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(I) X-ray production using relativistically intense laser pulses

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At relativistic intensities, electrons can be driven close to the speed of light, facilitating exploration of a new regime of laser-plasma interactions and high-field science. These intense pulses can drive matter into extreme states of temperature and pressure, mimicking those typically found in astrophysical environments, and leading to the observation of new states of high-energy-density matter. Advancements in intense laser matter interactions have also led to a new generation of pulsed particle and radiation sources, each with ultrashort, femtosecond-scale duration inherited from the laser driver. These sources can be used to study ultrafast dynamic phenomena in dense materials, such as material phase transitions and electron-ion equilibration.

In this talk, I will discuss our recent work performing high-resolution X-ray spectroscopy of K-shell emission from high-intensity (I ~10^{21} W/cm^2) laser experiments using the ALEPH laser at Colorado State University. Through measurements of K-shell fluorescence, electron emission and XUV spectroscopy of the plasma emission, we examine the generation and propagation of energetic electrons in thin foil and layered targets to elucidate the physics of high-intensity laser solid interactions. I will also discuss the generation of broadband hard X-ray sources through laser wakefield acceleration, generated by an intense laser pulse traveling through low-density plasma, and how these sources can be used to diagnose high-energy-density matter and phase transitions in dense materials.

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