Numerical simulations of laser-plasma interaction with "nanostructured targets"

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In this contribution we report on Particle-In-Cell simulations of ultra-intense laser interaction with nanostructured foam targets.
Modern-day ultra-intense laser facilities are able to provide ultra short (~30 fs) laser pulses with a very high contrast (as high as $\sim 10^{10}$). Although at relativistic laser intensities (I > $\sim 10^{18}$ W/cm^2) any material becomes a plasma in a few laser cycles, the short duration and the high contrast of the laser pulse might allow the nanostructure of a target to survive long enough to influence the interaction
The study of ultra-intense laser interaction with nanostructured targets has attracted significant attention recently[1,2,3] (e.g. grating targets have been used to study plasmonic effects at high field intensities, arrays of nanowires have been irradiated to obtain extreme plasma temperatures...).
In this contribution we are particularly interested in random nanostructures with a very low average density. This kind of target is one of the very few available options to obtain near-critical plasmas for Ti:Sapphire laser system. A recent experimental campaign performed at GIST PW-class laser facility [4] has shown that targets consisting in a solid foil coupled with a near-critical foam layer are particularly attractive for laser-driven ion acceleration, leading to higher ion energies and a higher total number of particles with respect to simple flat foils. This effect is attributed to the very efficient laser-target coupling in the near-critical plasma [5]. However a foam target consists of nanoparticles (~10nm radius) aggregated in larger structures, whose scalelength is close to the laser wavelength. Thus with high contrast laser systems, the nanostructure of the foam might play a role during the laser-plasma interaction. In previous numerical simulations, foam targets have been modeled with a simple uniform near-critical plasma.We present results of 3D PIC simulations (performed with open-source piccante[6] code) of laser interaction with a realistic model of nanostructured foam targets, based on the well known Diffusion Limited Aggregation[7] algorithm. These more realistic simulations lead to a better agreement with the experimental results if compared with simulations performed with uniform near-critical plasmas, highlighting also the role played by the nanostructure and suggesting possible strategies to improve the properties of the accelerated ions.

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