Kinetic Simulations of Parametric Instabilities and Hot Electrons Production in the Context of the Shock Ignition

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The shock ignition (SI) scheme in laser-driven Inertial Confinement Fusion (ICF) is attractive since it allows significant reduction of the driving energy requirements and improved hydrodynamic stability. It is achieved with a strong shock which is launched at the end of implosion phase by abruptly raising the laser intensity by one or two orders of magnitude. However, laser–plasma interactions at this stage are strongly nonlinear and the physics of laser spike absorption is important, while it is still one of the major unknowns in the shock-ignition scenario.

Recent experiments at Prague Asterix Laser System (PALS) conducted under the conditions compatible with SI and at wavelength of 1.315 μm have shown that a large portion of laser energy can be reflected by Stimulated Raman Scattering (SRS) with a relatively small number of generated hot electrons. A big difference in the absorption process and hot electron generation is not well understood. Simulations of the laser-plasma interaction for the conditions of this experiment are necessary.

In this work, we demonstrate the kinetic simulations of laser interacting with the plasma corona. The Particle-in-cell (PIC) simulations are based on the relativistic electromagnetic code EPOCH. The initial conditions are obtained from the hydrodynamics simulations. A large fraction of laser energy is transferred into hot electrons with temperature higher than hundreds keV and strong SRS accompanied with cavitation at quarter critical density and density profile modification (steepening around critical density). It is observed that the SRS becomes stronger and shifts to the less dense plasma in front of the quarter critical density region. The temperature of hot electrons oscillates due to the competition between different instabilities. A broad SRS spectrum is observed with many fractional harmonics which is a signature of strong secondary parametric instabilities. The processes of laser beam filamentation and two-plasmon decay are also discussed.

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.