MODELING AND EXPERIMENTAL STUDY OF CORRELATION BETWEEN Kα PHOTON TRANSPORT AND HOT ELECTRON DISTRIBUTION

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Ultrahigh (MA) currents of suprathermal (MeV) electrons that are driven through solids using relativistic laser pulses (intensity > 10^{18} W/cm^2) lie at the heart of numerous applications such as the generation of ultrashort secondary sources of particle and radiation (ions, x-rays, positrons, or neutrons), fast ignition of inertial confinement targets, or laser-driven hadron therapy. The study of electron transport in high-energy-density plasmas has been a critical area of focus to develop these applications. A number of experimental studies have been carried out in the past to characterize electron transport in different media such as insulators, metals, and compressed matter, e.g. [1, 2]. These experiments measure the characteristic Kα and Kβ emissions from the plasmas to infer hot electron distribution and plasma temperature. However, the correlation between the hot electron distribution and the size of the two-dimensional Kα emission pattern has not been clearly shown. Understanding the critical details of the correlation between Kα photons and the hot electron distribution advances the study the hot electron transport in ~~the~~ ultra-intense laser-matter interactions, and moreover it is important to optimize the Kα source as for laser conversion efficiency and brightness for various applications.

We have developed a 2D particle-in-cell code, PICLS, which includes atomic physics such as Coulomb collisions, ionizations, and x-ray radiation. Recently, a radiation transport module with NLTE emissivity/opacity was embedded in PICLS self-consistently [3], which enables us to study radiative processes in detail and also permits a direct comparison of x-ray signals observed in experiment with those calculated in the simulation.

Based on our experimental study using the 100 TW Leopard laser of the Nevada Terawatt Facility at UNR to shoot a 2μm thin copper foil, the Kα image observed at the back surface of the foil was ~ 5 times larger than the laser spot of intensity 10^{19} W/cm^2. The Kα image size becomes even wider when shooting a similar foil of lower-Z titanium. The Z-dependence of the Kα image size is confirmed by the PICLS simulation with the Kα calculation. Moreover, the simulation shows that the Kα photon distribution becomes estranged from the hot electron (> 10keV) distribution when the laser intensity reaches the strong relativistic regime. This discrepancy between Kα image and the hot electron distribution could be attributed to differences between the transport of hot electrons and Kα photons in the dense plasmas.

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