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PH2140 Mathematics on the Computer Assignment 2 10 August 2015

Fitting data to a curve: half-life of ^{137m}Ba

The data file Cs137.dat has data from a radioactive decay experiment involving Cesium-137 and its metastable decay product Barium-137m. ^{137}Cs has a half-life of 30.17 years. ^{137m}Ba on the other hand is short-lived and decays to its stable ground state by emitting a gamma ray. In the experiment, these gamma rays are detected by a Geiger counter, as a function of time.

The goal of this exercise is to fit the radioactive decay data to a curve and estimate the half-life of ^{137m}Ba. The number of counts ΔN detected in an interval Δt defines the decay rate $R = -\frac{\Delta N}{\Delta t} \approx -\frac{dN}{dt}$. We know from quantum mechanics that R is proportional to N, the number of radioactive nuclei present at time t. Therefore, we have,

$$\frac{dN}{dt} = -\lambda N \;\Rightarrow N = N_0 e^{-\lambda t},$$

where N_0 is the number of radioactive nuclei present at time $t = 0$, and $\lambda = 1/\tau$, where τ is called the *mean life* of the radioactive particle.

Equivalently, we can describe the exponential decay process in terms of the *half-life* $\tau_{1/2}$ which is defined as the time taken for N_0 to decay to half its value, so that

$$N = N_0(2)^{-t/\tau_{1/2}}.$$

The file Cs137.dat has two columns : the first is time in 20-second intervals and the second column indicates the number of decays detected during that time.

(i) Import the data into your notebook from Cs137.dat.

(ii) Define the appropriate fit function and fit the data to it. Hence estimate the half-life of ^{137m}Ba.

(iii) Plot the data as a function of time, with the fit function superimposed on it.

(iv) Plot the difference between your fit function and the data as a function of time.

Hint: Remember to account for the constant background level that persists in the data even after the ^{137m}Ba has decayed away.