Measurement of preheat due to electron transport in warm dense matter

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We present a novel approach to study electron transport in warm dense matter. We studied the effect of preheat by hot electrons originating in hot plasma near the ablation front through dense regions of shocked CH foam using x-ray Thomson Scattering (XRTS) at the Omega facility. The XRTS measurement was combined with VISAR and optical pyrometry (SOP) providing a robust EOS measurement [1]. An evidence of significant preheat contributing to elevated temperatures reaching $17.5 - 35$ eV in shocked CH foam was measured by XRTS. These measurements were complemented by abnormally high shock velocities of $\sim 80$ km/s observed by VISAR and early emission seen by SOP. The experimental results were first compared to EOS tables [2, 3] in Hugoniot calculations confirming that CH temperatures in the range of 20–30 eV correspond to measured shock velocities and matched with simulations carried out by high-energy density code Cassio to confirm that preheat modified the shock jump conditions [4, 5]. In order to study the contribution of the nonlocal electron transport to the observed preheat we used the Plasma Euler and Transport Equations Hydro code (PETE), which is a Lagrangian fluid model that includes nonlocal transport hydrodynamic model (NTH) [6]. These simulations provided excellent agreement with the experiment. Additional simulation confirmed that the x-ray contribution to this preheat is negligible. These findings enable bench-marking of electron conduction models in conditions relevant to ICF, such as those employed in the modelling of experiments performed at the National Ignition Facility (NIF) and convection phenomena in white dwarfs.

References