PHOTON EMISSION INTENSITIES IN THE DECAY OF U-235

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**Introduction**

- Uranium-235 is the parent of one of the natural radioactive decay series and appears in the background of any spectrometer and is also classed as a NORM (Naturally Occurring Radioactive Material).
- Uranium-235 decay is characterized by about fifty gamma-rays with E < 450 keV, most of them with weak emission intensities (< 1%).
- Probably due to the weak specific activity of U-235 and its presence in any background measurement, only a few experiments have been conducted to measure the photon emission probabilities associated to the U-235 decay.
- Recommended values are based on the intensity of the 185.72-keV gamma ray, used to normalize relative measurements.

**Gamma-ray spectrometry**

Measurements performed using high-purity germanium detector. Source at 10 cm from the detector window.

**Results**

For each peak with energy $E_i$, the absolute intensity, $I_i$, is computed as:

$$I_i = \frac{N_i \cdot C_{GI} \cdot C_{CI}}{A \cdot E_i \cdot E}$$

- $N_i$: net counts of the full-energy peak, obtained using GAMAVISION® for well isolated peaks or COLEGRAM for the complex regions,
- $C_{GI}$: correction for source geometry,
- $C_{CI}$: correction for coincidence summing effects,
- $A$: source activity (Bq),
- $E_i$: full-energy peak efficiency,
- $E$: acquisition live time (2.8 × 10<sup>7</sup> seconds).

**Conclusion**

The reference photon emission intensity (185.72 keV) is obtained with 1.28% relative combined uncertainty. Most of the present results agree with the tabulated data. Some discrepancies are noticed in the 70-keV and 90-keV energy regions: the complex spectrum structure with gamma- and K X-rays from different nuclides, together with the strong influence of the background and uranium self-fluorescence make it difficult to unambiguously attribute the counting to individual lines.

It is expected that these new experimental values will provide helpful information for further evaluation of the decay scheme of U-235 and Th-231.

**Source characteristics and standardization**

Source prepared at JRC-IRMM by deposition of a U-235 solution on glass plate.

Impurities quantified by isotope dilution mass spectrometry (U-234: 5.3%, U-236: 0.110% and U-238: 0.00005%).

Standardization carried out by alpha counting in a defined solid angle (OSA) geometry, using a partially depleted PIPS detector (Canberra) in a vacuum chamber.

Source activity, $A$, is defined as:

$$A = \frac{N \cdot E_{CM} \cdot C_{CM}}{C_{GI} \cdot C_{CI} \cdot E}$$

- $N$: net counts recorded by the detector
- $E$: acquisition live time
- $C_{GI}$: correction factor for impurities
- $C_{CI}$: geometrical factor
- $E$ being the solid angle), derived from: source-to-collimator distance: 166.29 (21) mm, collimator radius: 189 (2) mm, source radius: 7.8 (20) mm,
- $E$ is defined with 0.26% relative combined standard uncertainty.

**Relative and absolute photon emission intensities in the decay of U-235, and comparison with NUCLEIDE database**

Due to the equilibrium between U-235 and Th-231 it was also possible to determine some photon emission intensities associated to the decay of Th-231.