Experiments and modeling of photoionized plasmas at the Z facility

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Abstract

Astrophysical environments such as x-ray binaries, active galactic nuclei, and accretion disks of compact objects contain photoionized plasmas. Developments in pulsed power sciences like those at the Z pulsed-power facility facility at Sandia National Laboratories have led to the availability of a powerful x-ray source that enables us to produce and study in the laboratory photoionized plasmas relevant for astrophysics under well characterized conditions. We discuss an experimental and modeling effort in which the intense x-ray flux emitted at the collapse of a z-pinch experiment conducted at Z is employed to produce a neon photoionized plasma. The broadband radiation flux from the z-pinch is used to both drive the photoionized 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 a cm-scale gas cell located at several distances from the z-pinch, and the filling pressure is carefully monitored in situ 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 KAP crystals and a set of slits to record up to six spatially-resolved spectra per crystal in the same shot. 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 perform the analysis of the transmission spectra with the goal of extracting the charge state distribution and the atomic population kinetics of the photoionised plasma. The data analysis is performed with the aid of a novel application of genetic algorithms to plasma spectroscopy. Plans for producing photoionized plasmas of other elements and mixtures are discussed as well.

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