Simulations of electron and radiation preheat effects in laser-shocked 3D-printed plastic lattice media

K.H. Ma [1], R.W. Vandervort[1], N. Christiansen[1], T.A. Coffman[1], L.M. Green[1], B.M. Haines[1], Y. Kim[1], P.M. Kozlowski[1], R. Lester[1], D.W. Schmidt[1], C. Wong[1]

[1] *Los Alamos National Laboratory (United States of America)*

Los Alamos National Laboratory's Bosque campaign investigates how the mix [1] and thermalization of shell materials and fusion reactants affect fusion reactant rates. Here, mixing occurs via the shock-compression of a heterogeneous medium consisting of deuterated two-photon polymerization (2PP) 3D-printed lattices filled with tritium gas. Variations in lattice geometry, thickness, as well as gas fill composition enable a systematic approach in studying these mixing and thermalization effects. However, preheating from radiation and electron heat transport can alter the upstream lattice conditions, affecting the mixing behavior from shock compression.

In this study, we assess preheating effects on 2PP-3D lattice structures in shock-tube experiments conducted at the Omega laser facility [2]. In these experiments, OMEGA 60 beams irradiated a plastic ablator at one end of the shock tube at an intensity of 8 x 10^{14} W/cm^2, generating a shockwave into the lattice. A solid plastic witness disk was printed at the tube's center, and its expansion—captured radiographically—served as a diagnostic for preheating effects. This platform is subject to multiple preheating sources, including laser-generated hot electrons, hard X-rays, radiative shock preheat, and nonlocal electron heat transport.

Simulations are performed with the Eulerian radiation hydrodynamics code xRAGE. Radiative preheat effects are modeled with multigroup radiation transport, and electronic preheat effects are modeled with the reduced-order nonlocal electron transport model by Schurtz, Nicolaï, and Busquet (SNB). In this work, we extend the SNB framework to consider the effects of hot electrons on the experimental platform.

[1] B. M. Haines, R.C. Shah, et al., "*Observation of persistent species temperature separation in inertial confinement fusion mixtures*," Nat. Commun. 11, 544 (2020)

[2] R.W. Vandervort, N. Christiansen, et al., "*Observation of laser-driven and shock-driven preheat effects on 3D-printed, two-photon polymerization plastic lattices*" High Energy Density Physics, *In Press*

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