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Health-Physics Measurements

Neutron Activation Analysis with k_0 Standardization

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NEUTRON ACTIVATION ANALYSIS (NAA) is a sensitive and accurate tool for element analysis, complementary to non-nuclear analytical techniques. The combination of the facilities of our gamma spectrometry laboratory and the reference neutron fields of our BR1 reactor constitutes an excellent framework for research on NAA.

Objectives

- to develop and implement the k_0 standardization method for NAA, in close collaboration with scientific partners;
- to exploit fully the inherent qualities of NAA such as accuracy, traceability, and multi-element capability, and to ensure its position as a competitive routine chemical analysis technique;
- to acquire technical spin-off for our nuclear measurements services, enhanced support possibilities to other internal projects, and be a stimulus for professional contacts with the international scientific community.

Programme In k_0-NAA, the normalization of the analytical result is based on so-called k_0 factors, associated with each gamma line in the activation spectrum. These factors replace a series of nuclear constants, such as cross-sections and gamma-emission probabilities, and are determined in specialized NAA laboratories. This enhances the accuracy by avoiding the unnecessary build-up of uncertainties on the underlying physical constants. The k_0 factors are reactor- and detector-independent, and their values are agreed upon and used by a growing number of k_0 users all over the world. SCK•CEN is hosting an ongoing collaboration with the university of Gent and DSM Research to determine k_0 factors for short-lived isotopes at the BR1 fast-rabbit facility.

Achievements Together with IRMM, we took the first steps to (re)determine some k_0 factors. This fundamental work will make the k_0 method applicable to additional elements, such as fluor, or to short-lived isotopes of other elements, otherwise determined by their longer-lived isotopes. Using short-lived isotopes drastically reduces the irradiation, cooling, and measuring time, thus reducing cost and shortening the client's waiting time.

As another further refinement of the k_0 methodology, SCK•CEN developed a simple method for determining the burnup of certain neutron-flux monitors in an unknown, intense neutron field. In particular, we showed how to evaluate the burnup effects involved in the neutron activation of ^{197}Au prior to any neutron-flux characterization, based merely on the gamma-ray spectrometry of the ^{198}Au and ^{199}Au decay. In this way, the Au-Zr triple-monitor method, which is the default neutron-flux characterization technique for k_0-NAA, has been extended to evaluate also the most extreme neutron fluxes available in nuclear reactors.

In the trail of the k_0-NAA research, the laboratory for gamma spectrometry benefits from applying modern techniques, such as software to compute detector efficiencies for different geometries, a setup with fast electronics for the spectrometry of rather active sources, and Loss-Free Counting (LFC) modules with custom spectrum-analysis software to correct for pulse count losses due to system dead time and pulse pile-up. Aspects of these advanced techniques are being scrutinized; for example, SCK•CEN participates in EUROMET Project 428 on the "Transfer of germanium detectors efficiency calibration from point-source geometry to other geometries," using a (commercially available) semiempirical code. We also research the statistics involved in time-distorted counting experiments of Poisson processes. This pertains to about any nuclear measurement with pulse losses due to dead time and pulse pile-up. Of special interest is the counting statistics found in LFC-corrected gamma spectra. Our research already yielded unexpected information, at variance with existing assumptions on nuclear counting processes.

Partners, Sponsors, and Customers

Scientific partners Institute for Reference Materials and Measurements (IRMM) — Universiteit Gent (UG) — Atomic Energy Research Institute of the Hungarian Academy of Sciences (KFKI) — DSM Research BV — National Institute of Standards and Technology (NIST)

Scientific output

Publications in 1997

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