X-RAY TOMOGRAPHY OF WARM DENSE MATTER

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Studies of warm dense matter (WDM) is an emerging and challenging field that is at the border of condensed matter physics and plasma physics. WDM is created in laboratory in the interactions of intense laser (or particle) beams with solid-density matter. With a laser pulse focused to diameters of a few micrometers, gradients of the generated-plasma parameters and ultra-intense induced electric and magnetic fields are expected to be of a similar scale and, thus, measurements with high spatial resolution are desired. Because of the high density, only short-wavelength radiation may escape the interior of the target, thus, the inner-shell x-ray emission, e.g., K_ is an important instrument to yield valuable information on such plasmas. Furthermore, intensity and shape of inner-shell lines depend on properties of both the thermal (or "bulk") and suprathermal ("fast" or "hot") electron distributions.

Axially-resolved measurements are usually done with multilayer targets, where a layer of tracing species is embedded at varying (from sample to sample) depth (e.g., [1]), incurring, however, possible undesired inter-layer-edge effects and difficulties due to shot-to-shot irreproducibilities and target replacement. Here we introduce an alternative tomography-like approach allowing, under certain conditions, for obtaining data with high axial resolution using homogeneous targets.

The method was applied to analysis of spatial K_-yield distribution in thin Ti foils irradiated by 80 fs, 5 x 10^{19}W/cm^2 laser pulses. Preliminary results unambiguously show a strongly asymmetric axial distribution, with most of the radiation coming from the front side, while the radial distribution appears to be practically independent of the depth. Results obtained with dual-layer targets are in good qualitative agreement.

Together with recent advances in inferring detailed radially-resolved temperature and yield distributions [2] based on Kα line-shape analysis [3], prospects are good for achieving 3Dresolved measurements of bulk electron temperature and transport properties of suprathermal electrons, which is of primary importance for basic understanding of laser-matter interactions, benchmarking computer simulations, and various applications, such as laser-driven backlighters and fast ignition laser fusion.

[1] G. Malka et al, Phys. Rev. E, 77(2):026408–8, 2008.
[2] U. Zastrau et al, Phys. Rev. Lett., submitted.
[3] E. Stambulchik et al, J. Phys. A, 42:214056, 2009..