α-Radiation: Illustrations of the enormous range of decay rates in different nuclei

Consider a very simple model of a-radiation:

Assume the alpha particle (m = 6.64 x 10^{-27} kg) is trapped in a nucleus which presents a square barrier of width L and height U_o. To find the decay rate we consider:

(1) the "attempt rate" at which the alpha particle of energy E inside the nucleus hits the barrier

Rough estimate with E ~ 5 to 10 MeV: the alpha particle makes about 10^{21} "attempts" per second (~velocity/nuclear diameter)

(2) the tunneling probability for an alpha particle with energy E each time the particle hits the barrier. [For this order of magnitude calculation you may neglect G.] Here we use

$$T \approx e^{-2KL} \qquad K = \sqrt{\frac{2m}{\hbar^2}(U_0 - E)}$$

Because of the exponential this factor can vary enormously!