Mitigate the Rayleigh-Taylor instability by tuning the electron heating flux in the double-cone ignition scheme

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Laser fusion has a potential to provide humanity with an ultimate energy with low-carbon release. In 2022, the Lawrence Livermore National Laboratory achieved the fusion ignition target with a fusion energy gain greater than unit for the first time by using a 2.05 MJ laser energy [1], hailed as the Wright Brothers Moment of controlled nuclear fusion. The double-cone ignition (DCI) scheme is a novel fusion scheme that combines laser directly drive and magnetic field guided fast ignition [2-4]. The DCI scheme may achieve a high energy gain with a relatively small laser energy.

In order to achieve high-density compression, it is crucial to control the Rayleigh-Taylor instability during the compression process as shown Figure 1. In this work, we propose a machine learning method to suppress the RT instability by optimizing the electron heating conduction. The evolution of RT instability in planar and spherical configurations are investigated. Simulation results of MULTI-2D program [5] indicate that by controlling the time-varying electron heating flux, it is possible to suppress the RT instability while ensuring a high laser ablation efficiency. Thus, the high-density plasma required by the high gain fusion can be obtained via fine-tuned drive laser pulses.

References

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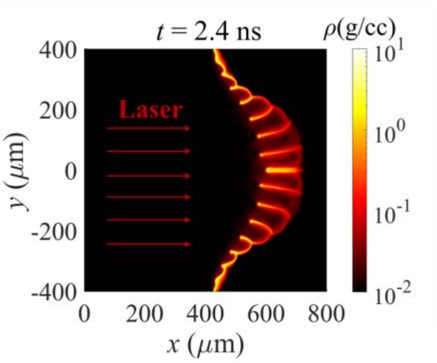

Figure 1 The development of RT instability during the compression driven by laser