Semi-analytic modeling of shock ignition

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The shock ignition (SI) scheme for inertial fusion confinement [1] separates the compression and the ignition of a Deuterium-Tritium target in two steps. The target is first imploded at low velocity to reduce the hydrodynamic instabilities. Then, a high power laser spike launches a shock that increases in pressure during convergence and ignites the fusion reactions in the center of the target. According to numerical simulations, the ignitor shock is seeded by an ablation pressure of 300 Mbar with a spike laser intensity of $5 - 10 \times 10^{15}$ $\mathrm{W/cm^2}$ [2]. The key features of shock ignition are the generation of this ablation pressure, the shock pressure amplification by at least a factor of thirty into the target shell and the shock coupling to the hot-spot.

We present here a new semi-analytical hydrodynamic model to describe the ignitor shock from its generation until the fuel ignition. During the shock propagation in the shell several processes contribute to its pressure amplification. The shock is propagating into a non inertial medium with high density and pressure radial gradients and an overall pressure increase with time. The collision with a returning shock coming from the assembly phase of SI enhance furthermore the ignitor shock pressure. The transmission efficiency of the shock through the shell/fuel interface depends on the impedances of the shell and the fuel which evolve with time. Also the increase of the hot spot pressure reduces the ignitor shock capacity to heat the hot spot. Thus the shock timing plays an important role in the shock coupling to the hot spot.

A semi-analytic criterion for ignition is expressed and the robustness of the SI scheme depending on the main implosion parameters is discussed. The analytical results presented here are confirmed by series of dedicated hydrodynamic simulations.

References

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