GENERATION AND PROBING OF WARM DENSE MATTER (Al) CREATED BY LASER-ACCELERATED PROTON BEAM

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Abstract. The possibility of producing, in a controlled way, matter at solid density (1-10 g/cm^3) while maintaining it at high temperature (1-100 eV), i. e. the warm dense matter (WDM), has been for a long time a desired goal since it is found in a large array of conditions, e.g. astrophysical objects or controlled thermonuclear fusion compressions. The lack of data in the WDM regime motivates the need for the design of experiments able to produce with high fidelity and very good characterization the warm dense matter sample in copious quantity. Laser-accelerated proton beams present a promising source for volumetric heating. Being produced in a very short time (few ps) they can deposit energy potentially in a shorter time scale than the expansion time of matter heated to a few eV, allowing the possibility to create isochoric heating over a large volume of matter. This technique allows to produce large amount of WDM, thus opening the way for measurements of WDM parameters. The goal of the work presented here was to characterize experimentally the warm dense matter generated by laser-accelerated proton beams. The proton source that induces the heating has been characterized in details. The heated sample conditions at different times during heating were inferred by coupling the time- and space- resolved interferometry diagnostic with the 1-dimensional hydrodynamic code (that includes proton stopping) that uses previously characterized proton source as input. In this way, we have minimized the number of free parameters in the modelling of the heating. We have shown that heating was isochoric and almost uniform along the target thickness with a maximum temperature of ~ 18 eV. In the end, X-ray Near Edge Absorption Spectroscopy (XANES) diagnostic has been used to study the structural modification of the warm dense aluminum sample. We have observed a progressive loss of ordering within solid density sample as the temperature rises from 300 K to > 10^4.