Investigation of laser-driven foam homogenization for ICF applications and its influence on ion temperature

L. Hudec[1], D. Blackman[2], A. Gintrand[2], O. Klimo[1,2], J. Limpouch[1], R. Liska[1],
O. Renner[2,3], V. Tikhonchuk[2,4], and S. Weber[2]

[1] *FNSPE, Czech Technical University in Prague, Prague, Czech Republic*
[2] *Extreme Light Infrastructure ERIC, ELI Beamlines Facility, Dolní Břežany, Czech Republic*
[3] *Institute of Plasma Physics, Czech Academy of Sciences, Prague, Czech Republic*
[4] *CELIA, University of Bordeaux, CNRS, CEA, Talence, France*

Laser interaction with foam materials of low average density is a topic of great interest due to various applications in ICF or as secondary radiation sources. The addition of an extra foam layer to the ICF target capsule can improve implosion symmetry and suppress the formation of hydrodynamic instabilities in direct-drive ICF or increase the efficiency of laser to X-ray conversion in indirect drive. However, modeling of laser-foam interaction is difficult due to very different scale lengths involved, and the predictive capability of numerical simulations has not been proven yet. We present a recently developed multiscale model [1] along with the results from the concurrent experimental campaigns at the PALS laser facility that are used to benchmark the accuracy of the model. Our multiscale approach describes the laser-driven homogenization of individual foam elements as a competition between isothermal expansion (due to volumetric heating by electron heat flux) and surface ablation by the incident laser. The microscale model is formulated in terms of ordinary differential equations for mass, momentum, and energy conservation, and its parameters are chosen according to the detailed PIC simulations of laser-cylinder interaction [2]. Our results suggest that the ion temperature in foam materials should be significantly higher than the electron temperature due to the internal collisions of the plasma flows originating from the heterogeneous foam microstructure. This foam-specific property could provide an additional benefit in the context of ICF, as plasmas with elevated ion temperature could potentially help mitigate laser-driven parametric instabilities (such as Stimulated Brillouin Scattering) due to stronger damping of ion-acoustic waves. The impact of foam microstructure on ion temperature has been demonstrated in the latest PALS experiments where the plasma temperatures were determined from X-ray spectroscopy. The predictions from our hybrid foam model are in good agreement with the data acquired in these experimental campaigns and could therefore provide guidance for the use of underdense foams in various applications.

References

[1] L. Hudec et al., Physics of Plasmas **30**, 042704 (2023)
[2] S. Shekhanov et al., Physics of Plasmas **30**, 012708 (2023)