Approximate Inverse Square Law for γ rays

Vivek Sagar, Prashansa Gupta and Atul Singh Arora

November 3, 2014

1 Introduction

In this experiment, we investigate the dependence of intensity of gamma radiation on the distance of the source.

2 Motivation

We would like to model the dependence of intensity of gamma radiation being received. For this purpose, we carry out the following experiment, note the values of intensity on distance at which the source is kept. It can be seen that this comes out to be an inverse square law dependence. Let us assume a general power-law dependence as

$$r \propto d^{-\alpha}$$

The slope from the plot of $\log r$ versus $\log d$ gives the power α.

3 Procedure

Operate the GM counter at the previously determined operating voltage i.e. 485V, and set the preset time to 60 seconds.

Three sets of background counts were taken. Placed the source in the end window detector stand. Beginning with the first slot, recorded three sets of counts for the set voltage. Repeated the procedure, increasing the distance, until the last slot was reached.

A graph of distance versus the counts was plotted, and error bars determined.

4 Observations and Calculations

The graph of distance versus the counts shows the inverse square dependence of intensity on the distance.

Another graph plots the log of both the counts and the distance, whose slope gives the square power.

Listing 1: Experimental Observations

```
Background Radiation Counts (in 60 sec)
-----------------------------------
51
44
46
43
42

Background Subtracted Count Rate (1/sec)
-----------------------------------
Slot No.        Count rate      Count rate      Count rate
2               63.64           65.01           63.68
3               32.78           33.21           33.93
4               19.81           19.41           20.41
5               14.29           13.51           13.61
6               10.44           10.66           10.99
7               7.33            7.28            7.28
8               5.39            5.34            5.86
9               4.48            4.13            3.76
10              3.46            3.66            3.36
11              2.86            2.99            3.14
12              2.13            2.21            2.21
```

The parameters from the log d versus log r graph are

$m = -1.86467 \pm 0.04755$

$c = 5.56091 \pm 0.0902$

Listing 2: Fit Result

```
plot 'exp2' using (log($1)):(log(($2+$3+$4)/3.0)), f(x)
fit f(x) 'exp2' using (log($1)):(log(($2+$3+$4)/3.0)) via m,c
```

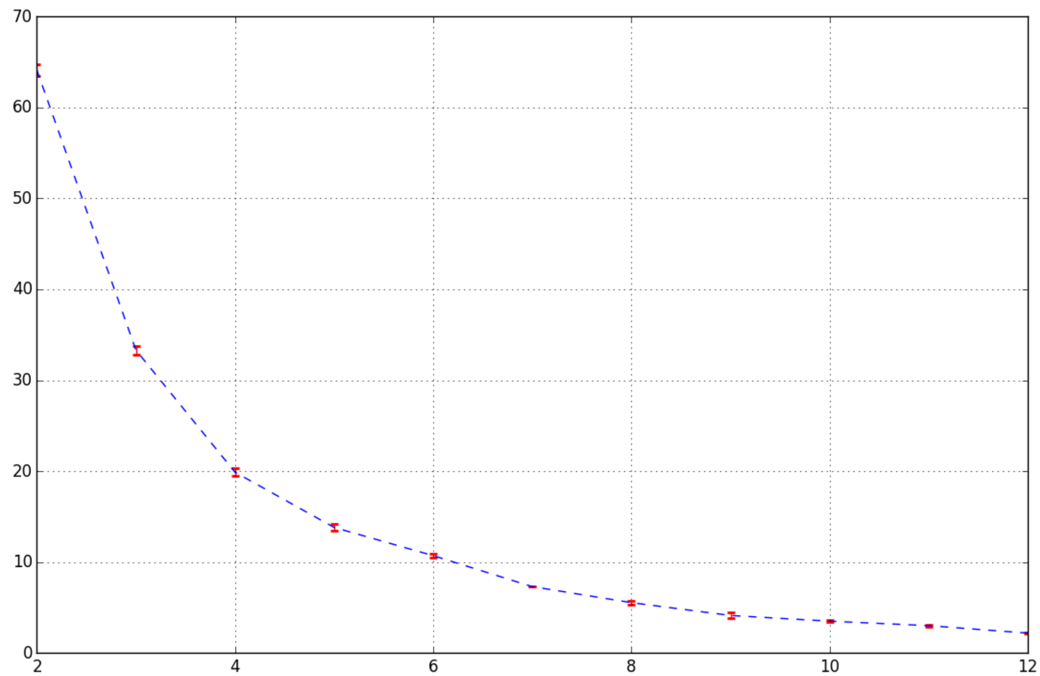

Figure 1: Count Rate (sec^{-1}) vs Slot No.

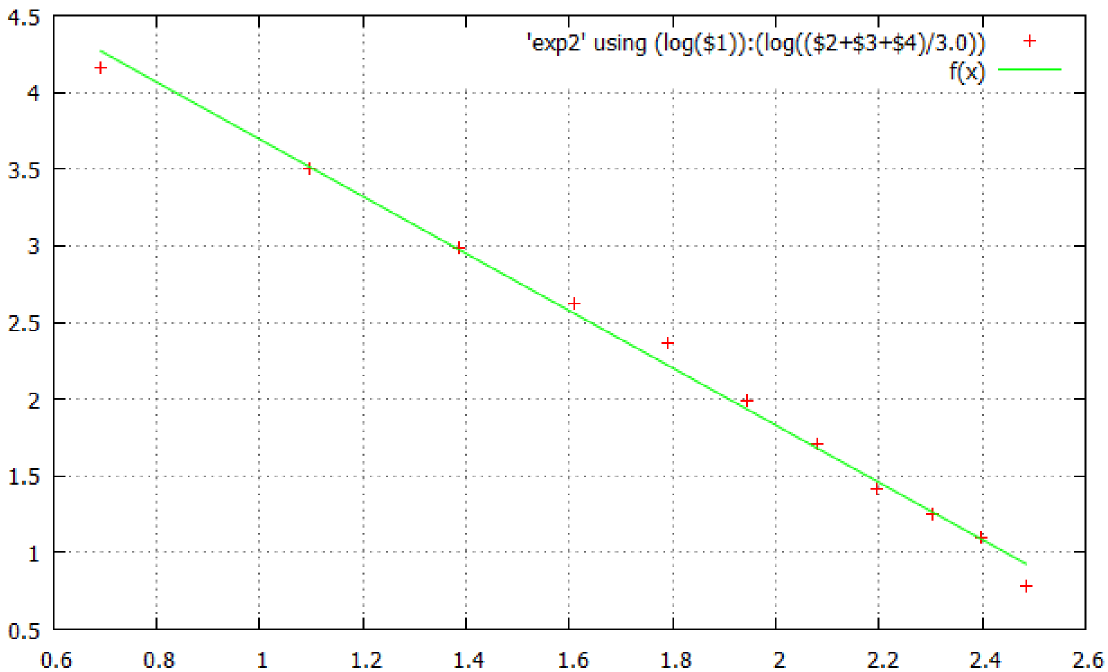

Figure 2: log r vs log d, where r is the average count rate (sec^{-1}) and d is the slot number

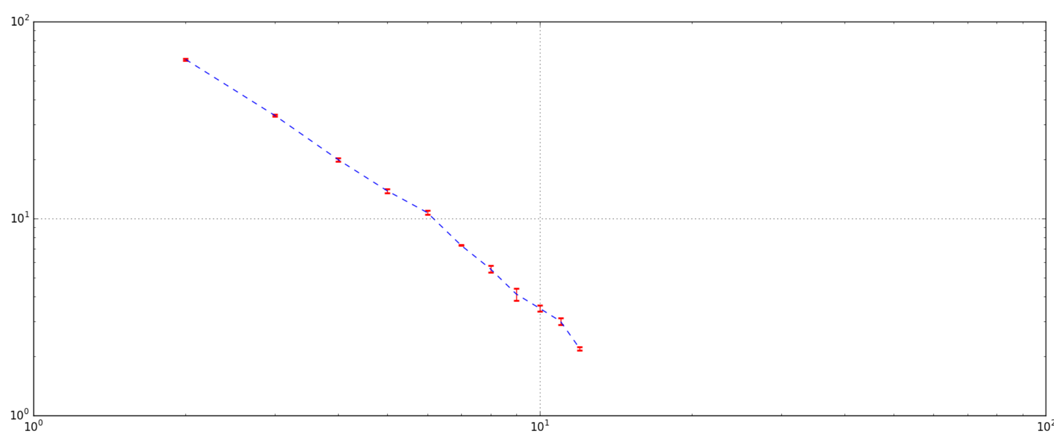

Figure 3: log r vs log d where r and d have been defined earlier

```
----------------------------------------------------------------------------------
After 5 iterations the fit converged.
final sum of squares of residuals : 0.0662985
rel. change during last iteration : -2.09323e-016

degrees of freedom    (FIT_NDF)                        : 9
rms of residuals      (FIT_STDFIT) = sqrt(WSSR/ndf)    : 0.0858283
variance of residuals (reduced chisquare) = WSSR/ndf   : 0.0073665

Final set of parameters            Asymptotic Standard Error
=======================            ==========================

m               = -1.86467         +/- 0.04755      (2.55%)
c               = 5.56091          +/- 0.0902       (1.622%)
```

5 Results

The plots show an approximate inverse square relationship between 'r' and 'd', since the obtained slope$= 1.8 < 2$ even after considering the errors.