Contribution ID: **18** Type: **not specified**

Synergy between multi-scale and multi-platform simulations and HED experiments at high power laser facilities

Wednesday 14 September 2022 09:00 (45 minutes)

With the dawn of novel high-power laser facilities, unprecedented energies and intensities have been achieved to access previously unseen extreme states of matter. These states not only span over a wide range of conditions, but also time scales. However, all our theoretical models and connected computer simulations are limited to specific parameter spaces and time scales. This means that no single simulation is capable of accurately describing the full scope of the plasma evolution in such experiments by itself. Our group has thus combined efforts of multiple teams to access novel multi-scale simulations to support our experiments by combining the inputs and outputs of multiple simulation platforms that each tackle a different regime or time-scale of the plasma evolution. We present three examples, where these composite simulations have been performed in order to capture the full experiment. We will discuss projects where particle-in-cell (PIC) simulations [1,2] were used to model the laser-target interaction on short-time scales and their output was then fed into a magneto-hydrodynamics simulation performed by the FLASH code [3] or multifluid simulations to describe the subsequent plasma evolution on a longer time scale to match our experimental measurements from PW lasers interacting with solid foil targets. We will also present a reverse process where a magneto-hydrodynamics simulation [3,4] was used to evolve two plasma jets forming a shockwave on a long spatial (mm) and temporal (ns) scales, but the output of these simulations was then used as input for PIC simulations [1] and continuum-kinetic simulations [5] in order to model the nonlocal kinetic effects within the shock structure that formed in this collision. These simulations are a preparation for an upcoming OMEGA shot day.

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Session Classification: Morning Session (Wednesday)