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Study the Effect of Weather Temperature on the Spectra of Gamma Rays for the Scintillation Detector Nai(Tl)

Abbas Hassan Abed- Allah[1] , Khalid Hussien Hatif[2]

[1]University of Babylon , College of Science ,Department of physics ,Iraq
[2]University of Babylon , College of Science ,Department of physics ,Iraq

Abstract

The effect of the weather temperature on the energy spectrum by the scintillation detector NaI(Tl) has been studied in this work. A radioactive cesium standard source Cs-137 with an energy 0.662 MeV was used and a heat source was used to control the temperature. Used also thermometers on right and left side from the detector to measure the appropriate temperature .A cup-shaped container containing all these parts was used to maintain the temperature constant to obtain on the best results .It was found that the peak position (centroid) decreases of spectrum and photo peak area when the temperature increased .The value of Net and Gross degreases with increasing temperature in the total area, and there is no understand behavior of Net and Gross the photo peak area. Also there is no clear behavior of the FWHM and energy of resolution for the photo peak.

Introduction

In this research we study the effect of weather temperature on the spectra of the gamma rays for the scintillation detector sodium iodide activated with thallium NaI(Tl). There are a multiple uses of this type of detector for the detection of gamma rays. NaI(Tl) use in different environmental fields and at variable temperatures to known if there is an effect of this continuous change of temperature on the detector work. Scintillation detector use for the detection the radiation resulting from decay the radioactive nuclei such as (potassium 40, uranium and thorium).Radiation detection is one of important role in many applications therefore the scintillation detector use in a wide range of fields for the detection of nuclear rays including health physics and in, environment field and in the high energy physics experiments[1].This detector also use in one of its most important applications in the field of nuclear medicine is cameras fluorescent gamma consisting of a large crystal of sodium iodide (NaI) and a large number of photomultipliers .One of important methods in the field of scientific physical, environmental and biological research is the use of radioactive elements (isotopes)[2]. The gamma ray is an electromagnetic ray that has no charge, so it is no affected by the electric or magnetic field. Gamma rays are emitted from natural and industrial radioactive source in the form of photons .It is characterized by its high penetration [3]. Gamma ray emitted from the isotopes is one of approach which its loss the excitation nuclide from the excess energy to converted these nuclide from high energy level to low energy level that's known radiation decay [4] . Detectors have evolved with development of nuclear physics .These detectors detect radiation by measuring its energy and depend on the interaction between the nuclear radiation and detector material. The flash detectors are characterized by high absorption [5] . The scintillation detectors for trigger system and neutron time–of flight measurement in the framework of NICA project operated in the strong magnetic field [6] .

Practical part: This work deals with description of the electronic counting and analysis system using the scintillation detector and the study every part of it and its preparation for the purpose of obtaining the best and accurate practical results .This research includes an explanation of the spectrum regions, standard radioactive sources , and the geometric arrangement.

Electronic counting and analysis system

The electronic counting and analysis system using to detection nuclear radiation and equipped by Spectrum Techniques company type (UCS-30) and using NaI(Tl) crystal by size (2 ×2) inch.

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1-NaI(Tl) Detector : This detector including two main parts are scintillation materials and photomultiplier tube . The scintillation material is characterized by the production of photons when remove the irritation that occurs in the material after it absorbs the gamma rays as shown in figure(1) .the thallium absorbs a part of the energy of electrons , causing the excitation of its atoms , and to get rid of the excess energy, thallium atoms are radiated [7][8]

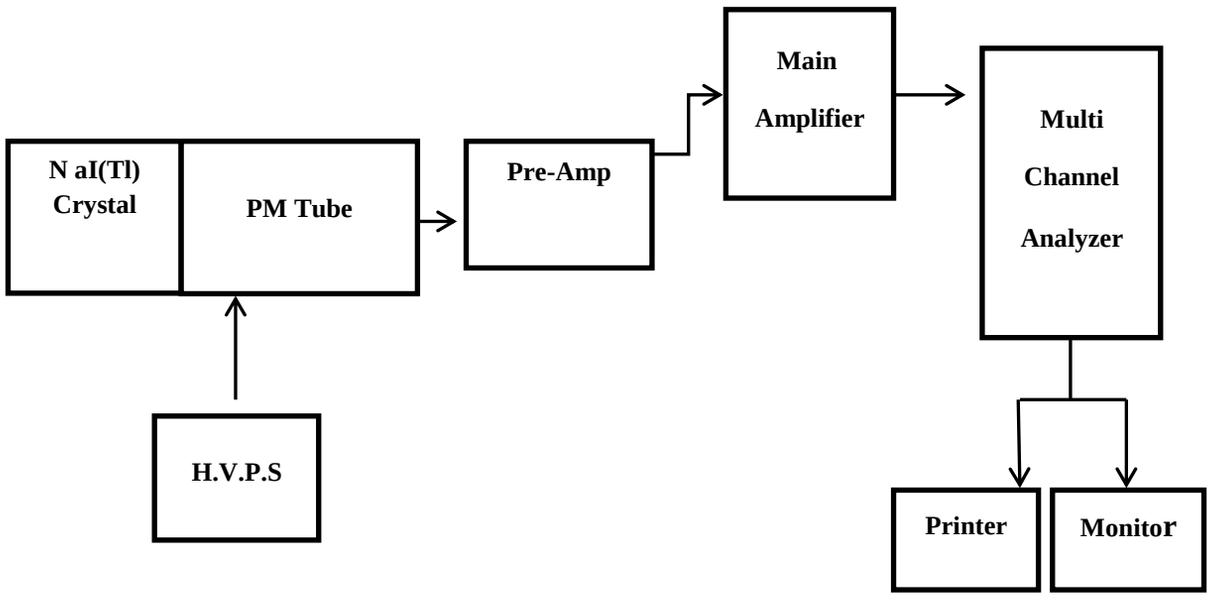
1-1-Preamplifier: I n the t is an electronic device that receive the charge coming from the detector and converted it to a current pulse the current pulse to the voltage pulse and amplifier the voltage pulse [9]

1-2-Main amplifier : The main amplifier enlarges the pulse out from the preamplifier to a level that can be analyzed from the multichannel analyzer (MCA) [10]

1-3-High Voltage power supply: The high voltage equipment works with the required voltage to make the photomultiplier with a range of (0-200) volt.

1-4-Multi-Channel Analyzer (MCA): The Multi-Channel Analyzer (MCA) used in this study is an advanced devices in the study of gamma ray spectra ,supplied by (Spectrum Techniques LLC) .It contains 4096 channels It is characterized by its high ability analyze gamma spectra .The (MCA) converts the pulse coming from the main amplifier into the digital numbers. The system ,reduce the exposure time to ray and simplify the real time check of the spectrum[11]

2-Radioactive Source: Was use Cesium radioactive (Cs-137) with an energy of (0.662 MeV)



Fig(1):The Block diagram of the counting system.

-Geometric Configuration : An electric heat source was used that raised the temperature by five degree Celsius starting from 20 c^0 degrees until a temperature 45.The distance between the detector and heat source is 45 cm. And used two thermometers to measure the temperatures, each one of them was 15 cm away from the detector from each besides . A container coated with a temperature preservative was used the container containing the detector ,the radioactive source the heat source and thermometers for purpose to stay the temperature longest possible period and to obtain the best result as shown in figure (2).

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Fig (2): Geometric configuration that used in work field

Theoretical side

Energy resolution (R) : is the ability of detector to analysis the particles or photons it have different energies .The energy resolution represented by (R) and can be calculated by this equation.[12]. [13]

$$E.R== \frac{FWHM}{Cent.} \times 100\% \quad \text{.....(1)}$$

FWHM: Is full width half maximum .

Cent: is centroid represent the photo peak position .

Photo peak: represented full absorbs to energy of photon gamma ray inside detector crystal. The photo peak appearing in photoelectric interaction .

Total Area of spectrum : is number of the pulses for all channels and it measure by (Counts/Sec).

Photo Peak Net Area: its represent the area from the begin from the photo peak to the finish photo peak and the unit measure is (Counts/Sec).

5-Results and discussions:

Here the results obtained from the practical side will be mentioned . These results are shown in Table (1), and these results will be discussed.

The result of the present work shown in the Table (1)

Temperature	**Total area**		**Photo peak (0.662 MeV)**				**Energy resolution**
T C^0	**Net** (c/sec)	**Gross** (c/sec)	**Net**(c/sec)	**Gross**(c/sec)	**FWHM** (ch.no.)	**Peak position** (ch.no.)	**R%**
20	1232±35	1243±35	410±20	423±21	118	1365	1157
25	1225±35	1241±35	411±20	423±21	116	1356	1169

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30	1221±34	1237±35	406±20	421±21	114	1344	1179
35	1222±35	1236±35	408±20	421±21	116	1325	1142
40	1219±34	1237±35	409±20	422±21	117	1301	1112
45	1221± 34	1231±35	408±20	421±21	113	1268	1122

Total spectrum area

The effect of temperature on the total area of the cesium spectrum .The effect of temperature on the Net total area of the cesium spectrum and according to the results mentioned in Table No.(1), the relationship between the change in the temperature and Net total area is drawn as shown in figure(3).

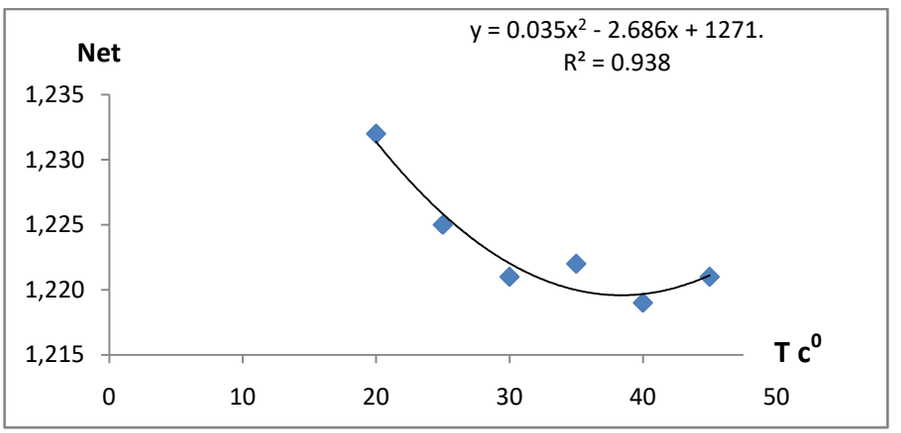

Fig (3): The distribute Net count with change temperature for Cs-137 total area

As it is observed that when the temperature increases , the total area of the spectrum decreases. This result can be explained by the loss of a number of photons due increased scattering of the photons .This applies to the same for the Gross total area of the spectrum according to the results mentioned in Table (1). The relationship between the change in temperature and the Gross is found, when the temperature increases , the Gross area of the spectrum decreases , as shown in figure (4).

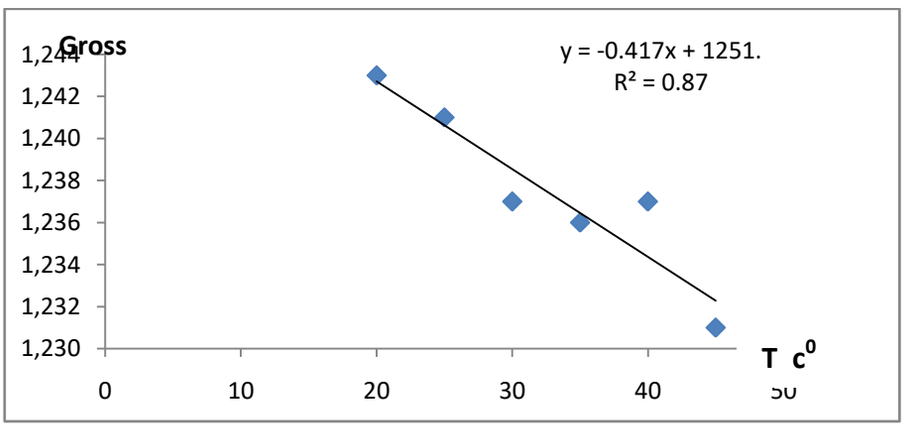

Fig (4): The distribute Gross count with change temperature for Cs-137 total area

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The Photo peak area

1- The study of the effect the temperature on the photo peak spectrum . In the study of the effect temperature change on the Net of photo peak area, according to the results mentioned in Table (1).The relationship between the change in temperature and the Net area of the photo peak was drawn as shown in figure (5). It was found that the relationship of Net with the change in temperature is no clear behavior.

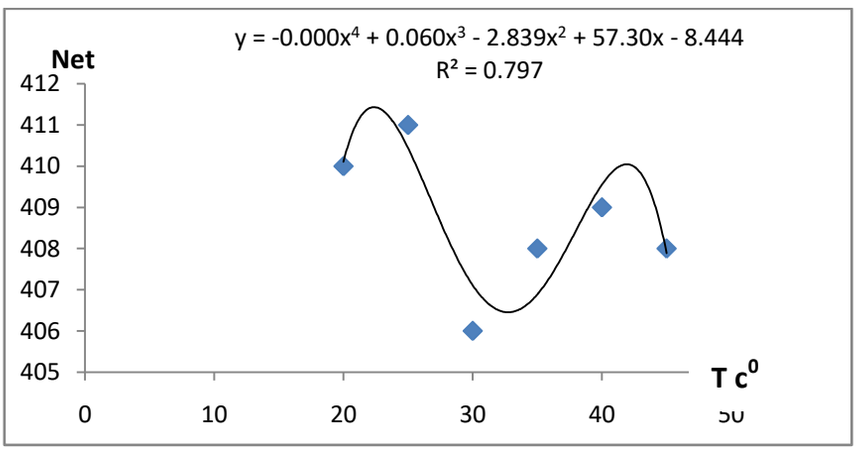

Fig (5): The distribute Net count with change temperature for Cs-137 photo peak.

2- The effect of temperature on the (Gross) photo peak of the cesium spectrum , the effect increase of the temperature on the (Gross) photo peak of the spectrum is shown in the figure(6) .Through this figure we notice that there is no clear behavior of the (Gross) when the temperature changes.

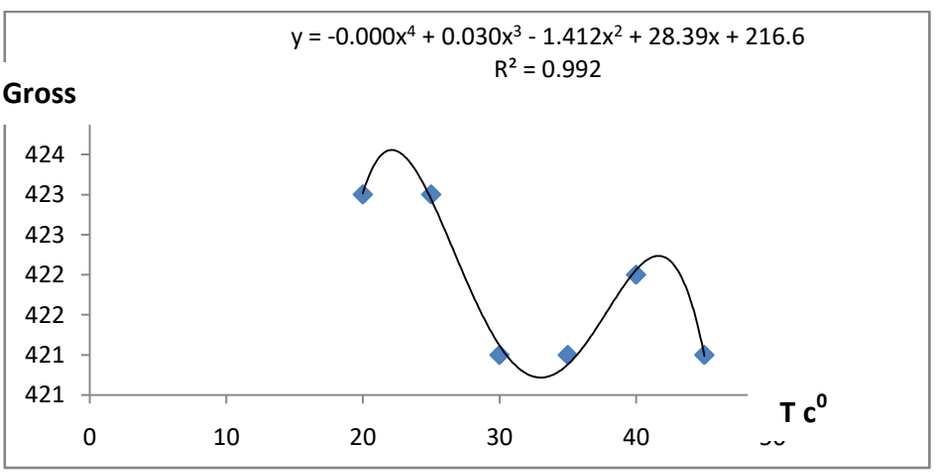

Fig (6): The distribute Gross count with change temperature for Cs-137 photo peak

3- The effect of temperature on the full width at high maximum (FWHM) photo peak of the Cs-137. The effect increase of the temperature on the (FWHM) photo peak of the spectrum, according to the results mentioned in Table (1). is shown in the figure(7) above .Through this figure we notice that there is no clear behavior of the (FWHM) when the temperature changes.

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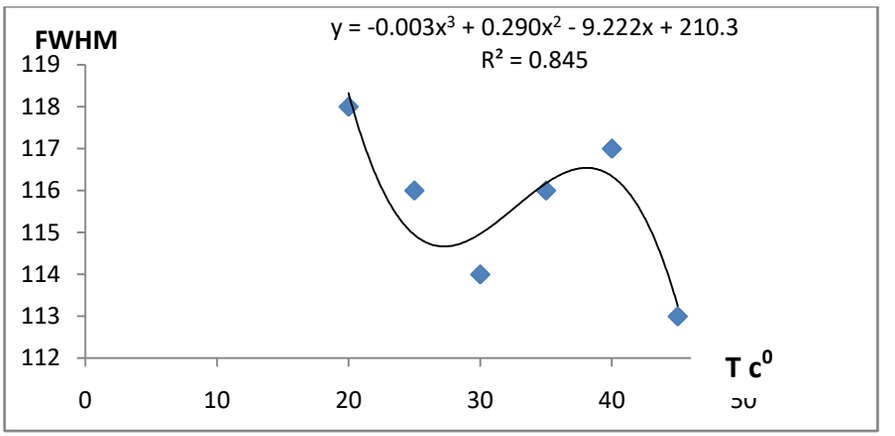

Fig (7): The plot show that the distribute FWHM with change temperature for (Cs-137) photo peak

4- The effect of temperature on the position of the photo peak of the Cs-137.The effect of temperature on the (centroid) of the spectrum is according to the results mentioned in Table (1), as shown in figure (8) .

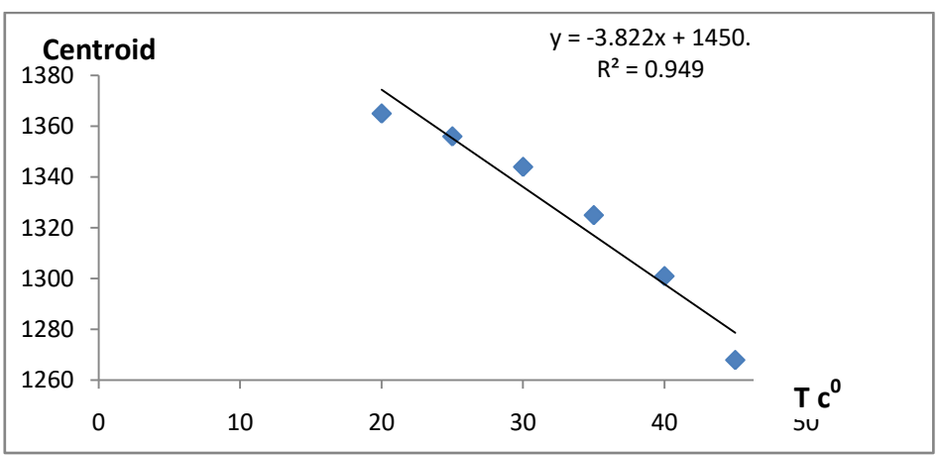

Fig (8): The distribute position photo peak (centroid)with change temperature for (Cs-137) photo peak

The clearest effect observed in this research is the effect of the position photo peak with temperature of crystal NaI(Tl) ,as by increasing the temperature for every 5 degree Celsius , starting from 20 degrees to 45 degrees , then the position of the photo peak decreases with increasing temperature this result agreement with previous studies [14]

5- The effect of temperature on the energy resolution (R) in the photo peak of the Cs-137 .The relationship between temperature and energy resolution as shown in figure (9). Through this figure we notice that there is no clear behavior of the (R) when the temperature changes .

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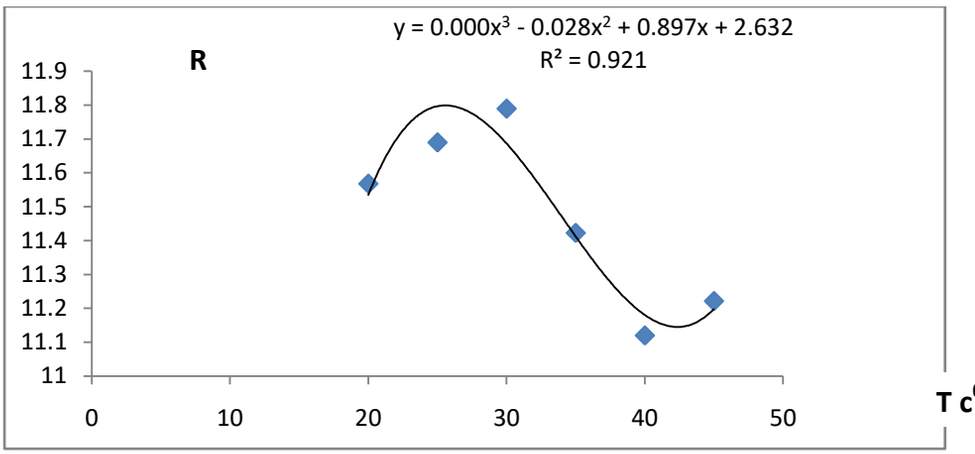

Fig (9): The distribute the energy resolution with change temperature for(Cs-137) photo peak.

Conclusion:

From this study was conclusion the following

1-The temperature effect on the gamma-ray spectra in scintillation detector is significantly effect on the total area of the spectrum, where it was observed that the values of (Net) and (Gross) are inversely proportional to the increase in temperature. that's meaning when the temperature increases the (Net) and (Gross) decrease.

2- In photo peak region we notice that the photo peak position (centroid) decrease when the temperature increases (inversely proportional) while we notice that the (Net, Gross and FWHM) not have clear behavior.

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