γ ray spectroscopy using a scintillation detector

PH3105

2024-09-25

Debayan Sarkar
22MS002

Diptanuj Sarkar
22MS038

Sabarno Saha
22MS037

Contents

I. Introduction

The experiment aims to find out the γ ray spectra for a $^{137}_{55}\mathrm{Ce}$ using a scintillation detector using a Single Channel Analyser(SCA).

II. Gamma Ray Interaction with Matter

There are three dominant interactions of γ ray with matter, namely photoelectric effect, compton scattering and pair production. Since we dont work with high enough energies. However, γ rays emitted from $^{137}_{55}\mathrm{Ce}$ theoretically could undergo pair production, but the probability of that happening is negligible.

II.1. Photoelectric Effect

An incident γ-ray photon undergoes an interaction in which it hits a bound electron, transfers its energy completely and then an energetic **photoelectron** is emitted. These photoelectrons have almost the energy of the γ ray emitter by the source, minus a small amount of binding energy. We also note that photoelectric effect cannot happen with free electrons.

The probability of photon interaction taking place at a certain distance from the nucleus is given by

$$\tau \propto \rho \frac{Z^n}{E_\gamma^{3.5}}$$

where n varies between 4 and 5, Z is the atomic number and E_γ is the energy of the γ ray. We also see jumps in interaction probability when the energy of the γ ray is close to the binding energy of certain shells like K etc. The probability of photon interaction is given below. The electrons ejected due to photoelectric effect are almost all of the same energy, thus they form a delta like peak in the energy spectrum.

II.2. Compton scattering

The next kind of interaction is called Compton Scattering. Here an incident γ ray photon scatters off of an electron and then transfers part of its energy to the photon based on the angle of scatterring. We also know that scattering can take place between the photon and the electron at any angle between 0 and π. Thus we observe a compton continuum in the energy spectrum. The scattering probability increases linearly with Z(atomic number). The kinetic energy of the electron after Compton scattering at an angle θ is given by

$$E_e = h\nu \left(\frac{h\nu / m_0 c^2 (1 - \cos\theta)}{1 + h\nu / m_0 c^2 (1 - \cos\theta)} \right)$$

III. Scintillation energy detector

IV. Pulse height analysis

V. Graph

VI. Conclusion

VII. Supplementary