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PHYS307 Applied Modern Physics

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Exp. MP-AG The Absorption of Gamma Rays

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Trial 1	Trial 2	Trial 3	Average
1932	1831	1914	1892

Table 1: Background Intensity [counts/min]

Mass per cross sectional area of Pb [g/cm²]	Trial 1	Trial 2	Trial 3	Average	Corrected Average
0	26780	27188	27063	27010,33	25118,33
3,5	18733	18874	19035	18880,67	16988,67
7	14028	14171	13979	14059,33	12167,33
10,5	10598	10644	1066	7436	5544
14	8576	8280	8334	8396,667	6504,667
17,5	6552	6728	6592	6624	4732
21	5413	5606	5479	5499,333	3607,333
24,5	4697	4566	4565	4609,333	2717,333

Figure 1: Counting rates of radiation from ^{137}Cs for different thickness of lead

Slope of the line = $21759e^{-0.088x}$
Mass absorption coefficient $\mu_m = 7.76\times10^{-3}$ cm^2/g
Linear absorption coefficient $\mu = 0.088$ cm^{-1}
Apparent energy value of γ-rays from ^{137}Cs = 667.0 keV
Accepted energy value of γ-rays from ^{137}Cs obtained from Fig.AG.1 = 661.6 keV
Percentage error in the energy of γ-rays from ^{137}Cs = 0.81 %

1. What is the half thickness of γ-rays from ^{137}Cs in lead?

The half thickness $d_{1/2}$ of a material is the thickness that decreases the incident radiation energy by one half. We can express this quantity as follows

$$d_{1/2} = \frac{\ln 2}{\mu} \tag{1}$$

As we stated above μ is 0.088 cm^{-1}. So

$$d_{1/2} = \frac{\ln 2}{0.088} \tag{2}$$

$$d_{1/2} = 7.87cm \tag{3}$$

2. Compute the percent of an incident beam of γ-rays from ^{137}Cs after passing through 2 mm of lead.

$$I = I_0 e^{-\mu x} \tag{4}$$

μ=0.088 cm^{-1}, x is 0.20 cm, $\rho_{Pb} = 11.3g/cm^3$

$$\frac{I}{I_0} = e^{-\mu x} = e^{-0.088\times0.20} \tag{5}$$

$$\frac{I}{I_0} = e^{-0.0176} \tag{6}$$

$$\frac{I}{I_0} = 0.98 \tag{7}$$

above results show that the transmitted beam. Therefore %2 of the beams is absorbed.

3. Would the semilog graph of intensity versus thickness of the absorber be a straight line if the γ-radiation contained γ-rays of two different energies? Explain.

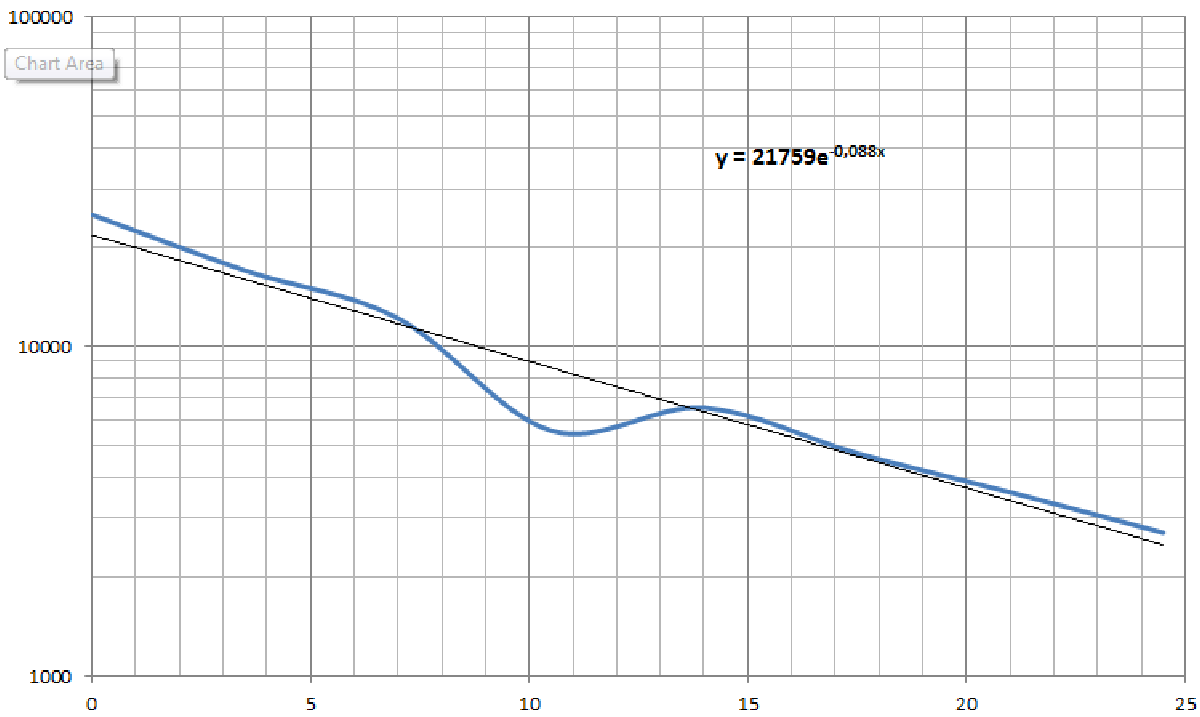

Figure 2: Graph of Intensity versus Thickness of the Absorber

No, if there were two absorption coefficients, Eq. 4 would have the form of

$$I = I_1 e^{-\mu_1 x} + I_2 e^{-\mu_2 x} \tag{8}$$

When the logarithms of both sides are taken, this does not reduce to a straight line.

4. The mass absorption coefficient of iron is 0.058 cm^2/g for 1.24 MeV γ-rays. What percentage of the beam of such γ-rays is transmitted (if any) through an iron plate 3 cm thick? (ρ_{Fe}=7.86g/cm^2)

μ_m=0.058 cm^2/g, x=3 cm, $\rho_{Fe} = 7.86$ g/cm^3

$$\mu = \rho_{Fe}\mu_m = 7.86 \times 0.058 = 0.46cm^{-1} \tag{9}$$

$$\frac{I}{I_0} = e^{-\mu x} = e^{0.46\times 3} = e^{-1.38} = 0.25 = 25\% \tag{10}$$

Discussion and Conclusion

The absorption of nuclear radiation is important in many applications. In this experiment we measured the gamma rays in different thickness. As we expect before the experiment, decreasing in thickness of lead causes to decrease in counting rates of gamma radiation. We used Cesium-137 (^{137}Cs) which is a good beta-gamma radiation source. According to our results, we can state that gamma ray intensity decays exponentially with the thickness of the material.