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First measurements of detailed absolute emission intensities of L X-ray emitted by actinides using a metallic magnetic calorimeter

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Precise quantification of radionuclides in a radioactive sample by photon spectrometry requires a good knowledge of the photon emission intensities. However, they are hardly better known than to within 1%. In the case of actinide L X-rays, although their emission intensities are large, they are not detailed in the databases; sometimes there exist no measurements, therefore the intensities are based only on calculations using fundamental parameters and have large uncertainties. The lack of accurate measurements is due to the limited energy resolution of semiconductor detectors and the knowledge of the full energy peak (FEP) efficiency.

In order to take benefit of the high energy resolution of cryogenic detectors, a metallic magnetic calorimeter (MMC) was developed with a FWHM energy resolution of about 30 eV below 60 keV. Its FEP efficiency has been carefully calibrated with an Am-241 standard source, coupled with Monte Carlo simulations to provide an efficiency curve below 100 keV. The L X-ray and the gamma-ray spectra of 6 actinides were obtained with high resolution and with a large statistics of a several millions of events. For the first time, a cryogenic detector provides absolute photon emission intensities.

For 4 actinides, the measured total L X-ray emission intensities are in good agreement with the recommended values. The high-energy resolution gives access to a high level of details: for each actinide, more than twenty L X-ray emission intensities are given and X-ray satellite structures are clearly visible due to multiple vacancy states during the atomic relaxations. In this work, we will present the experimental protocol implemented to obtain the absolute emission intensities. Some of the measured X-ray emission intensities will be discussed and compared with existing measurements or with recommended and calculated values. The detailed emission intensities will be shown as well as the intensities of the satellite structures.

Less than 5 years of experience since completion of Ph.D

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