Measurement of Highly-Charged Ions Aids International Energy Program

NIST researchers have used a unique device called an Electron Beam Ion Trap (EBIT) to produce and study highly-charged ions of heavy elements that are relevant to the development of controlled fusion energy. Atoms of the heavy elements hafnium (Hf), tantalum (Ta), tungsten (W), and gold (Au) were stripped of 60 or more electrons and held in the EBIT while their radiative properties and atomic structure were studied. Experimental observations in combination with sophisticated plasma kinetic modeling uncovered combinations of soft-x-ray emission lines that are suitable for use by fusion scientists in analyzing the super-hot plasmas in ITER* and other fusion energy devices.

The NIST measurements have also produced results of significance to fundamental science and the theory of Quantum Electrodynamics (QED). The first simultaneous observation of the sodium D-line doublet in heavy sodium-like ions has enabled accurate measurement of the giant relativistic splitting for several large values of ionic charge. Unlike neutral sodium, where the splitting is one part in a thousand of the mean emission frequency, the relativistic and QED effects for heavy elements become so strong that the line separation is comparable with the mean frequency (Figure 4.1). NIST measurements of these lines can now serve as essential benchmarks for the most advanced relativistic and QED theories of atomic structure.

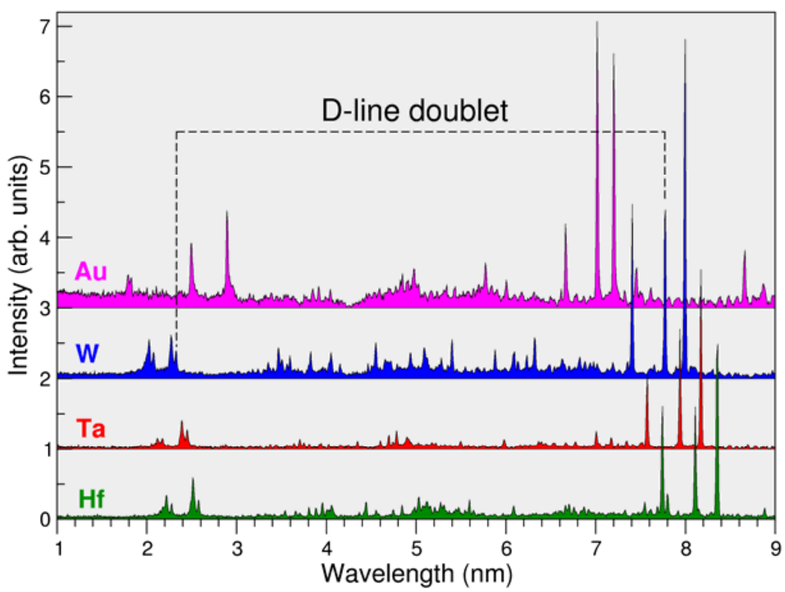

Figure 4.1: Measured soft x-ray spectra from highly-charged ions of Hf, Ta, W, and Au. The D-line doublet for sodium-like W⁶³⁺ is shown by dashed lines.

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