,4], Xiaohui Yuan[3,4], Yutong Li[1,2,3,6], Jie Zhang[1,3,4].

[1] Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, [2] School of Physical Science, University of Chinese Academy of Sciences, [3] Collaborative Innovation Center of IFSA(CICIFSA), Shanghai Jiao Tong University, [4] Key Laboratory for Laser Plasmas (MoE), School of Physics and Astronomy, Shanghai Jiao Tong University, [5] CAS Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, [6] Songshan Lake Materials Laboratory

e-mail(speaker): daiyu@iphy.ac.cn

Hydrodynamic instability induced by laser (or x-ray) ablation is a major concern in inertial confinement fusion (ICF). As an intrinsic problem in implosion scheme, hydrodynamic instability causes fuel mixture and shell rupture not only reducing the implosion performance but also increasing the difficulty of ignition. It has been intensive studied that instability develop when ablation happens. However, significant perturbation growth has been observed when laser is over whose growth rate may exceed that in acceleration phase. Experimental results combined with hydrodynamics simulation indicate that the release of pressure which reserved in the solid density region causes this phenomenon. And lack of ablative suppression furtherly enhances modulation growth. Besides, rarefaction wave generated from the rare side thoroughly pulls apart the target which should also be taken into consideration when the shell is compressed into a thin slice. This experiment is carried out on Shenguang-II laser facility using side-on x-ray backlight photography to measure the areal mass nonuniformity during and after the laser ablation period. Thin plastic plane with sinusoidal modulation on the front side is directly irradiated by laser beams. Framing camera provides satisfied results to restore the fluid process. The preadded perturbation grows from linear phase to nonlinear phase dominated by Rayleigh-Taylor instability. After a period of time, sinusoidal modulation turns into "spikes" and "bubbles". When laser ablation is over, rarefaction wave generates from the rare side whose intensity and speed are determined by the laser's power density and waveform. At the same time, "bubbles" run through the whole target while "spikes" further stretch resulting in secondary growth of mass nonuniformity.

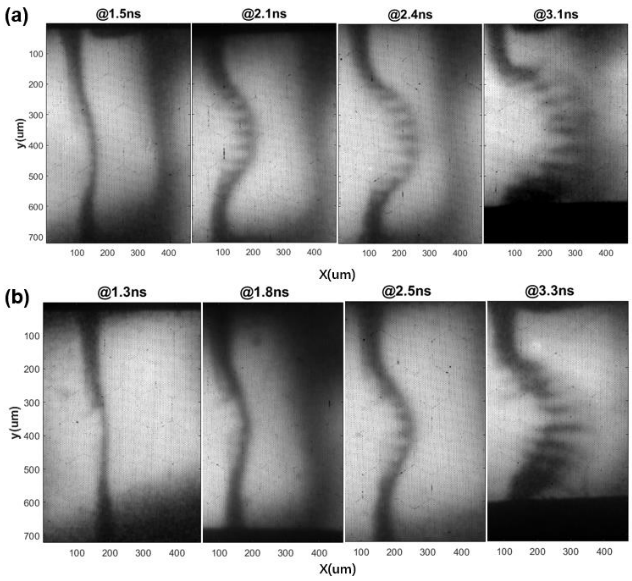

Figure 1. Experimental results are shown upside with respective time point. 20um plastic plane is irradiated with different laser energy. (a) 320J (b) 600J. Laser duration is 2.5ns and waveform is square wave for both shots.