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Relative Efficiency Determination of a Ge(Li) Detector in the Energy Range from 0.08 — 2.5 MeV

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Relative full energy peak efficiency, between 0.08 and 2.50 MeV, of the CANBERRA, model 7229 – 7500 Ge(Li) gamma ray detector is described. The measurements have been performed with gamma rays from ^{182}W, and ^{226}Ra radio-active sources. As a test of the accuracy of the efficiency curve, obtained in this experiment, the relative intensities of more intensive gamma ray transitions in the decay of ^{133}Ba have been measured and compared with the results of other authers.

In the last ten years utilization of different types of Ge(Li) gamma ray detectors for measuring both intensities and energies of gamma rays has been well established. Numerous papers (Sarantifes & Gronemeyer 1969) have reported the measurements of both relative and absolute efficiency of various types and configurations using different sets of standard gamma sources. Other papers have reported some emperical methods for determination of the relative efficiency. However, utilization of different gamma sources for the relative efficiency determination may lead to some discrepancies related with normalization of different efficiency curves belonging to these different sources.

Zobel *et al.* (1977) have been suggested the ^{226}Ra in equilibrium with its short-lived daughters as a good standard for relative efficiency calibration of Ge(Li) detectors with high accuracy in view of its many intense components of gamma rays in the energy range from 186 to 2.45 MeV.

The aim of this work is to determine the relative efficiency curve of the CANBERRA model 7229-7500 Ge(Li) detector with 45.5 mm diameter and 44 mm length in the energy range from 0.08 to 2.50 MeV, using ^{226}Ra and ^{182}W gamma sources. The ^{182}W gamma source was used to cover the efficiency curve at energies lower than 186 KeV.

As a further test of the accuracy of our efficiency curve, the relative intensities of the most intensive gamma ray transitions of ^{133} Ba have been reinvestigated in an independent experiment using the obtained efficiency curve. The obtained results agree within 2% with those reported by Inoue *et al.* (1973) and McNells & Campbell (1973).

Experimental Method

The ^{226}Ra and ^{133}Ba sources were obtained from commercial supplier, while the ^{182}Ta source was obtained by irradiation of a thin foil of natural Ta in the Egyptian Research Reactor. Diameter of different sources does not exceed 3 mm, so they may be considered as point sources. All measurements were taken with the sources placed coaxially at a distance of 20 cm from the front face of the Ge(Li) detector to insure the same detector source geometrical configuration.

The gamma spectrometer consists of CANBERRA model 7229-7500 Coaxial Ge(Li) detector with its own model 2001 preamplifier, an ORTEC model 450 research amplifier, an ORTEC model 408A biased amplifier and ORTEC model 6240B multichannel analyzer. An ORTEC model 459 high voltage supply was used for biasing the detector.

Optimum energy resolution and linearity of the spectrometer was achieved by choosing the optimum integrating and differentiating time constants of the research amplifier, which provides nearly a pure Gaussian shape of the peaks. The energy resolution of the spectrometer was better than 1.8 KeV (FWHM) at the 1.332 MeV gamma ray line of ^{60}Co.

The energy values of the photo-peaks were calculated by measuring composite spectra consisting the gamma ray lines under investigation simultaineously with sources, with well known gamma ray energies.

From the measured spectra the peak areas of the selected gamma ray lines were determined by direct summation of the channel contents after the background was subtracted.

Experimental Results

The relative efficiency curve was determined using the relation.

$$\eta_i^S = \frac{I_i}{I_i'} = \frac{A_i}{I_i' A_k}$$

where η_i is the relative efficiency at the gamma ray line, I_i is the relative intensity of the ith line with respect to the main peak denoted as k. I'_i is the reference relative intensity for the ith line. A_i and A_k are the full – energy peak areas of ith and kth gamma ray lines, respectively.

One of the measured spectra showing the gamma ray lines from the decay of ^{133}Ba is presented for demonstration in Fig. 1. The relative intensities of gamma ray transitions from ^{182}W and ^{226}Ra with its daughters reported by McNells & Campbell (1973) and used in this paper as reference intensities are tabulated in Table 1. To increase the accuracy of the efficiency curve of the detector the most intensive gamma ray lines were chosen. Using the reference intensities outlined in Table 1 and measured ones for the same gamma ray lines an efficiency calibration curve for the CANBERRA model 7229 – 7500 detector was determined as presented in Fig. 2. The errors indicated in this figure include the errors in both relative and reference intensities. Error in our relative intensities includes, in its turn, the statistical error of the peak area which does not esceed 0.5% and an error of the background under the peak area estimated as not more than 2%. Normalization of both curves obtained for ^{182}W and ^{226}Ra was done at the most flat portion of the ^{182}W curve.

As a further test of the accuracy attainable with the obtained efficiency curve, the relative intensity of gamma ray transitions of ^{133}Ba were accurately measured and calculated. The obtained intensities are listed in Table 2 together with those obtained by Inoue *et al.* (1973) and McNells & Campbell (1973). It is seen from this table that our relative intensities are in good agreement with the previously reported ones within 2% accuracy.

Acknowledgement

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Table 1. Gamma-Ray energies and relative intensities of ^{226}Ra and ^{182}Ta isotopes.

Isotope	E_γ (KeV)	Relative Intensity	Isolope	E_γ (KeV)	Relative Intensity
^{226}Ra	0186.211	009.00 ± 0.10	^{182}Ta	0084.681	007.64 ± 0.15
^{214}Pb	0241.981	016.06 ± 0.19	"	0100.110	043.72 ± 0.87
"	0295.213	042.01 ± 0.53	"	0152.428	021.32 ± 0.42
"	0351.921	080.42 ± 0.81	"	0156.384	008.10 ± 0.18
"	0609.312	100.00 ± 0.92	"	0179.391	009.38 ± 0.19
"	0768.356	010.90 ± 0.15	"	0198.348	004.37 ± 0.09
"	0934.061	006.93 ± 0.10	"	0222.104	022.77 ± 0.44
"	1120.287	032.72 ± 0.39	"	0264.069	011.04 ± 0.22
"	1238.110	012.94 ± 0.17	"	1121.270	100.00 ± 1.50
"	1377.669	008.87 ± 0.15	"	1139.030	047.40 ± 0.94
"	1509.228	004.78 ± 0.09	"	1221.400	079.30 ± 0.94
"	1729.595	006.29 ± 0.10	"	1230.980	033.40 ± 0.67
"	1764.494	034.23 ± 0.44			
"	1847.420	004.52 ± 0.09			
"	2118.551	002.53 ± 0.05			
"	2204.215	010.77 ± 0.20			
"	2447.860	003.32 ± 0.08			

Table 2. Relative intensities of ^{133}Ba isotope.

E (KeV)	Relative intensity		
	Present work	McNells & Campbell (1973)	Inoue *et al.* (1973)
160.63	1.04 ± 0.16	1.21	0.98 ± 0.07
223.10	0.76 ± 0.08	0.80	0.76 ± 0.05
276.38	11.24 ± 0.23	11.43	11.60 ± 0.50
302.71	29.61 ± 0.60	29.29	29.60 ± 1.50
356.04	100	100	100
383.85	14.66 ± 0.38	14.47	14.90 ± 0.60

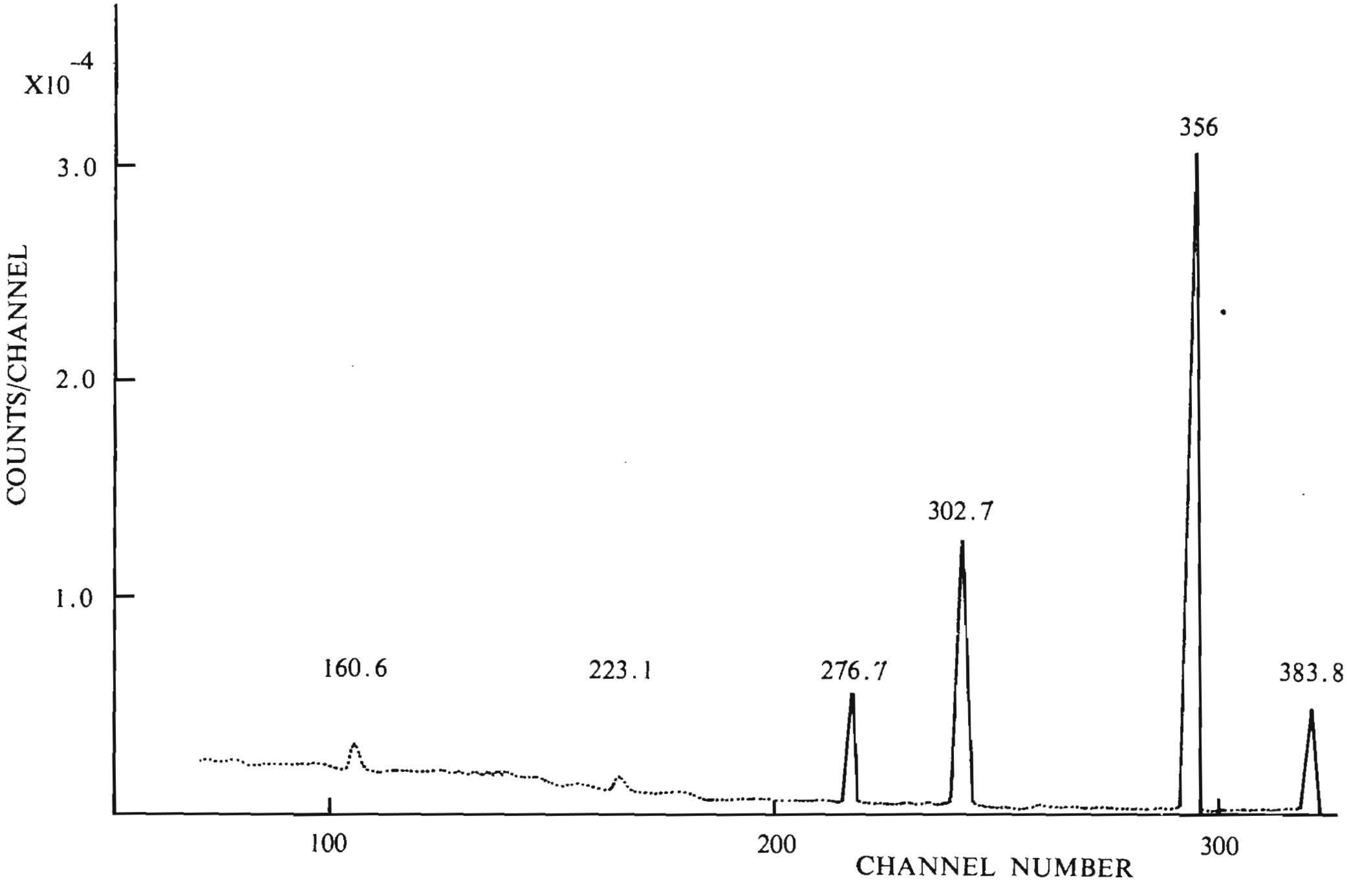

Fig. 1. The Gamma-ray specirum of ^{133} Ba

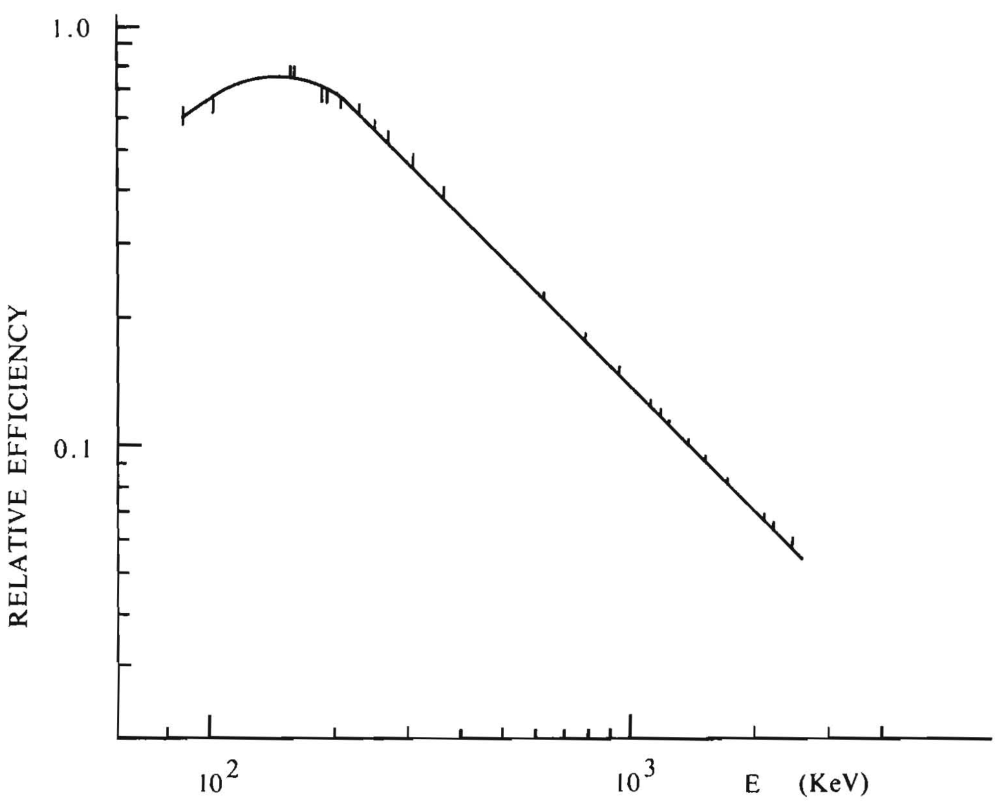

Fig. 2: The Relative efficiency Curve of the Ge (Li) detector.

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تحديد الكفاءة النسبية لكاشف الجرمانيوم في مجال الطاقة ٠,٠٨ - ٢,٥٠٠ ميجا الكترون فولت

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درست الكفاءة النسبية لكاشف أشعة جاما الجرمانيومي ماركة «كانبرا» طراز ٧٥٠٠ - ٧٢٢٩. وقد تمت القياسات باستخدام مصدرين لأشعة جاما هما الوولفرام ١٨٢ (^{182}W) والراديوم ٢٢٦ (^{226}Ra) ولاختبار مدى دقة منحنى الكفاءة فقد تم قياس الشدة النسبية لأشعة جاما الناتجة عن الانتقالات الخاصة بالتفكك الاشعاعي لنواة الباريوم ١٣٣ (^{133}Ba) وقورنت النتيجة مع نتائج باحثين آخرين.