Physicists 790 Seminar

Kinetic Modeling of Ultra-Intense X-Ray Laser-Matter Interactions

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Abstract:
Although hard-x-ray free-electron lasers (XFELs) have only existed since 2009 when the Linac Coherent Light Source (LCLS) at Stanford created its first laser pulse, their capabilities have already had a profound impact on the physical, chemical, and biological sciences. The LCLS can produce extremely short (< 100 fs) millijoule x-ray laser pulses with more than 1012 photons each [1], making it the brightest x-ray source ever produced in a laboratory by several orders of magnitude, and more than a billion times brighter than synchrotron sources. Such characteristics enable XFELs to create and probe warm and hot dense plasmas of relevance to astrophysical processes in stellar interiors, giant planet cores, galactic nuclei, and x-ray binaries. An LCLS beam can be intensified to ~1020 W/cm2 when focused to submicron spot sizes, making it possible to isochorically heat solid matter well beyond a million degrees (> 100 eV). Such intensities can produce highly ionized plasmas via sequential single-photon absorption and subsequent Auger decay. The fast photoelectrons and Auger electrons initiate the heating process via collisional ionization. A photoionization model that takes into account the suborbital cross sections and KLL Auger ionization has been developed in a kinetic plasma simulation code, PICLS, that solves the x-ray transport self-consistently [2]. The interaction between short XFEL pulses of varying spot size (intensity) with several low-Z (13 < Z < 29), solid targets is studied with the code, and the resulting energy density, ionization degree, and heating spot size are compared with recent LCLS experiments [1].


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