X and XUV opacity measurements in dense plasmas

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We present a recent experimental work at the LULI-2000 facility on X and XUV opacity measurements in mid-Z laser produced plasmas. The aim of this work is to simultaneously measure absorption structures in X and XUV ranges providing thus two different approaches to estimate in-situ plasma temperature and validate with better accuracy of the atomic-physics codes. We have been interested in plasma conditions corresponding to temperatures between 20 eV and 25 eV, and densities of the order of magnitude of 10^{-3}g/cm^3 to 10^{-2}g/cm^3. We investigate the Ni, Fe, Cr and Cu 2p-3d X-ray absorption structures whose spectral position is dependent on plasma temperature which allowed to estimate its value. This is essential for the analysis of the XUV spectra since in mid-Z plasma at these conditions the average Rosseland opacity mainly depends on the XUV $\Delta n=0$ (n=3) transitions.
During this experiment, we have also studied X-ray 2p-nd transitions, with n>3, by using samples with bigger areal masses.

The experimental scheme is based on an indirect heating of multilayer thin foils by two gold cavities heated by two nanosecond doubled-frequency 300 J beams. The temperature gradient inside the foil is reduced during the spectroscopic measurement because of symmetric irradiation of the foil by the cavities. So we consider that the mid-Z plasma is close to the local thermodynamic equilibrium. This plasma is probed by an X-ray backlight source created by a gold foil heated by a third nanosecond beam with an energy E~20-40 J. This backlight source is directly recorded in X-ray and XUV ranges by two different spectrometers. Mainly, a third spectrometer composed of two independent tracks detects the (output) signal passing through the thin foil also in X-ray and XUV ranges. So with these four measurements, we can observe the absorption of the different samples in the two ranges.
In addition to the main spectrometers, three other diagnostics are used. An independent measurement of the radiative temperature of the cavities is performed with a broad-band time-resolved spectrometer. A time-integrated spectrometer with high spatial and spectral resolution is used to compare the balanced emissivity of each cavity during the shots. Finally a pinhole camera is placed to observe the X-ray emission of the cavities and the backlight source in order to check their alignment. The association of all these diagnostics allowed us to better characterize the sample and constrains the interpretation of the opacity data.