NEW MEASUREMENTS OF X-RAY FUNDAMENTAL PARAMETERS

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STATE OF THE ART

X-ray fundamental parameters are of the utmost importance for quantitative and qualitative X-ray based techniques. In reference-free methods, the quality of the analysis result is directly dependent on the reliability of such parameters characterizing the interaction between X-ray photons and matter: $\mu$, $\omega$, $f$. New values of these parameters can be obtained either by experimental work, using modern facilities, or through quantum mechanical calculations.

The mass attenuation coefficients ($\mu/p$)

Several databases exist and some of them are accessible to the community: Berger¹ (available online (NIST-XCOM) or xraylib), Henke² (available online (CXRO)), Elam³, Ebel, Cullen⁴. Unfortunately, large uncertainties are reported.

Transmission measurement of thin samples: the Beer-Lambert law links the transmission to the total mass attenuation coefficient $\mu/p$ to independent measurement of the sample mass ($M$) and area ($A$) is needed

→ evaluation of the bias introduced by possible elemental impurities ($k_p$)

→ special care was taken to characterize the photon beam (stability, monochromaticity, size)

→ careful evaluation of the combined standard uncertainty budget

MEASUREMENT OF THE MASS ATTENUATION COEFFICIENTS OF Cu (LNHB & PTB)

Transmission measurement of thin samples: the Beer-Lambert law links the transmission to the total mass attenuation coefficient $\mu/p$ to independent measurement of the sample mass ($M$) and area ($A$) is needed

$\mu/p = -\frac{A}{M} \times \ln \left( \frac{I}{I_0} \right) \times k_p$

Relative difference of this experimental work compared with databases

The fluorescence yields ($\omega$)

The available databases contain only limited experimental results, together with theoretical calculations. Nonetheless, discrepancies exist between tables: see example between Bambynek⁶, Krause⁷ and Hubbell⁸

DETERMINATION OF $\mu$, $\tau$, $\omega$, and $f$ OF Sn

1. $\mu$ are measured by a transmission setup using samples of different thicknesses in the 0.1-35 keV energy range

2. Partial attenuation coefficients due to the L subshells are derived from $\mu$

3. Fluorescence spectra are recorded as the excitation photon energy is progressively increased across each partial L transition edge

4. $\omega$ and $f$ are derived from fluorescence spectra using Sherman’s equations

5. A fitting procedure is used to take into account the electron correlation effect on the photoabsorption coefficient ($\tau$) near the transition energies, starting with the L₁ subshell to derive $\omega_0$ and $\tau_0$, which are then used to derive $f_0$ with an excitation energy above L₂ …

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