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Numerical Study of Heavy-Ion Stopping in Foam Targets with One-Dimensional Subcell-Scale Hydrodynamic Motions

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When designing parameters of ion-driven warm dense matter experiments with low-density foam targets[1], the foams are usually regarded as homogeneous media. For more detailed design, initial inhomogeneous porous structure of the foam target should be taken into account, since the mass stopping power of heavy projectiles can change with the target density and temperature[2]. In this regard, heavy-ion stopping in foam targets with subcell-scale hydro motions was numerically investigated.

To simulate porous foam targets, we employed a simple 1D periodic multilayer model consisting of thin solid slabs and voids between them. The averaged pore diameter and cell-wall thickness of the foam were represented by the gap width between the slabs and the slab thickness, respectively. The electronic state of target atoms were approximated by a finite-temperature Thomas-Fermi model with given Wigner-Seitz radii. The density- and temperature-dependent stopping cross sections were evaluated using a binary encounter model. We tested a combination of Na (Z1 = 11) projectiles and subrange Al (Z2 = 13) foam targets with ρ ≈ 0.01–0.1ρsolid. The incident projectile energy was adjusted so that the Bragg peak was roughly at the center of the target. The hydrodynamic motion of the multilayer target was calculated with a 1D code MULTI[3].

Macroscopic hydrodynamic response of the foam was similar to that of a homogeneous target with the same mass thickness. Before homogenization by hydro motion, the total projectile energy loss in the foam target was smaller than that in the homogeneous equivalent. During homogenization, hot dense spots appeared at the positions where the pores (gaps) originally existed, owing to stagnation of the blow-off materials. As a result, even after the pores are filled with the blow-off materials, the initial inhomogeneity was not completely smeared out and the total energy loss in the foam target was still not equal to that in the homogeneous equivalent.

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