Simulations of a conical target for Warm Dense Matter-experiments*

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In recent experiments at GSI liquid carbon was investigated using spectrally resolved x-ray scattering from laser-irradiated shocked carbon samples [1]. The goal of the upcoming experimental campaign is a more accurate determination of the solid-liquid phase transition of carbon. For these experiments it was proposed to used a conical target configuration which allows to increase the compression and the temperature in the laser-driven shock compared to irradiation of a plane foil [2]. The target consists of a tapered tube made of gold filled with graphite of $\rho_0 = 1.9\,\mathrm{g/cm^3}$ initial density. The wide side of the cone is irradiated with a laser. The length of the cone, $L = 140\,\mu$m and the radius of the narrow end, $r_1 = 20\,\mu$m were fixed by demand of the scattering diagnostics. The radius of wide side, $r_0 = 90\,\mu$m was adapted numerically to the nhelix laser parameters.

Simulations were done using the RALEF-2D code [3] which solves the one-fluid one-temperature hydrodynamic equations in two spatial dimensions by a second-order Godunov-type numerical scheme using the ALE approach. Thermal conduction, radiation transport, and laser energy deposition by means of inverse bremsstrahlung absorption are coupled using a symmetric semi-implicit approach with respect to time discretization. Here we present the results for a $\lambda = 532$ nm laser pulse of 30 J over a focal spot of radius $r_f = 125\,\mu$m; the 11-ns long pulse was ramped with 3-ns linear rise and fall intervals. The spectral opacities and the equation of state data were generated with the THERMOS code [4].

For the planar carbon foil the simulation shows a density of $\rho = 3.3\,\mathrm{g/cm^3}$ and a temperature of $T = 0.25$ eV. The calculated density distribution in the conical target is displayed in Fig. 1. A shock wave induced by the laser in the graphite propagates to the narrow end of the cone and becomes stronger due to reflection at the interface to the gold shell, as shown in Fig. 1a. An increase of density to $\rho = 3.4\,\mathrm{g/cm^3}$ due to reflection of the shock wave on the gold interface can be seen from the density distribution at $t = 9$ ns. The reflection at the axis of symmetry corresponds to $t = 13.5$ ns (Fig. 1b). Because of the converging axial symmetry, at this time the shock wave is amplified in a small region near the axis ($\rho = 4.75\,\mathrm{g/cm^3}$). A planar shock develops at the end of the cone with a density of $\rho = 3.75\,\mathrm{g/cm^3}$ and a temperature of $T = 0.7$ eV resulting from the propagation of the laser launched shock at $t = 16$ ns (Fig. 1c).

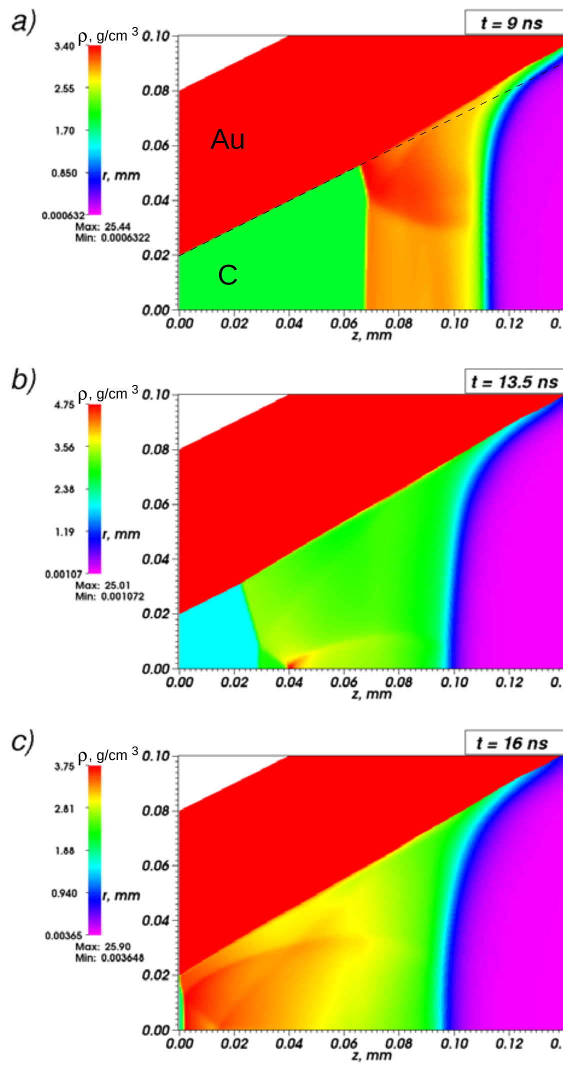

Figure 1: Color contour plots of density ρ in a conical target at different times. The laser beam comes from the right.

References

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