Investigating atomic kinetics in photoionized plasma experiments using x-ray transmission spectroscopy

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We discuss an experimental effort to create and study astrophysically relevant photoionized plasmas in the laboratory. Conditions relevant to the extreme environments in x-ray binaries, accretion disks around black holes, and active galactic nuclei have long been experimentally inaccessible. Astronomers looking to understand such objects rely on the accuracy of the photoionization models they use, yet we are only beginning to have the ability to probe this regime experimentally with devices such as the Z-Machine at Sandia National Laboratories.

Our experiment employs the intense x-ray flux emitted at the collapse of a Z-pinch to heat and backlight a neon photoionized plasma contained within a cm-scale gas cell with atom number densities of 10^{17} to 10^{18} cm^{-3}. The broadband x-ray flux at the gas cell at the peak of the x-ray drive is of order 10^{12} W/cm^2 producing an order of magnitude range in ionization parameter from about 5 to 50 erg*cm/s, depending on gas filling pressure. The resulting plasma conditions are determined using K-shell line absorption spectroscopy from a KAP crystal spectrometer capable of capturing both time-integrated and time-gated transmission spectra. Analysis of these spectra yields ion areal densities and the charge state distribution, which can be compared with simulation results from atomic kinetics codes. In addition, the electron temperature is extracted from level population ratios of nearby energy levels in Li-like ions, which can be used to test heating models of photoionized plasmas as well.

This work was sponsored in part by DOE NNSA HEDLP grant DE-NA0003875, DOE Office of Science Grant DE-SC0014451, the Wootton Center for Astrophysical Plasma Properties, and the Z Facility Fundamental Science Program of SNL.