Opacity measurements of hot expanded metallic plasma wires

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The purpose of this experiment is to characterize the expansion and absorption of hot plasmas in cylindrical geometry, in homogeneous temperature and density conditions (T≈20 eV and $\rho \approx 10^{-3}$-10^{-2} g/cm^3) and close to local thermodynamic equilibrium (LTE). In the proposed experimental set up [1], a thick 100 microns diameter metallic wire is heated symmetrically by the blackbody radiation of two gold Hohlraums irradiated by laser (squared pulses of 1 ns@2ω, 500 J). The hot plasma is then probed with a delay (from 1 to 5 ns) by a secondary X-ray source created by focusing a short pulse (500 ps@2ω, 20 J) on a thick gold foil. A « point-projection » spectrometer based on a cylindrically curved TlAP crystal (R=100 mm) coupled to an Image Plate detector is used to perform a spectral and spatial imaging of the plasma. The spectral range is 700-1500 eV (resolution of 2 eV) to study the L-shell transitions of mid-Z elements (Cu, Zn, Fe) or K-shell lines of Mg. The spatial resolution is about 20 µm (dimension of the focal spot of the backlighter). The duration of temporal integration is 500 ps (backlighter duration). Compared to thin foils, that we employed in past absorption experiments [2-8], the use of thick wires has its own advantages and disadvantages. They are cheap, easy to produce and can be handled without special precautions. However, the wire is not heated in volume: it forms a superficial plasma which expands cylindrically with large gradients of temperature and density. A « point-projection » spectrometer is needed to record a frequency- and space-resolved image of the backlighter transmitted through the plasma. The optical depth of the plasma can then be reconstructed as a function of its radius and of the photon frequency of the source by applying the Abel transform on the measured signal. The processed signal is thus free (in theory) of temperature and density gradients since the method resolves them. It is also possible to infer a radial density profile of the plasma. The main drawback is a much greater sensitivity to noise (the Abel transform involve the derivative of the signal), which must be taken into account in the experimental set up (filters, shields) and in the numerical analysis, the need for a point-like source (in space and time) and a relevant radiography diagnostics. We will present preliminary results of the campaign.

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