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Genetic Algorithm for waveform optimization to suppress RT instability

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Laser fusion is of great importance for the clean energy revolution, which is essential for human's sustainable future. Rayleigh-Taylor instability (RTI) is a fluid instability that occurs at the interface where the directions of density gradient and pressure gradient are not the same. In central ignition schemes, both the outer interface of the ablation layer during acceleration and the inner interface of the fuel during stagnation meet the conditions for RT instability growth. The RT instability amplifies non-ideal factors in the implosion process, affecting fusion ignition and burning efficiency. RT instability is one of the biggest challenges for achieving robust ignition and high-gain burn in laser fusion. [1].

Studies on the ablative RTI of modulated targets demonstrate the linear theory[2] can adequately describe the development of ablative RT instability for planar targets. Machine learning based waveform optimization[3] can effectively suppress the development of ablative RT instability. In this work, the amplitude of RT instability with a wavelength of 140 μm at the end of the laser pulse is decreased by nearly 35% compared to before optimization. The early stage of ablative RTI in spherical targets can be well described by the linear theory of ablative RTI. Optimizing the waveform under spherical targets is expected to significantly reduce the RT instability during the implosion process.

References

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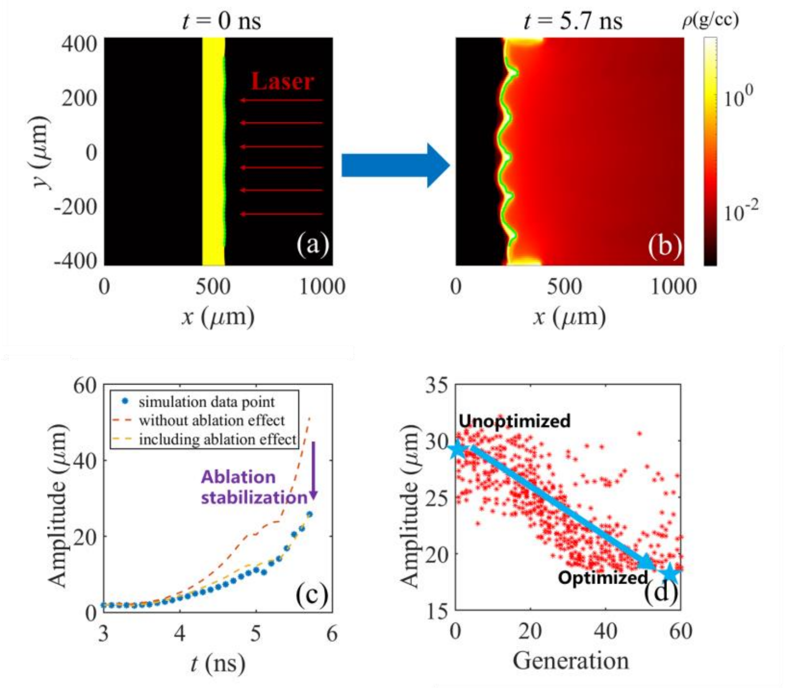

Figure 1. (a) Initial configuration of laser ablated planar modulated target (b) Position of planar target and ablation surface (green line) at the end of laser pluse (c) The simulation results and theoretical curves of the RT instability amplitude of the ablation surface, theoretical curves including and excluding ablative stabilization are presented (d) Optimization effect of genetic algorithm on the instability amplitude of ablation surface at the end of laser end time