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Radiation-hydrodynamic simulations of backlighter options for FAIR

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Multidimensional codes, which combine the solution of the fundamental hydrodynamic equations with the spectral transfer equation for thermal radiation and with an accurate scheme for thermal conduction, provide an indispensable tool for the design and the analysis of experiments as well as for the understanding of physical phenomena at high energy density. The main motivation for the development of the radiation-hydrodynamics code RALEF-2D [1] and the equation-of-state code FEOS [2] was to support the undergoing and future research at GSI [3] and at the upcoming FAIR accelerator facility [4]. Furthermore, recent devel-opment of RALEF-2D yielded a new hybrid model [5] of laser energy deposition as a combination of the geometrical optics ray-tracing method with the one-dimensional solution of the Helmholtz wave equation.

Measurements of the heavy-ion stopping in laser-generated dense plasmas at high temperatures at GSI were of crucial importance for the indirect drive scenario of heavy-ion fusion and for the ion-driven fast ignition concept. The corresponding RALEF-2D simulation results [6] for the hohlraum X-ray spectra as well as for the plasma column densities were essential for understanding the measurements and for optimization of the experimental setup. Now, current research for planned warm dense matter experiments at GSI and FAIR focusses on the design of diagnostical options, especially of backlighter sources for opacity measurements.

For ion-beam heated foils, an intense VUV-backlighter (~10-15 eV) will be needed. Simulations of a helium plasma accelerated by a plasma gun and compressed inside conically shaped glas targets have been performed to find the best geometry for maximum compression and heating. Fig. 1 (see PDF) shows three simulated configurations initially filled with helium gas at room temperature and 60 mbar pressure and an initial velocity of 20 km/s of the already 10-times compressed plasma cloud at the exit of the plasma gun. The corresponding experimental measurements indicate that such configurations might be promising VUV-backlighter options. Further spectral measurements and simulations with thermal radiation transport are planned.

For opacity measurements of expanding laser-heated plasmas a second backlighter option is needed. Here, Fig. 2 (see PDF) shows a simulation of a gold hohlraum backlighter target heated by the short pulse (10 ps, 50 J) option of the PHELIX laser at GSI with a peak maximum of the simulated hohlraum spectra at 100-120 eV.

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[6] S. Faik, An. Tauschwitz, M. M. Basko, J. A. Maruhn et al., HEDP 10 (2014) 47.

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