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Notes

On measurement of the K X-ray absorption jump factors and jump ratios of Gd, Dy, Ho and Er by attenuation of a Compton peak

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ABSTRACT

The article entitled "Measurement of the K X-ray absorption jump factors and jump ratios of Gd, Dy, Ho and Er by attenuation of a Compton peak" by Budak G, and Polat R, published in the Journal of Quantitative Spectroscopy and Radiative Transfer 2004;88:525–532, carries out an inadequate treatment of their measured data that renders their results unsuitable for practical use. The analysis and evaluation below describes precisely the mistakes that invalidate the conclusions of this article.

1. Analysis and evaluation

Budak and Polat [1] use the same experimental arrangement as the one developed by Ayala and Mainardi [2], hence it is not true, as stated in their abstract, that their results are the "first measurements for this combination of energy and elements". Furthermore, this article is a short version of an article published previously in another journal [3], showing the same figures, except that Ref. [1] does not report data for Terbium.

What is wrong in Ref. [1] can be seen in its Fig. 2, which shows the raw measured spectra, hence the abscissa is not the energy of the photon but the channel number in the multichannel analyzer (MCA). To get the spectra in terms of the energy of the radiation energy incident on the detector, an unavoidable deconvolution of data must be performed, which is not done in Ref. [1]. Channel number and energy are not related by an arithmetic rule of three.

Deconvolution of a measured spectrum is a usual practice, but in order to substantiate criticisms, the theory of the method will be outlined below. If we denote by n the MCA channel number, the measured spectrum without an absorber, $I_1(n)$, is a consequence of a convolution of the spectrum emitted by the target, $I(E)$, and expressed by the integral [4].

$$I_1(n) = \int_{E_0}^{E_1} I(E) \cdot R(n,E) \cdot \varepsilon(E) \cdot dE$$

where $R(n,E)$ is the energy resolution function of the detector (see Ref. [5]) and is usually taken to have a Gaussian shape with a FWHM that depends on the energy. In Ref. [1], the FWHM is considered to be 160 eV independent of the energy and worst yet, this is the resolution at 5.9 keV but the measurements are around 60 keV, where the FWHM is between 500 and 600 eV. The efficiency, $\varepsilon(E)$, must be measured for each detector and for a Si(Li) detector, around 60 keV, it is a strongly decreasing function of the energy, and about two orders of magnitude smaller than at 5.9 keV. A Si(Li) detector is doubtfully considered a suitable detector in the energy range around 60 keV, given its poor efficiency. A high purity Germanium detector should have been used instead. Neither the FWHM nor the efficiency, around 60 keV, have been reported. Finally, $I(E)$ is the Compton profile of the aluminium sample, which is the first energy spectrum that this procedure requires. Once all these functions are known, the above integral can be deconvoluted to find $I(E)$. The equation for $I_1(n)$, shows that there is not a unique correspondence between the channel

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number at the MCA and the photon's energy of the incident spectrum.

After all the above is done, and after an absorber of the element of interest, having a suitable thickness t, is introduced, the attenuated spectrum, $I_2(n)$ is measured. This spectrum can be represented by the integral

$$I_2(n) = \int_{E_1}^{E_2} IA(E,t) \cdot R(n,E) \cdot \varepsilon(E) \cdot dE.$$

After a careful deconvolution, the absorption function $IA(E,t)$ is found. The absorption function $IA(E,t)$, also defined in Ref. [2] is given by

$$IA(E,t) = I(E) \cdot \exp(-\mu(E) \cdot t).$$

This whole procedure has to be carried out for each measured element.

An alternative to the deconvolution process was used in Ref. [2], that is, a fitting of data to a parametric function for $IA(E,t)$, but without ignoring the functions $R(n,E)$ and $\varepsilon(E)$. The two curves shown in Fig. 2 of Ref. [1] are the unattenuated spectrum, $I_1(n)$, and the attenuated spectrum $I_2(n)$, respectively. Their ratio, channel by channel, generates Figs. 3–6, in which the abscissa is the channel number, not the energy. In other words, it is straightforward to see that the ratio $I_2(n)/I_1(n)$ does not provide the function $IA(E,t)$, for the elements considered, which is the purpose of these kind of experiments.

In the experiment performed by Budak and Polat [1], they do not optimize the thickness of the absorber, as was done in Ref. [2]; they do not set the angle source-scatterer-detector to overlap the K-edge energy of each measured element with the energy where the Compton peak has a maximum, something that was done, justified and recommended in Ref. [2] and their error analysis is very poor, unjustified and barely an estimation. The poor-looking data shown on Figs. 3–6 are nothing but a consequence of an improperly performed experiment and its data analysis.

Finally, it is concluded that the data reported by Budak and Polat [1] on the absorption jump factors are of no practical use.

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