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Advances in Direct Laser Acceleration: High-Brightness X-ray and Neutron Sources via Plasma Guiding, High-Z Targets, and Flying Focus Pulses

Tuesday, October 7, 2025 4:20 PM (30 minutes)

Intense lasers enable a range of schemes for generating high-energy particle beams in university-scale laboratories. In direct laser acceleration (DLA), the leading edge of the laser pulse ionizes the target material, forming a positively charged plasma channel that traps and accelerates electrons. DLA offers exceptional conversion efficiency —often exceeding 20% —making it highly suitable for driving secondary radiation sources. This talk reviews recent advances aimed at pushing the efficiency and applicability of DLA for X-ray and neutron generation.

I will present experimental and numerical studies showing how DLA performance can be enhanced by tailoring the target's atomic number to sustain electron injection, and by employing flying-focus pulses to stabilize the plasma channel and extend the acceleration length.

Building on these developments, I will demonstrate how high accumulated neutron yields were achieved via bremsstrahlung from MeV electron beams in high-repetition-rate laser shots, and how a bright Compton X-ray source can be realized using counter-propagating pulses in a near-critical plasma plume.

The talk will conclude with projections for scaling these approaches to the multi-petawatt regime, where improved overlap between electron energies and neutron production cross-sections is expected to enable non-destructive material analysis and support industrial applications.

Cohen, I., et. al, **Undepleted direct laser acceleration**, Sci. Adv.10,eadk1947(2024).

Cohen, I., et. al, **Multi-scale analytical description of an expanding plasma slab**, Physics of Plasmas 31.1 (2024).

Meir, T., et. al, **Plasma-guided Compton source**, Physical Review Applied, 22(4), p.044004 (2024).

Cohen, I., et. al, **Accumulated laser-photoneutron generation**, The European Physical Journal Plus, 139(7), pp.1-7(2024).

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