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Observation of Interspecies Ion Separation in Inertial-Confinement-Fusion Implosions via Imaging X-ray spectroscopy[1]

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Interspecies ion separation has been proposed as a yield-degradation mechanism in inertial-confinement-fusion (ICF) experiments. We present direct experimental evidence of interspecies ion separation in direct-drive ICF experiments performed at the OMEGA laser facility. These experiments were designed based on the fact that interspecies ion thermo-diffusion [1] would be strongest for species with large mass and charge difference. The targets were spherical plastic shells filled with D_2 and Ar (1% by atom). Ar K-shell spectral features were observed primarily between the time of first-shock convergence and slightly before neutron bang time, using a time- and space-integrated spectrometer, streaked crystal spectrometer, and two gated multi-monochromatic X-ray imagers fielded along quasi-orthogonal lines-of-sight. Detailed spectroscopic analyses of spatially resolved Ar K-shell lines reveal deviation from the initial 1%-Ar gas fill and show both Ar-concentration enhancement and depletion at different times and radial positions of the implosion. The experimental results are interpreted with radiation-hydrodynamic simulations that include recently implemented, first-principles models [2] of interspecies ion diffusion. The experimentally inferred Ar-atom-fraction profiles agree gently with calculated profiles associated with the incoming and rebounding first shock. This work was done in collaboration with P. Hakel, S. C. Hsu, E. L. Vold, M. J. Schmitt, N. M. Hoffman, R. M. Rauenzahn, G. Kagan, X.-Z. Tang, Y. Kim, and H. W. Herrmann of LANL, and R. C. Mancini of UNR. LA-UR-16-24804.

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