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High-resolution absorption spectroscopy of photoionized silicon plasma, a step toward measuring the efficiency of Resonant Auger Destruction

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A remarkable opportunity to observe matter in a regime where the effects of General Relativity are significant has arisen through measurements of strongly red-shifted iron x-ray lines emitted from black hole accretion disks. The lines are believed to originate from the photoionized plasma in the close proximity to the black hole. The spectra carry encoded information about the physical structure of the disk and thus, the black hole itself. However, decoding this unique information requires an accurate spectrum formation model. A major uncertainty in the spectral models is the efficiency of Resonant Auger Destruction (RAD), in which fluorescent $K\alpha$ photons are resonantly absorbed by neighbor ions. The absorbing ion preferentially decays by Auger ionization, thus reducing the emerging $K\alpha$ intensity. The RAD process has been proposed as the reason that $K\alpha$ lines from L-shell ions are not observed in iron spectral emission from some black hole accretion disks, but the question remains why such lines are observed from silicon plasma surrounding other accretion powered objects. Are the observations different because the RAD efficiency is different, or are the differences due to the structure of the accretion flow? To help answer this question, we are investigating photoionized silicon plasmas produced using intense x-rays from the Z facility. The incident x-ray spectral irradiance is determined with time-resolved absolute power measurements, multiple monochromatic gated images, and a 3-D view factor model. The charge state distribution, electron temperature, and electron density are determined using space-resolved backlit absorption spectroscopy. These measurements are strengthened by the fact that the high spectral resolution and the narrow lines arising from the photoionized plasma enable the observation of detailed energy level structure. The measurements constrain photoionized plasma models and set the stage for future emission spectroscopy directly investigating the RAD process.

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