Gamma-ray attenuation

Criteria
DCP

Aim
To investigate the attenuation of Gamma-rays in metals, and to find the attenuation coefficient and the half-value thickness.

Apparatus
Gamma-source (Cs-137), G.M.Tube, Signal-amplifier, Counter-device, metal plates of Lead and Aluminium, micrometer-measuring tool.

Law of attenuation of Gamma-rays in a material:

The Gamma-rays interacts with matter by

1. Photoelectric effect – energy of gamma-photon is fully transferred to an inner-shell electron.
2. Compton scattering – energy of gamma-photon is partly transferred to an outer-shell electron, the gamma-photon continues with lower energy (higher wavelenght).
3. Pair production – energy of gamma-photon is fully transferred to the creation of an electron-positron pair.

The reduction in intensity of Gamma-rays (or the equivalent here: counts per time measured through the fixed area of the G.M.Tube window) occurs of two reasons:

1. intensity decreases inversely proportional with the square of distance from the source (the rays spread out in a sphere).
2. intensity decreases exponentially as a function of travelling distance in material (attenuation because of interaction with matter).

We are investigating the second intensity decrease, attenuation of Gamma-rays in two chosen metals, Lead and Aluminium.
Intensity (or counts per time) I as a function of distance travelled in the metal (or thickness of the metal) x is:

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

This law is a mathematical analogy with the decay-law. *The linear attenuation coefficient*, μ, is analogous with the decay-constant, *k*. There is a similar analogy between the half-value thickness $x_{½}$ and the half-life time $T_{½}$.

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Procedure
Measure background radiation.
Measure Gamma-radiation with fixed distance for different thickness of metal-plates and for the two types of metal.

Investigate data assuming the exponential attenuation-law.
Determine a value of μ and $x_{½}$.
Compare with table-values, knowing the energy of the Gamma-rays – or, if not knowing this energy, use the results to give an estimate of this energy.

Discuss possible random and systematic errors.

Uncertainty of counting, if N counting in a time period: +/- squareroot (N).
Relative uncertainty: +/- squareroot (N)/N.

σ_f bidraget til μ fra fotoeffekt

σ_c bidraget til μ fra comptoneffekt

σ_p bidraget til μ fra pardannelse

η lineær energiabsorptionskoefficient

$\eta = \mu \cdot E_a/E_{foton}$ hvor E_a er den del af fotonenergien, der gennemsnitlig afsættes som varme (se side 232)