Observation of nonlocal electron transport in Warm Dense Matter

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We present the first measurement of nonlocal electron transport on Warm Dense Matter (WDM) [1]. The experiment was carried out at the OMEGA laser facility, where we used 15 beams drove a fast compression wave in low-density CH foam generating WDM conditions. We combined multiple independent diagnostics including spatially and spectrally X-ray Thomson Scattering (XRTS), velocity interferometry (VISAR) and streaked optical pyrometry (SOP) to provide a robust measurement of the thermodynamic conditions in the sample. XRTS observed elevated temperatures within the compression wave reaching to $17-35$ eV, while the SOP and and VISAR both detected abnormally high shock velocities with a significant decay profile. The SOP diagnostic also registered early emission indicating presence of preheat of the cold material ahead of the compression wave. The experimental results were first compared with Cassio simulations, but consistency with the measurement was not found. These simulations in conjunction with FLYCHK calculations confirm that x-ray flux deposited in the CH was negligible.

In order to study the contribution of the nonlocal electron transport, we used the Plasma Euler and Transport Equations Hydro code (PETE), which is a Lagrangian fluid model that includes nonlocal transport hydrodynamic model (NTH) [2]. These simulations provided excellent agreement with the experiment and additional insight into the physics within this experiment. We find that it is the nonlocal electrons originating from the compressed plasma close to the shock front that are allowed to transport further ahead leading to a spatial structure of the shock wave and formation of the preheat region. These findings enable bench-marking of electron conduction models in conditions relevant to inertial confinement fusion, such as those employed in the modelling of experiments performed at the National Ignition Facility or Laser Megajoule, as well as laboratory astrophysics including convection phenomena in white dwarfs or supernova explosions.

References

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