ECE770-T14/QIC 885: Quantum Electronics & Photonics

Problem Set 2, Winter 2014, Instructor: A. Hamed Majedi

Problem 1- Consider a rectangular potential barrier.

a) Find the transfer matrix associated with the rectangular potential barrier.

b) Using the result of part a), find the transfer matrix associated with a potential barrier with delta function potential.

Problem 2- Consider a double quantum well heterostructure made of GaAs/AlGaAs with a potential as shown in Figure . Consider the effective mass of electron is $0.07m_o$.

a) Sketch the energy of an electron, E, with respect to the transmission coefficient, $T(E)$. You may also want to ketch E vs. $-\ln(T)$.

b) Find the transmission resonances of the structure.

c) What would be the approximate life time of the resonance states.

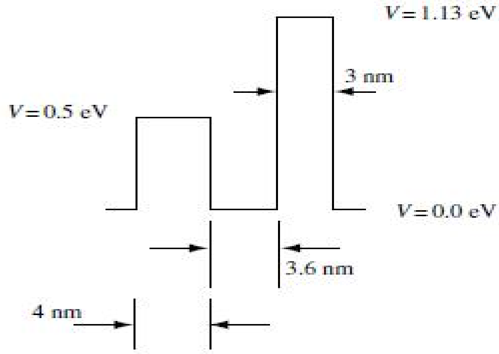

Figure 1: Potential Barrier in the GaAs/AlGaAs Heterostructure

Problem 3- Identify the allowed energy bands and energy band gaps for the electron transmission through a multiple quantum well structure consisting of 12 identical one-dimensional potential barrier each of energy 10 eV and width 0.1 nm that is sequentially placed every 0.5 nm (so that the potential well between each barrier has width 0.4 nm).

How do you expect the velocity of the transmitted electron to change as a function of energy?

Hint: You need to write down a computer program to solve this problem.

Problem 4- Consider an electron in a 1D infinite square quantum well that is in the nth energy level. An instantaneous force exerts a momentum p_o to the electron. What is the probability in which the energy of the electron being the same as before.

Problem 5- A simple harmonic oscillator (SHO) is initially (at time $t = 0$) in a state with wavefunction, $|\Psi\rangle = A\sum_{n=0}^{N} c^n|\psi_n\rangle$ where $|\psi_n\rangle$ are the SHO energy eigenfunctions, c is a complex number such that $|c| < 1$.

a) Determine the normalization constant A.

b) Find the wavefunction of the system at a later time $t > 0$, i.e. $|\Psi(t)\rangle$.

c) Compute the probability of finding the system again in the initial state at a later time, $t > 0$.

d) Calculate the expectation value of the total energy of the system.

Due: Wednesday Feb. 12, 2014. (before starting the class)