Temperature determination of shock-compressed foams using x-ray fluorescence spectroscopy

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Temperature is a fundamental parameter in plasma physics and is a critical input to model and predict plasma properties. Despite its importance, experimental measurements of temperature in the high-energy-density regime are sparse due to the limited number of diagnostic techniques available for temperatures in the 10s of eV range. We present the use of x-ray fluorescence spectroscopy (XFS) to determine the temperature in shock-compressed foams at temperatures of 30–75 eV. XFS interrogates the plasma with an external energy source (typically x-rays or electrons) to fluoresce specific ions in a plasma to determine the ion distribution, and in turn the plasma temperature. Cobalt-doped foams were shock compressed using a planar drive at the OMEGA laser facility and probed with a Zn Heα x-ray source. Analysis of the resulting cobalt Kβ x-ray fluorescence spectra allow the temperature to be determined in the shocked foams. When properly calibrated, this method promises to provide a robust technique to infer temperatures in high-energy-density physics experiments in the 10s of eV temperature range of interest for hydrodynamics and equation of state experiments.

We present the analysis of XFS data using multiple codes, including rate matrix and Monte Carlo methods, and compare the results to hydrodynamic simulations. We find that hydrodynamic simulations predict a lower temperature in the shocked foams compared to analysis of the XFS data using collisional radiative codes. This disagreement can be explained by the radiation hydrodynamic codes underpredicting the plasma temperature or the collisional radiative codes underpredicting the cobalt ionization as a function of temperature, motivating future work to improve the models and cross-calibrate the temperature in the experiments to resolve this discrepancy.

This work performed under the auspices of U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344 and supported by Laboratory Directed Research and Development (LDRD) Grant Nos. 18-ERD-033 and 22-ERD-005. RWF acknowledges support from DOE, National Nuclear Security Administration under Award Number(s) DE-NA0004147, and Office of Science, Office of Fusion Energy Sciences, under Federal Prime Agreement DE-AC02-05CH11231.

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