Project Report
Properties of Alpha Emitting Isotopes
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November 18, 2021

Aim

To study some of the properties of alpha-emitting isotopes.

- To determine the decay ratio of Th^{230}.
- To determine an unknown source from it's Alpha energy.

Theory

Introduction

Unlike gamma rays as we discussed in our experiments, alpha particles are massive. They get very slightly deflected when they pass through matter. Therefore, they move in a straight line more or less. They only lose their energy through the Coulomb interaction. Neglecting other interactions, the energy loss of alpha particles can be modelled using stopping power data. When an alpha particle penetrates a detector, it deposits energy using this assumption.

In this experiment, Am^{241} and Th^{230} alpha sources will be examined.
The alpha decay data for these isotopes are as follows:

Isotopes	$E_a(KeV)$	$I_a(\%)$
^{241}Am	5388.2	1.62
	5442.8	13.06
	5485.5	84.51
^{230}Th	4438.4	0.03
	4620.5	23.41
	4687	76.33

Th^{230} is an intermediate product in the decay chain of U^{238}. It undergoes α-decay into Ra^{226}. As sown above, it has three peaks, two strong and one weak.
Am^{241} is a radioactive isotope of Americium. It undergoes α-decay to Np^{237}. With one clear spectral line at 5.485 MeV and one weak at 5.442 MeV.

MCA, Resolution and Photopeak Efficiency

The energy channels for a detector are usually not calibrated. We shall use sources with known energy spectrum to calibrate. We shall Th^{230} for calibration.

To calibrate, we take the two peaks of Th^{230} and fit them to $y = ax + b$ and get.

$$E_{channel} = a(q + \frac{b}{a})$$

The resolution of the peaks would be,

$$R = \frac{\delta E_{FWHM}}{E} \times 100$$

And photopeak efficiency,

$$\text{Photo peak efficiency} = \frac{\text{Area under peak}}{\text{Area under spectrum}} = \frac{\text{Sum of counts in peak}}{\text{Total counts in spectrum}}$$

Procedure

- **Calibration**
  - Set HV bias to 60V, Environment to Vacuum, amplifier gain to 30 and MCA input to 8192 channels and live time to 50s.
  - Put Th^{230} in front of the detector and take counts for 50s. Without clearing the screen, put Am^{241} in front of the detector and take counts for another 50s.
  - Perform calibration from the peaks obtained.
- **Determination of energies and photopeak efficiency of Th^{230}**
  - Place Th^{230} in front of the detector and take readings for 200s.
  - Determine Energies from calibration and photpeak efficiency from Counts under curve.
- **Determination of unknown source**
  - Put the unknown source in front of the detector.
  - Take counts for 50s.
  - Measure peak energy and determine the source.

Observation and Analysis

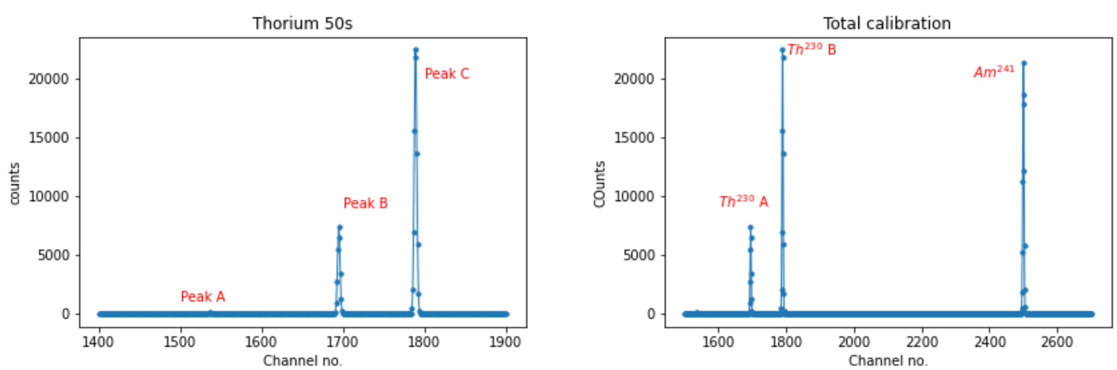

Figure 1: Calibration

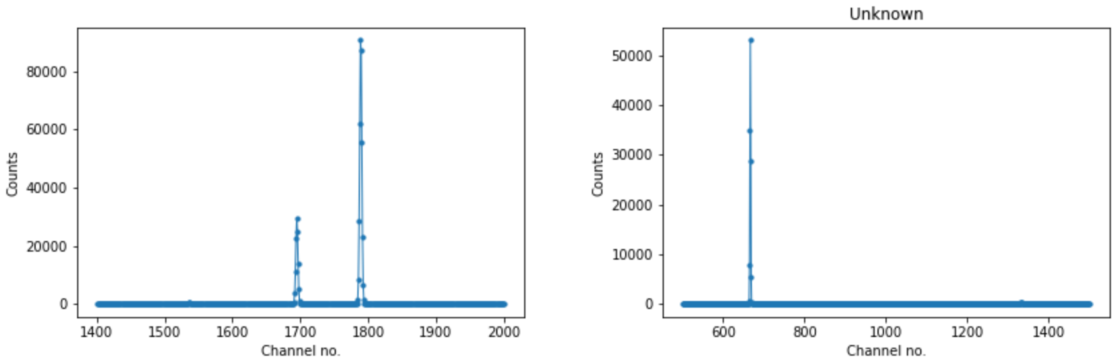

Figure 2: Thorium 200s reading and Unknown source

Calibration

Using the three prominent peaks from the total 100s calibration data,
Centroid of Peak 1 = Chan no. 1685.12 = 4.6025 MeV
Centroid of Peak 2 = Chan no. 1789.42 = 4.687 MeV
Centroid of Peak 3 = Chan no. 2500 = 5.4855 MeV

This was obtained by fitting the data to gaussian curves in scipy.

Now we can easily determine the slope and intercept from this,

$$m = \frac{E_3 - E_2}{N_3 - N_2} = 1.124 \times 10^{-3} MeV$$

$$c = E_2 - m \times N_2 = 2.68 MeV$$

Determination of Energies and decay ratios of Th^{230}

The energy can be calculated from formula

$$E = m \times \text{Channel no.} + c$$

	Peak 1	Peak 2	Peak 3
Centroid	1536.12	1695.13	1789.41
Energy(E_{th} MeV)	4.4024	4.581	4.687
Area under Peak	1244	112796	365316
Total area	479451	479451	479451
Decay ratio (%)	0.2344	23.53	76.19

This data is very close to the actual alpha decay data for Th^{230} given above.

Determination of unknown source

For the unknown sources, fitting the data to gaussian in scipy gave me the centroids for the peaks.

Peak 1 = Chan no. 666.92
Peak 2 = Chan no. 1333.36
From which we can determine the energies from our earlier formula,

$$E = m \times \text{Channel no.} + c$$

Energy of Peak 1 = 3.426 MeV
Energy of Peak 2 = 4.18 MeV
The energy of the first Peak which is the dominant one corresponds very closely to the Energy of Th^{232}.

Conclusion

We make the following remarks about the above study :

- Th^{230} has three prominent peaks, of which only two are reliable and were used for calibration.
- We calculated the decay ratios of Thorium which agreed pretty well with the actual data.
- We detected one peak for Am^{241}, as the second peak of Americium could not be resolved.
- The first peak of the Unknown Source has very similar energy to that of the spectral peak of Th^{232}. Therefore we conclude that the unknown source is likely $Th6232$.