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Hybrid Modeling of Fast Electron Transport and EMP Generation in Nanosecond Laser-Target Interactions

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High-intensity laser interactions with solid targets generate powerful radiofrequency and microwave electromagnetic pulses (EMP) that scale with laser energy and intensity. The fundamental origins and underlying physical mechanisms of laser-induced EMP emission remain an unresolved challenge in high-energy-density physics, necessitating more sophisticated diagnostic and modeling approaches. These pulses are presumed to be created by large electrical currents that arise in the target during the interaction. In laser plasmas, electrical currents are carried mainly by fast electrons. This study employs a multi-physics hybrid framework to simulate laser-plasma interactions on a nanosecond timescale, aiming to bridge the gap between microscopic particle dynamics and macroscopic evolution. Firstly, the fast electron distribution is obtained using approximate theoretical relations for the current plasma state. Secondly, the fast electron transport is simulated via the Geant4 Monte Carlo toolkit. Finally, the ion motion is captured by the FLASH radiation-MHD code. This hybrid approach facilitates a deeper understanding of the time evolution of fast electron transport during laser-target interaction, which is crucial for understanding the origin of the intense EMP field. The numerical results are compared to the experimental measurements obtained at the Prague Asterix Laser System facility.

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