Photoionised plasma experiments at Z

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Photoionised plasmas are found in astrophysical environments such as x-ray binaries, active galactic nuclei, and in the accretion disks of compact objects. New, high spectral resolution x-ray observations from photoionised plasmas have been recorded in recent years by the Chandra and XMM-Newton orbiting telescopes. These observations provide a wealth of detailed information and have motivated new efforts at developing a detailed understanding of the atomic kinetics and radiation physics of photoionised plasmas. The Z facility at Sandia National Laboratories is a powerful source of x-rays that enables us to produce and study photoionised plasmas in the laboratory 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 experiment conducted at the Z pulsed-power machine of Sandia National Laboratories is employed to produce a neon photoionised plasma. The broad band radiation flux from the z-pinch is used to both create the neon photoionised plasma and provide a source of backlighting photons to study the atomic kinetics through K-shell line absorption spectroscopy. The design of the experiment involves view factor calculations to model the radiation flux driving the plasma, and radiation hydrodynamic simulations to evaluate the overall dynamics and uniformity of the plasma. The plasma is contained in cm-scale gas cell located at about 5 cm from the z-pinch, and the filling pressure is carefully monitored all the way to shot time since it determines the particle number density of the plasma. Time-integrated and gated transmission spectra are recorded with a TREX spectrometer equipped with two elliptically-bent crystals and a set of slits to record up to six spatially-resolved spectra per crystal in the same shot. The spectral resolution is approximately 1000. The transmission data shows line absorption transitions in several ionization stages of neon including Be-, Li-, He- and H-like Ne ions. Detailed modeling calculations of the absorption spectra are used to interpret and model the high-resolution transmission spectra recorded in the Z experiments with the goal of extracting the charge balance and the radiation flux driving the plasma, as well as to determine the ionization parameter of the plasma. The data analysis is performed with the aid of a novel application of genetic algorithms to plasma spectroscopy.

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