ATOMIC KINETICS AND HEATING OF A NEON PHOTOIONIZED PLASMA EXPERIMENT AT Z

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Detailed x-ray spectral observations performed with the Chandra and XMM-Newton orbiting telescopes provide critical information on photoionized plasmas. However, the complexity of the astrophysical environment makes spectral analysis challenging, and thus laboratory experiments are important for data interpretation and testing of modeling codes[1]. The Z facility at Sandia National Laboratories is a powerful source of x-rays to produce and study in the laboratory photoionized plasmas under well characterized conditions. We discuss an experimental and theory/modeling effort in which the intense x-ray flux emitted at the collapse of a z-pinch implosion driven by Z is employed to produce a neon photoionized plasma[2-3]. The broadband x-ray radiation flux from the z-pinch both creates the plasma and provides a source of backlighting photons to probe it through K-shell line absorption spectroscopy. The plasma is contained in a cm-scale gas cell that can be located at several distances from the z-pinch and filled with different neon gas pressures. This set up permits a systematic study of the photoionized plasma for a range of ionization parameter values from 1 to 100 erg•cm/s. The transmission spectrum is recorded using a spectrometer equipped with two elliptically-bent KAP crystals and a set of slits to record up to six spatially-resolved spectra per crystal in each shot. The transmission data shows a rich line absorption spectrum that spans several charge stages of neon including Be-, Li, He- and H-like ions. Analysis of the spectrum produces the areal-density of the ions and an estimation of the electron temperature. The time-history of the x-ray drive is characterized with view-factor model calculations that are constrained with time-resolved side-power and gated narrow-band images of the z-pinch. Transient and steady-state atomic kinetics calculations are used to model the ionization of the plasma, assess the degree to which the plasma has achieved steady-state, and to aid with the interpretation of the charge state distribution extracted from the analysis of the time-integrated experimental spectra. In addition, the population ratio of Li-like neon $1s^2 2p$ to $1s^2 2s$ levels determined from the absorption spectrum analysis provides an estimate of the electron temperature and thus information on plasma heating. These results are compared with simulations performed with radiation-hydrodynamic and kinetic codes.

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