KrF Nike Laser as a Powerful Platform for Experimental X-Ray Spectroscopy of High-Z Ions

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The NRL Nike laser is capable of delivering several kilojoules of ultraviolet light (λ = 248 nm) on a target within several nanoseconds which is sufficient to produce high-Z ions with multi-keV ionization potentials. As such this system is a unique platform to benchmark high-energy-density plasma diagnostics and relevant atomic physics simulations.

For this purpose two high-resolution x-ray spectrometers have been added to the Nike diagnostic suite. One is a survey instrument covering the spectral range from 0.5 to 19.5 angstroms, and the other is an imaging spectrometer using a spherically curved crystal. The survey instrument allows simultaneous high-spectral-resolution observations of both K- and L-spectra up to Z= 30, L- and M- ones to 50 and M- and N-spectra of highly-charged ions with nuclear charge Z=70-85. The imaging spectrometer provides even more detailed spectra within a narrower variable spectral band with a substantially higher efficiency. Measurements and analyses of isoelectronic sequences from several elements greatly assist in identification of specific spectral lines that are of major interest.

One of the goals of this study of x-ray spectra is to provide more insight into the M-band contribution to the total energy balance inside hohlraums of indirect laser fusion experiments. The Nike shots taken with a power density of 2×10^{14} W/cm^2 on the foils of Hf, Ta, W, Pt, Au and Bi confirmed presence of strong spectral lines from Ni-like ions along with multiple satellite lines originating from the lower stages of ionization. High-quality n=2-n=3 spectra from L-shell ions of elements from Y to Sn were also measured for calibration and testing.

Simulations of the measured spectra were performed with the collisional-radiative code NOMAD. The atomic data including level energies, radiative and autoionization transition probabilities, and collisional cross sections were calculated with the relativistic Flexible Atomic Code by Gu. A typical simulation would include about six ionization stages with a total of ~30,000 atomic levels. The effects of ionization potential lowering and opacity were taken into account as well. The synthetic spectra will be compared with the measured data. The typical values of electron temperature and density derived from comparisons are on the order of 2000 eV and 10^{21} cm^{-3}.