Physics 4410
Quantum Mechanics 2

Lecture 36

Quantum tunneling

November 30, 2020

1. Review the Bohr-Sommerfeld approximation. What happens if there are "hard wall" boundary conditions?

Activity 1: Quantum bouncing ball.

Consider a quantum "bouncing ball" falling under the influence of gravity:

$$V(x) = \begin{cases} mgx & x > 0 \\ \infty & x < 0 \end{cases} .$$

(a) How should we implement Bohr-Sommerfeld quantization?

(b) Estimate the allowed energy levels E_n.

2. Describe quantum tunneling within the WKB approximation.

Activity 2: Scanning tunneling microscope.

One of the ways we image atoms in solids is by measuring a current of quantum tunneling electrons from a STM device. Imagine an electron moving in the following potential:

$$V(x) = \begin{cases} -V_0 & x < 0 \text{ or } x > a \\ 0 & 0 < x < a \end{cases} .$$

Here V_0 is called a "work function" for the metals.

Using the estimates $V_0 \sim 5 \times 10^{-19}$ J, the electron mass $m \sim 10^{-30}$ kg, and any fundamental constants, estimate how far the STM tip must be from a metal in order for quantum tunneling to not be negligible.