Limitations on the Lifetime Spectra Decomposability applying the Iterative Least-Square Reconvolution Method with the Instrument Response Functions (in)directly obtained from 207-Bi and 60-Co

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The knowledge of the lifetime spectrometer's *instrument response function* (IRF), also known as the *resolution function*, is crucial for a profound analysis, i.e. the correct decomposition to obtain the *true* information: the characteristic lifetimes and its corresponding contributions. The IRF is commonly modelled by a superposition of Gaussian distribution functions since an analytical solution for the convolution with an exponential distribution function exists. Therefore, the acquired lifetime spectra can be described in total as an analytic function and, hence, the least-square fitting can be easily applied, as it was first shown by Kirkegaard and Eldrup in 1972 [1].

However, the *iterative least-square reconvolution approach* [2] determines the best fit of the recorded lifetime spectrum by *re-convoluting* a sum of N expected exponential distribution functions with an experimentally obtained IRF. For a laboratory setup, two variants are well-known to determine the IRF from experiment: the direct method using 60-Co and the indirect method applying 207-Bi. For both methods, the energies of the gamma-rays are considerably shifted from the energies accompanying the creation (1274keV) and annihilation (511keV) of a positron using 22-Na: 60-Co (1170keV, 1330keV), 207-Bi (570keV, 1064keV). Therefore, significant deviations in the retrieved information can be observed, since the IRF strongly depends on the energy deposited in the scintillation material. Even an additional (de)convolution with an empirically chosen Gaussian function (FWHM) mapping/adjusting the energies of the used isotopes, indicates no farther improvements in terms of spectra decomposability.

Here we present a detailed study regarding the spectra decomposability by using the reconvolution approach with the IRFs (in)directly determined from two isotopes: 60-Co and 207-Bi. We can show that not only the width (~FWHM) of the IRF but also the shape of the IRF indicate differences from the true underlying IRF and, thus, an analysis using the reconvolution method is almost impossible to apply.

References

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