(U) Spectral Signatures from Hydrodynamics Simulations

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Abstract

In 2015 larger-than-expected opacity of iron was reported to have been measured at Sandia's Z facility [1]. In order to help interpret this unexpected result, two-dimensional radiation hydrodynamics simulations of Sandia's dynamic hohlraum have been performed using the Cassio code [2]. The results of these simulations are now starting to be postprocessed with the (open-source) FESTR spectroscopic-quality radiation-transport code [3-6] in order to obtain synthetic spectra with the goal of helping to resolve this ongoing controversy. With this type of "whole-experiment" modeling that is now available, we plan to investigate the validity of assumptions (such as target uniformity and others, see, e.g. [7]) typically adopted in the process of inferring opacity from experimental data.

Example of Postprocessing of a Hydrodynamics Simulation

In this work we illustrate the steps that were carried out in this newly developed capability of spectral postprocessing of hydrodynamics simulations. First, a time history of the dynamic hohlraum was computed with Cassio [2] on a 2D Cartesian mesh with refinement and the results were exported in the EnSight format [8]. These hydro dumps were then translated into FESTR-formatted input using the Saruman converter [9] that spins the cylindrically symmetric 2D Cassio mesh into a 3D unstructured mesh used by FESTR (with this arrangement the FESTR interface is kept completely general and independent of any hydrocode that might be used to drive the spectral postprocessing). Synthetic spectra are then computed based on this hydro information using the Los Alamos OPLIB opacity tables [10] via FESTR's link [9] to the opacity mixing code TOPS (see [11] for an online portal to TOPS/OPLIB).

In Fig. 1 we show the simulated state of the dynamic hohlraum at the time instant of 22 ns overlayed with the ray of interest (i.e., the line of sight) propagating at 9° with respect to the axis of symmetry, in accordance with the geometry of the diagnostics deployed in Sandia experiments [1]. The results of this simulation are shown in Fig. 2; at this moment the mesh had 808003 spatial zones and the shown spectrum was calculated by transporting a ray that cut across 1057 zones, of which 63 zones represented the opacity foil containing iron and magnesium. In Fig. 3 we show a time integrated spectrum covering 3.4 ns of the dynamic hohlraum's evolution, and in Fig. 4 we present the time history of x-ray emission integrated across a selected photon-energy band. These preliminary results clearly show the formation of iron and magnesium absorption lines as the opacity foil is backlit by the continuum spectrum emerging from the deeper regions of the dynamic hohlraum. With this type of "whole-experiment" modeling that is now available, we plan to investigate the validity of assumptions (such as target uniformity and others, see, e.g., [7]) typically adopted in the process of inferring opacity from experimental data.

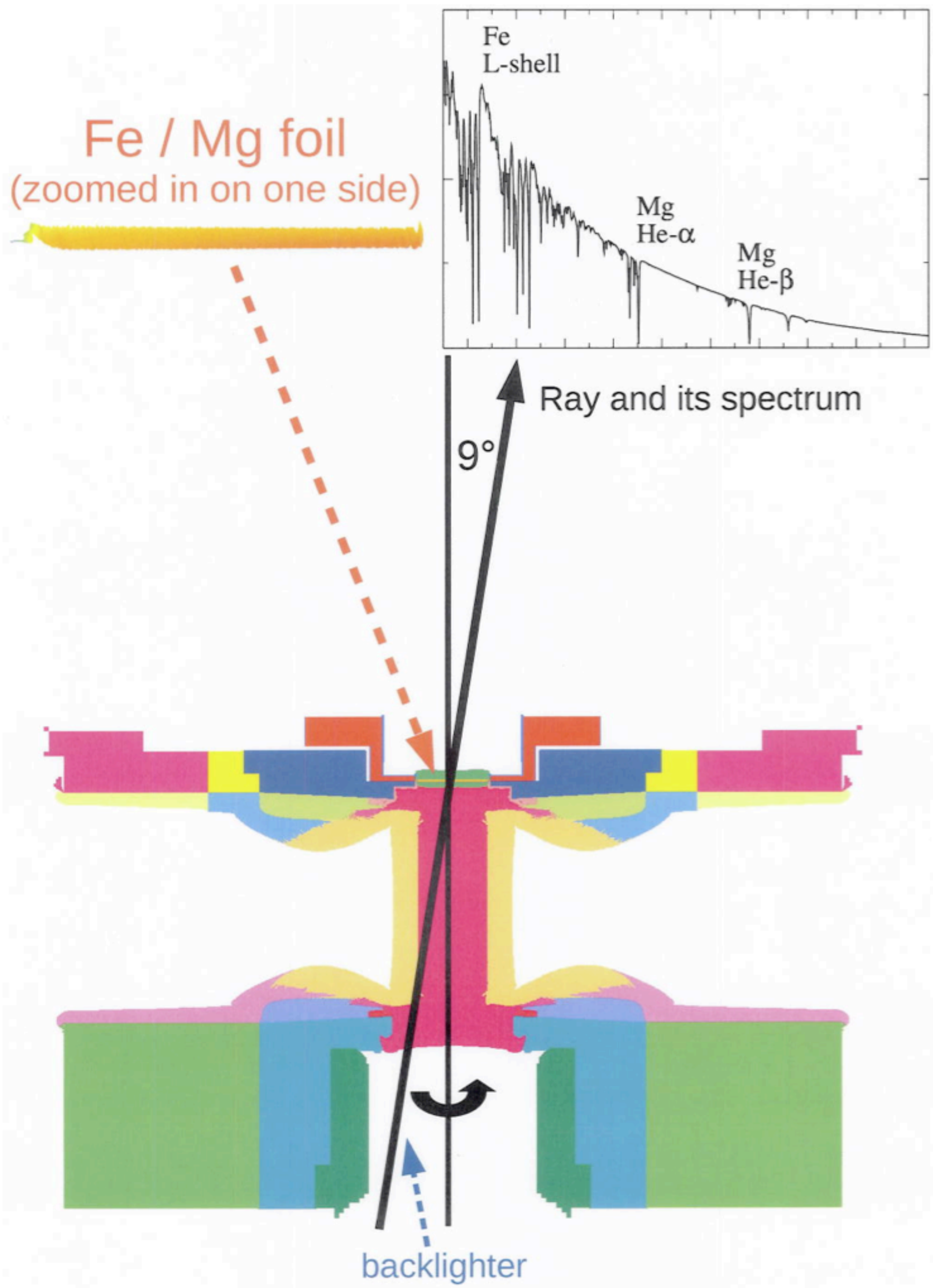

Figure 1. The state of the dynamic hohlraum at time 22 ns as modeled by the 2D cylindrically symmetric Cassio simulation; the "rear" side of the studied ray builds up the spectrum that backlights the opacity sample foil, yielding the Fe and Mg absorption spectra recorded by the diagnostics positioned above the dynamic hohlraum.

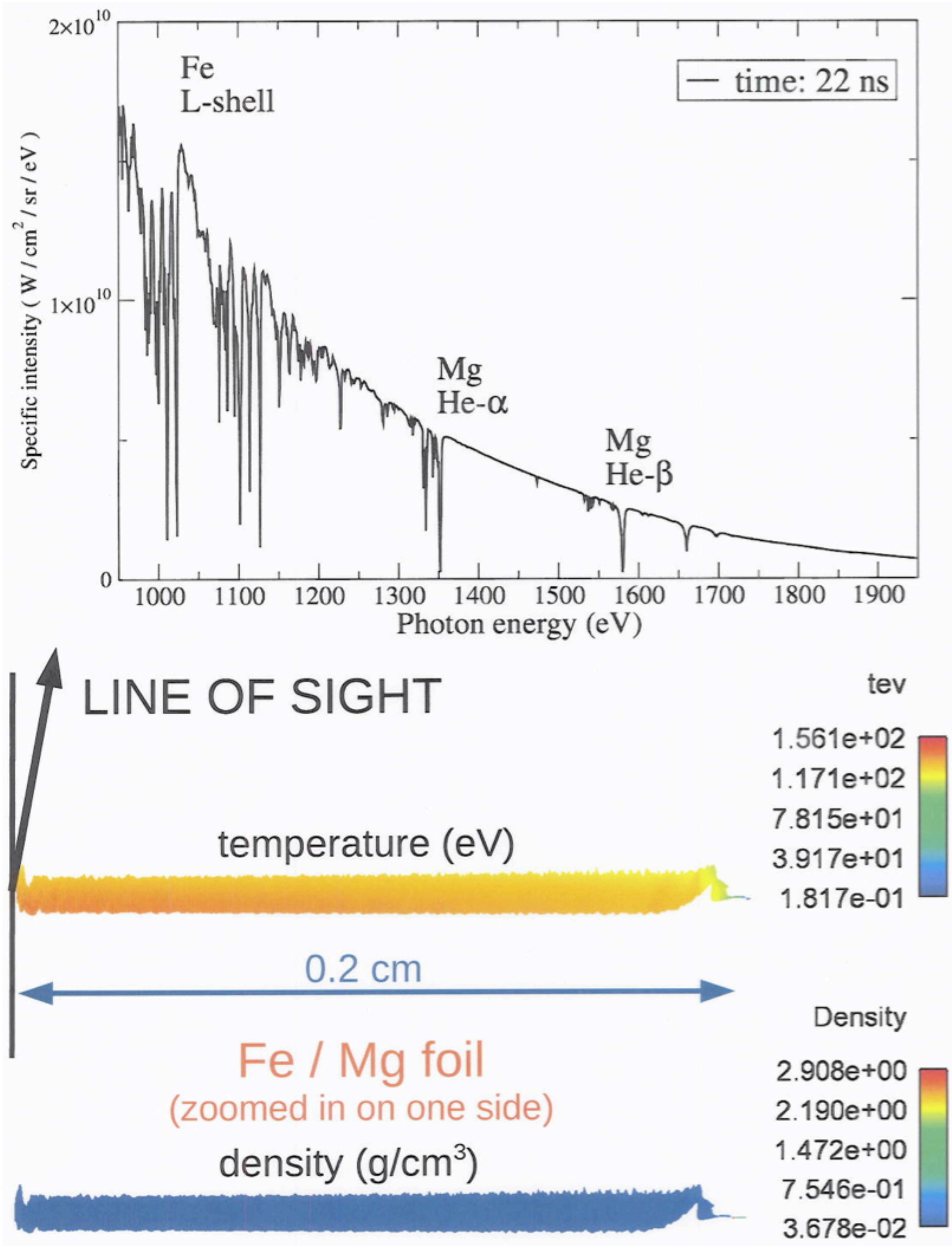

Figure 2. Spatially resolved temperature and density conditions across the opacity foil at time 22 ns of the Cassio simulation and the associated instantaneous, spatially-resolved synthetic spectrum.

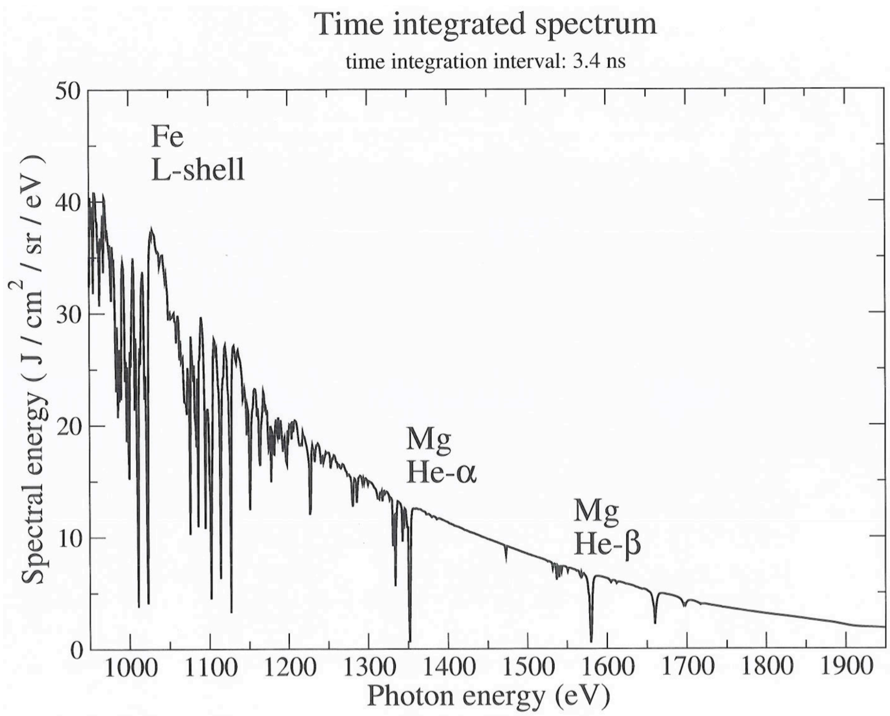

Figure 3. Synthetic spectrum along the ray shown in Fig. 1, integrated between times 20.0-23.4 ns of the Cassio simulation.

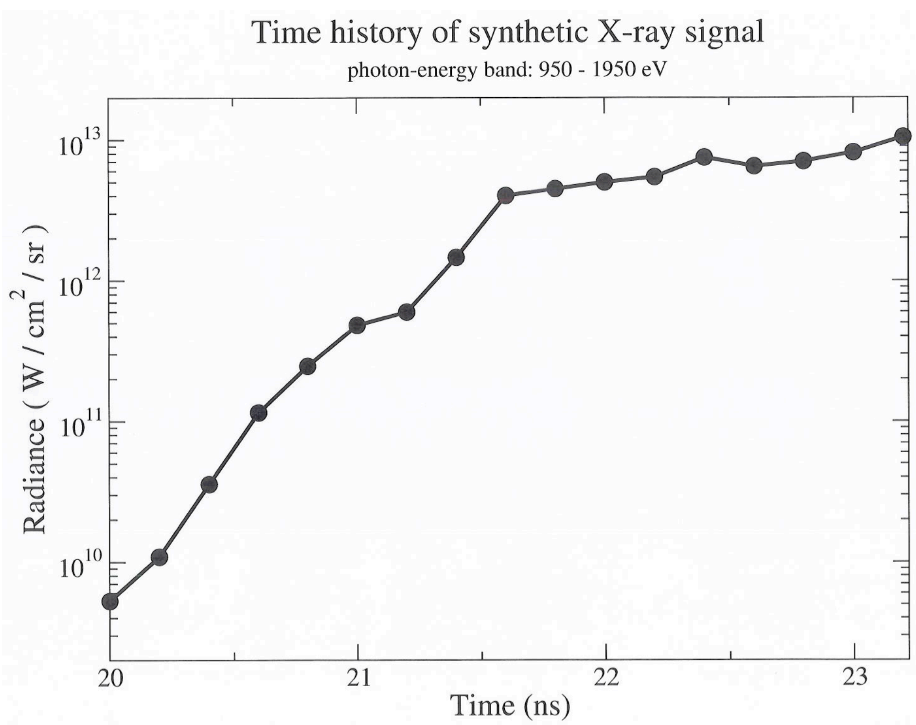

Figure 4. Synthetic time history of signal intensity along the ray shown in Fig. 1, integrated across a 1 keV-wide photon-energy band.

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