Denver X-ray Conference 2020 Abstract

Superconducting microcalorimeters for measurements of x-ray fundamental parameters

Databases of x-ray fundamental parameters for x-ray analysis include fluorescence line energies and relative intensities, as well as line shape information including line widths and asymmetries. Although these parameters are often assumed to be well-established, this is not uniformly true. For example, fully 75% of the measurements in the official US database are over 50 years old and pre-date the optical/x-ray interferometer systems that finally tied x-ray wavelength scales to SI units.

Fundamental parameter measurements can be challenging because of the time required and the difficulty in achieving reliable absolute energy calibration. The US National Institutes of Standards and Technology (NIST) has begun a new program to improve the situation. One critical piece is a spectrometer made of superconducting microcalorimeters, Transition-Edge Sensors (TESs). A TES is an energy-resolving detector, which operates at the superconducting transition temperature of a thin film, typically 0.1 K. Arrays of hundreds of TESs currently achieve 3 eV to 4 eV resolution at 5900 eV. Unlike a wavelength-dispersive spectrometer, the TES can measure a very broad energy range all at once. This ability offers speed and stability advantages in the characterization of multiple emission lines, as well as direct characterization of asymmetric lines more thoroughly than any single “peak energy” figure can convey.

We present results from an array of 50 TESs to study the positions and shapes of the L-line emission from four lanthanide elements. Employing the well-characterized 3d transition metals as our calibration reference standards, we find that the TESs can be calibrated to absolute accuracy of approximately 0.1 eV for use in estimating unknown line energies, a level of accuracy far better than existing published uncertainties in many cases. We also discuss the future potential for calorimeter-based approaches to improve the metrology of x-ray fundamental parameters.