K-LINE SPECTRA OF WARM, DENSE PLASMAS PRODUCED BY INTENSE PULSED ELECTRON BEAMS*

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Warm, dense plasmas can be produced at the tip of a plasmafilled rod-pinch diode[1] (PFRP) on the Gamble II generator at the Naval Research Laboratory. The PFRP concentrates a high current (500 kA), 2 MeV, 60 ns electron beam at the pointed end of a 1 mm diameter tapered tungsten rod. At the time of maximum thermal energy density, the tungsten plasma parameters are estimated to be: 12 times ionized, near solid density (20 g/cm^3), 25 eV, and 2.4 MJ/cm^3.

This paper reports the first measurements of K-line spectra from the PFRP, taken with a curved crystal transmission spectrometer that previously recorded spectra from dense laser-irradiated targets[2]. The radiation passes through two apertures onto the crystal, which diffracts the radiation in the K-line range and focuses it on the Rowland circle 1 m away, where an image plate records two symmetric spectra that allow a quantitative evaluation of absolute energies. With a quartz 30-31 crystal this system clearly resolves tungsten's two K_α lines just below 60 keV, and even separates the $K_{\beta 2}$ line from the $K_{\beta 1-3}$ complex around 66 keV. Within the measurement uncertainty, the line shapes are identical to those from a cold calibration source; improved resolution is needed to see the approximately 0.05 keV shift in x-ray energy associated with the estimated plasma ionization.

Besides tungsten, spectra have been obtained from materials such as CsI, Se and Lu by replacing the tungsten rod with a hollow aluminum tube and filling the end with the material of choice.

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1. B.V. Weber, et al., "Ultra-High Electron Beam Power and Energy Densities Using a Plasma-Filled Rod-Pinch Diode," Phys. Plasmas, **11**, 2916 (2004).
2. J.F. Seely , et al., "Hard X-ray spectroscopy of inner-shell K transitions generated by MeV electron propagation from intense picosecond laser focal spots," High Energy Density Physics **5** (2009) 263–269.