Increasing hydrodynamic efficiency in laser direct-drive implosions using double-ramp pulses

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Temporal intensity gradient of laser pulse plays a critical role in laser direct-drive ablation process. In a planar direct-drive implosion experiment at a peak laser intensity over 10^{15} W/cm^2, we have demonstrated that the hydrodynamic efficiency can be greatly enhanced by matching the electron-ion collision mean free path with the conduction zone length, through tailoring the slopes of a double-ramp laser pulse. Compared with a square pulse, the burn-through depth is increased over 140% and the shell velocity is increased by a factor of 2.2 with an optimized double-ramp pulse. As a result, the general hydrodynamic efficiency is enhanced by 5-7 times. Analytical analysis indicates the intensity should be limited below ~$3.2*10^{15}$ W/ (cm^2 ns), which enables an efficient conversion of absorbed laser intensity into thermal electron flux. These results indicate a special route to improve the hydrodynamic efficiency in NIF-scale direct-drive implosion experiments.

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