Benchmarking Accretion Disk Models Using Photoionized Laboratory Plasmas

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Radiation-matter interactions in high-energy-density plasmas play a crucial role in the physics of many astrophysical objects. The radiative properties of abundant elements with relatively high atomic number, such as iron, often play a crucial role. Accretion-powered objects such as X-ray binaries and active galactic nuclei are an example of current interest. Intense X-ray emission from infalling matter can drive gas in the accretion disk into a photoionization equilibrium, in which the dominant ionization process is X-ray photoionization rather than particle collisions. Detailed modeling of photoionized plasmas is essential to understand observations of accretion-powered objects, but remains extremely difficult. However, scaled laboratory experiments are now able to directly benchmark the models. These experiments use the 1.0×10^{21}erg/s X-ray pulse emitted by a Z-pinch plasma at the Sandia "Z" facility to produce photoionization equilibrium in uniform, low-density samples of iron co-mixed with low-Z tracer elements. The physical parameters needed as inputs to plasma photoionization models are all measured: the X-ray source has a near-blackbody spectrum with temperature 170 ± 34 eV, plus a small superthermal enhancement above 2 keV; the X-ray flux at the sample is greater than 3.0×10^{19}ergs/s/cm^2; and the electron density is 1.5×10^{19}/cm^3 based on the measured expansion of the iron sample. The resulting photoionization parameter ($\xi \equiv 4\pi$ flux/electron density) is approximately 30, which is astrophysically relevant. Measured absorption and emission spectra indicate that the dominant charge states for iron are Fe+16 and Fe+17. Comparisons with models are underway and initial results will be presented. Finally, it is noted that other integrated experiments on high-energy-density plasmas are becoming possible with the new generation of experimental facilities; some initial ideas are sketched out for discussion.

References:

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