CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

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Project Number

S1808

Project Title

Modeling an Ideal Structure of Energy Barrier to Minimize the Energy Loss of Electron Waves Undergoing Quantum Tunneling

Abstract

Objectives/Goals

The objective is to model a quantum tunneling barrier with a specific structure that minimizes the frequency of electron wave oscillations, which indicates the energy of electrons deflected by the barrier, thereby maximizing the energy of electrons that are tunneled through the barrier.

Methods/Materials

Through programming in C, 4 computer simulations were carried out. Stimulations 1 to 4 contain mathematical models of a rectangular barrier (horizontal function), triangular barrier (linear function), trigonometric barrier (sin/cos function), and a normal distribution barrier (Gaussian function), respectively. The emission height of an electron wave is initialized to be 0.5 units, and the height (potential energy) of all four barriers are set to 1000 units. By using Schrodinger equations, the behavior of electron waves was monitored throughout the simulation. Each simulation consisted of 1000 frames, and the frames were compiled into a GIF. Observation focused on the coordinate x=70 on the horizontal axis of the gif, and all four simulations were paused when oscillation of reflected electron wave occur at the coordinate. The frequencies of electron waves were calculated by dividing the number of oscillations over a period of 10 units. The barrier with the least frequency was determined to be the ideal structure for minimizing the energy loss of particles.

Results

My tests allowed me to conclude that the more a barrier is shaped similar to a uniform wave, energy loss of particles will be less. The rectangular barrier and triangular barrier produced oscillation of 29 cycles per second over 10 length units on the horizontal axis, while trigonometric barrier produced a relatively less oscillation frequency of 26 cycles per second, and N.D. barrier, modeled by Gaussian equation, resulted in a minimal oscillation frequency of 19 cycles per second.

Conclusions/Discussion

The results I obtained suggest that a smooth and normal-distribution-shaped energy barrier conserves a high percentage of potential energy for particles tunneled through it. This ideal structure can be applied to quantum microscopy to increase the efficiency of tunneling and imaging process. Furthermore, the Gaussian structured barrier can be implement in design of artificial light sources to decrease the waste of electricity.

Summary Statement

As the energy barrier is shaped increasingly similar to the shape of a wave packet, I found that the energy loss of the electron wave packets tumbled through it decreases.

Help Received

Richard Scalettar