Physics eExp

Inverse square law of radiation (intensity-distance dependence)

A. Objective: To investigate the inverse square law for γ-radiation.

B. Safety

Use a lifting tool to handle the radioactive source. Never touch a source with bare fingers. After finishing the experiment, place the radioactive source back in the container and wash your hands thoroughly.

C. Theory (Ref.)

A γ-radiation source is moved relative to a GM tube (Fig. 1). The actual distance between the two is equal to $d + x$, with d being the distance measured on a bench scale and x an unknown fixed distance relying on the size of the GM tube and the source. The average count rate, after removing the background reading, n, should be proportional to the total emission rate of γ-particles, N, divided by the area of a shell, A , i.e.

$$n \propto \frac{N}{A} = \frac{N}{4\pi(x+d)^2} \quad \text{or} \qquad (1)$$

$$\frac{1}{\sqrt{n}} = k\,(d+x) = k\,d + k\,x, \text{ where } k \text{ is a constant.} \qquad (2)$$

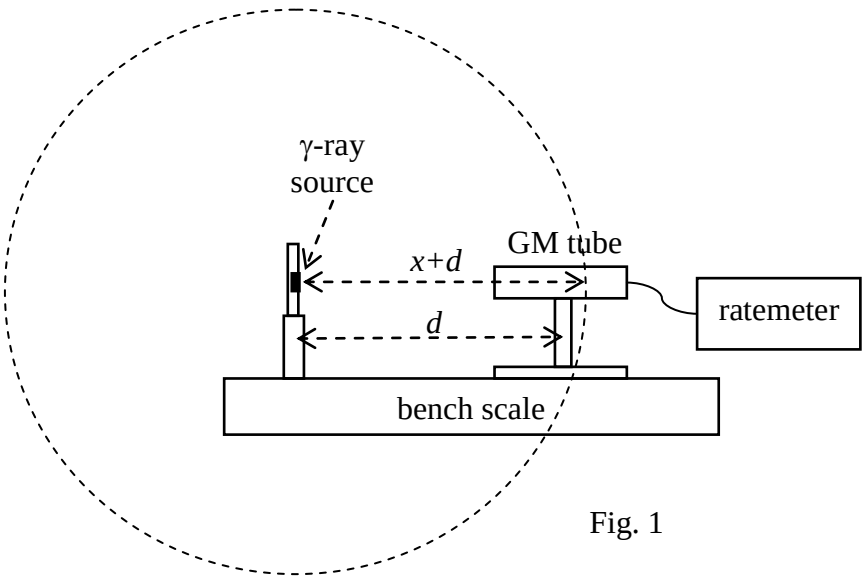

Fig. 1

The plot of $\frac{1}{\sqrt{n}}$ against d is a straight line. The slope is k and the intercept is x.

D. Experiment

D.1. Safety consideration

The radiation exposure shown by a survey meter placed 30 cm away from the source is _____ (mR hr^{-1}) or _____ (mSv hr^{-1}). Assess the risk of the experiment.

D.2 Radiation-distance dependence

- Set up the experiment as shown in Fig. 1. Place a Geiger Muller (GM) tube at the "zero" end point of the scale. Connect the GM tube to a ratemeter. Applied 400 V to the GM tube.
- Record the number of counts of the background for 300 s = _____.
- Place a γ-ray source (sealed Ra-226) at a distance of 50 cm from the GM tube. Move the source towards the GM tube with 5 cm per step. Record the number of counts for 300 s for each step. Subtract the background count from the data. Calculate the count rate, *n* and complete Table 1.

Table 1 Each measurement lasts for 300 s.

Background counts (in 300 s)									
Background count rate (/s)									
Distance, *d* (cm)	50	45	40	35	30	25	20	15	10
Number of counts, *N*									
Count rate (counts s^{-1})									
Corrected count rate, *n* (counts s^{-1})									
$1/\sqrt{n}$									

E. Analysis and conclusion

- Plot $\frac{1}{\sqrt{n}}$ versus *d*.
- Hence derived *k* and *x*.
- Discuss the meaning of *k* and *x*.

- END -