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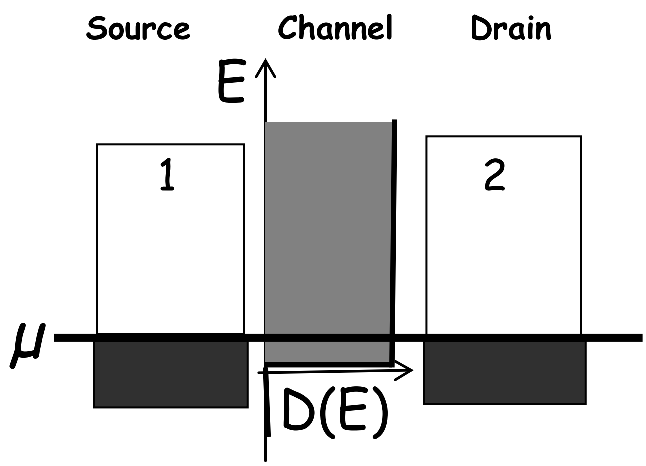
ECE 495N, Fall'08 ME118, MWF 1130A-1220P

Fundamentals of Nanoelectronics

HW#2: Due Wednesday Sept.10 in class.

Please turn in a copy of your MATLAB codes for Problems 1, 2.

Consider the same problem as in HW 1, namely a channel with a density of states given by, $D(E) = D_0\, \vartheta(E)$, where ϑ represents the unit step function. The equilibrium electrochemical potential μ = 0.1 eV and $k_B T_1 = k_B T_2 = 0.025\, eV$. Assume the escape rates γ_1 and γ_2 to both be equal to 10 meV, and the density of states (for E>0) D_0 to be 0.1 / eV.



Problems 1 and 2 below require a computer evaluation of the current expression discussed in class:

$$I = \frac{q}{\hbar}\int_{-\infty}^{+\infty} dE D(E-U)\frac{\gamma_1\gamma_2}{\gamma_1+\gamma_2}\left[f_1(E) - f_2(E)\right] \quad (1)$$

but Problem 2 also requires an additional self-consistent evaluation of U from the equations

$$N = \int_{-\infty}^{+\infty} dE D(E-U)\frac{\gamma_1 f_1(E)+\gamma_2 f_2(E)}{\gamma_1+\gamma_2} \qquad (2)$$

and $$U = U_L + U_0(N - N_{eq}) \qquad (3)$$

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Problem 1: Calculate the current (I) versus drain voltage (V_D) for –0.4V < V_D < +0.4V assuming $U_0 = 0$, and

(a) $U_L = 0.5 * (U_{source} + U_{drain})$,
(b) $U_L = U_{source}$,
(c) $U_L = U_{drain}$.

Note that $U_{drain} = U_{source} - qV_D$, $\mu_1 = \mu + U_{source}$, $\mu_2 = \mu + U_{drain}$

Problem 2: Calculate the current (I) versus drain voltage (V_D) for –0.4V < V_D < +0.4V assuming $U_0 = 5$ eV and $U_L = U_{source}$.

Problem 3: Electrons in a semiconductor obey a modified Schrodinger equation which in one dimension has the form

$$i\hbar \frac{\partial \psi}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2 \psi}{\partial x^2} + \alpha \frac{\partial^4 \psi}{\partial x^4}$$

where α and m are constants. Assume a solution of the form (ψ_0 being a constant)

$$\psi(x,t) = \psi_0 e^{ikx} e^{-iEt/\hbar}$$

to find the dispersion relation E (k).