

Study for Gamma Ray Spectra of Cascading Decay

Fatima Abd-Alamir Jassim

Department of Physics, College of Education (Ibn Al-Haithem), Baghdad University, Baghdad-Iraq.
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Abstract

Relative intensity to the single peaks and true sum peaks to the elements of cascading decay of gamma-rays as ^{60}Co and ^{88}Y have been measured for different point source-detector distances by using $3'' \times 3''$ NaI(Tl) detector into two different methods. These methods give a good information to distinguish between single and true sum peaks especially in analysis a complex pulse height spectrum ; where the relative intensity for true sum peak varies with source – detector distance while it is independent for single peak. The results of two the methods are in fair agreement.

الخلاصة

تم قياس الشدة النسبية لذرى منفردة ذات طاقات معلومة ولذرى جمع حقيقي لعناصر ذات انحلال متسلسل لأشعة كما مثل ^{60}Co , ^{88}Y ولمسافات مختلفة بين المصدر النقطي المشع وبلورة الكاشف الوميضي $3'' \times 3''$ NaI (TI) باستخدام طريقتين مختلفتين وذلك للتمييز بينهما. ففي مخططات الانحلال الكثيرة التركيب فقد يؤدي حدوث ذرى الجمع الى الخلط بين الذرى الأصلية وبين ذرى جمع حقيقي. حيث وجد أن الشدة النسبية للذرى المنفردة تكون ذات قيمة ثابتة لا تعتمد على المسافة في حين تكون الشدة النسبية للذرى الجمع الحقيقي دالة الى المسافة. وقد كانت نتائج الطريقتين متطابقة الى حد ما.

Introduction

If two gamma-rays interact with detector within the resolving time of the pulse- amplitude for circuit only one pulse will be stored with amplitude equal to the sum of the pulses.

The true sum pulse occurs for radionuclide emitting two or more cascading photons as shown in Fig. (1) [1]. Within the resolving time of spectrometer, it almost occurs when the decay time of cascading photons is ≤ 100 ns [2]. To distinguish between single pulses and true sum pulses in complex height spectrum from a NaI (TI) scintillation spectrometer is that ;

The count rate of single pulses varies linearly with the peak efficiency (E)

$$N_{\text{single}} = IE$$

while that of the sum pulses varies quadratically

$$N_{\text{true sum}} = I E_1 E_2$$

where I is the source strength, E_1 and E_2 the peak efficiencies of two emitting gamma rays in cascade from ref. [3].

Experimental Procedure

1- The present measurements were performed using a spectrometer composed of $3'' \times 3''$ NaI(Tl) detector, amplifier and multi-channel analyzer.

2- The peaks area was measured by the total numbers of counts recorded in the full energy peak (N), as table (I) presents.

3- The value of single peaks efficiencies for (^{60}Co , ^{88}Y) where calculated from the relation between peak efficiency (E) in percentage (%) and the gamma-ray energy (E_γ) in MeV by a least-squares fit of the form :

$$\log (E) = \log (C) - K \log (E_\gamma)$$

Where	Source-detector distance
$\log (E) = 5.2 - 0.93 \log (E_{\gamma})$	3 cm
$\log (E) = 4.9 - 0.91 \log (E_{\gamma})$	5 cm
$\log (E) = 4.7 - 0.89 \log (E_{\gamma})$	7 cm

as suggested by ref. [4].

The values which were calculated from above relations are represented in table II.

4- Relative intensities for single peaks and true sum peaks of (⁶⁰Co, ⁸⁸Y) gamma decay were obtained by two methods, ref. [5].

4-1 The observed relative intensities values (I_r) were measured by the ratio of total numbers of counts in peaks N(i) as the following relationships clear that :

$$I_r = \frac{N(2)}{N(1)} \quad \text{For single peak}$$

$$I_r = \frac{N(2,1)}{N(1)} \quad \text{For true sum peak}$$

where N (2,1) is the number of counts in true sum peak and N(1) is normalized.

4-2 : The calculated relative intensities values (I'_r) were calculated by the following relationships;

$$N(i) = I'_r E_i, \quad i = 1,2,3 \dots \dots \dots$$

$$N(2,1) = I'_r E_1 E_2$$

So the relative intensity for single peaks is

$$I'_r = \frac{N(2)}{N(1)} = \frac{IE_2}{IE_1} = \frac{E_2}{E_1}$$

and the relative intensity for true sum peak ;

$$I'_r = \frac{N(2)}{N(1)} = \frac{IE_1 E_2}{IE_1} = \frac{E_1 E_2}{E_1}$$

We can consider (E₁ E₂) is the efficiency of true sum peak. Tables I and II present the observed and the calculated relative intensities values for gamma-rays.

Results and Discussion

Relative intensities for single peaks and true sum peaks were determined by two different methods as in tables I and II for radionuclides emitting two cascade photons.

The great advantage of these methods is to distinguish between single peaks and true sum peaks in analyzing a complex pulse height spectrum where the relative intensity for true sum peak varies with source-detector distance while it is unvaried for single peak. In the present work were found the observed relative intensities values for gamma-ray are in fair agreement with those which were calculated.

Table I: Photopeak areas and observed relative intensities of gamma-rays from (⁶⁰Co, ⁸⁸Y) decay for different source-detector distances.

Source	E _γ (MeV)	Photo-Peak Area (count/sec)			Observed Relative Intensity		
		Source-Detector Distance (cm)			Source-Detector Distance (cm)		
		3	5	7	3	5	7
⁶⁰ Co	1.173	1007.15±1.20	832.18±1.2	599.77±0.28	100±0.17	100±0.17	100±0.19
	1.333	899.35±1.67	740.01±0.85	533.3±0.69	89.29±0.19	88.92±0.15	88.92±0.16
	2.506 (1.173+1.333)	20.12±0.15	11.50±0.13	5.52±0.1	1.99±0.02	1.38±0.02	0.92±0.02
⁸⁸ Y	0.898	458.45±0.59	285.2±0.46	192.1±0.39	100±0.18	100±0.23	100±0.29
	1.836	237.5±0.4	150.24±0.31	101.34±0.25	51.8±0.11	52.68±0.14	52.75±0.17
	2.734 (0.898 +1.836)	6.91±0.1	2.70±0.1	1.31±0.02	1.51±0.02	0.95±0.04	0.68±0.01

Table II: Photopeak efficacy and calculated relative intensities of gamma-rays from (^{60}Co , ^{88}Y) decay for different source-detector distances.

Source	E_γ (MeV)	Photo-Peak Efficiency (E%)			Calculated Relative Intensity (I_r)		
		Source-Detector Distance (cm)			Source-Detector Distance (cm)		
		3	5	7	3	5	7
^{60}Co	1.173	2.21	1.28	0.93	100	100	100
	1.333	1.97	1.14	0.83	89.14	89.06	89.25
	2.506 (1.173+1.333)	4.36×10^{-2}	1.46×10^{-2}	0.77×10^{-2}	1.97	1.14	0.83
^{88}Y	0.898	2.84	1.63	1.18	100	100	100
	1.836	1.47	0.85	0.62	51.76	52.15	52.54
	2.734 (0.898+1.836)	4.17×10^{-2}	1.39×10^{-2}	0.73×10^{-2}	1.47	0.85	0.62

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