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Particle in cell simulations of laser absorption in low density foams

Low-density foam targets play an important tole in inertial confinement fusion (ICF)research, having been proposed as ablators for the fusion capsule. Due to their non-trivial internal structure, they can enhance absorption and reduce hydrodynamic instabilities. The interaction of intense lasers with the foam microstructure, made by solid filaments and voids, presents unique challenges in modeling due to very different scales in the problem. In this work, we employ two-dimensional particle-in-cell (PIC) simulations, using the SMILEI code, to study laser-generated plasma behavior of a plastic (TMPTA) filament (radius $0.1\ m$, initial density $1g/cm^3$) irradiated by a high-intensity laser (wavelength 0.35 µm, intensity $10^{14}\ W/cm^3$) under both S and P polarizations. This problem has been already considered in [1], which has been taken as a starting point of the present work. Our results reveal that foam homogenization is governed by a combination of collisional and resonance absorption. During the initial 6–8 ps, the ablation causes an initial expansion of the filament, with the removal of material. Subsequently, the filament undergoes radial compression, with collisional heating dominating the energy deposition form about 8 ps, driving the complete expansion. Simulations with and without collisions demonstrate that collisional absorption enhances energy transfer to electrons, accelerating homogenization and suppressing resonance effects. The interplay of these mechanisms results in rapid plasma formation and efficient ion heating (average energies ~5 keV).

[1] Shekhanov, S. et al. (2023) 'Kinetic modeling of laser absorption in foams', Physics of Plasmas, 30(1), p. 012708.

Author: ZURZOLO, Antonio (Dipartimento Energia, Politecnico di Torino, 10129 Torino, Italy)

Co-authors: FROIO, Antonio (Dipartimento Energia, Politecnico di Torino, 10129 Torino, Italy); Dr CONSOLI, Fabrizio (ENEA C.R. Frascati - Nuclear Department, 00044 Frascati, Italy); PEREZ, Frederic (LULI); Dr CIPRIANI, Mattia (ENEA C.R. Frascati - Nuclear Department, 00044 Frascati, Italy); Dr TESTONI, Raffaella (Dipartimento Energia, Politecnico di Torino, 10129 Torino, Italy); Prof. BONIFETTO, Roberto (Dipartimento Energia, Politecnico di Torino, 10129 Torino, Italy)

Presenter: ZURZOLO, Antonio (Dipartimento Energia, Politecnico di Torino, 10129 Torino, Italy)

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