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Hidden Charge States in Soft-X-Ray Laser-Produced Nanoplasmas Revealed by Fluorescence Spectroscopy

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Highly charged ions are formed in the center of composite clusters by strong free-electron laser pulses and they emit fluorescence on a femtosecond time scale before competing recombination leads to neutralization of the nanoplasma core. In contrast to mass spectrometry that detects remnants of the interaction, fluorescence in the extreme ultraviolet spectral range provides fingerprints of transient states of high energy density matter. Spectra from clusters consisting of a xenon core and a surrounding argon shell show that a small fraction of the fluorescence signal comes from multiply charged xenon ions in the cluster core. Initially, these ions are as highly charged as the ions in the outer shells of pure xenon clusters with charge states up to at least 11+. Subsequent electron transfer and thermalization followed by nonradiative recombination produce significantly lower charge states within a few hundred femtoseconds. Thus, a sacrificial tamper layer provides an efficient electron source for partial neutralization of highly charged ions created in the center. The significant reduction of charge states increases the available time for recording a diffraction pattern in coherent imaging experiments.

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