

**Physics 4410**  
**Quantum Mechanics 2**

**Lecture 37**

**Quantum metastable states**

December 2, 2020

1. Describe quantum tunneling within the WKB ansatz.

2. Give a semiclassical argument for the time it takes a particle to tunnel out of a metastable region.

### Activity: Alpha decay.

Many heavy and unstable nuclei decay by the emission of  $\alpha$  particles ( ${}^4\text{He}$  nuclei). A toy model for this is to consider a particle of mass  $m$  and charge  $+2e$  moving in the following one dimensional potential: (note that radius  $r \geq 0$ ):

$$V(r) = \begin{cases} 0 & 0 < r < a \\ \frac{2Ze^2}{4\pi\epsilon_0 r} & r > a \end{cases} .$$

- (a) Write down an abstract formula for the lifetime of the heavy nucleus (i.e. for the time it will take for the  $\alpha$  to tunnel outside).

**(b)** Estimate the tunneling integral, and thus the lifetime of the heavy nucleus.

(c) Give a heuristic argument why heavy nuclei are less stable than lighter nuclei.