9/17/09

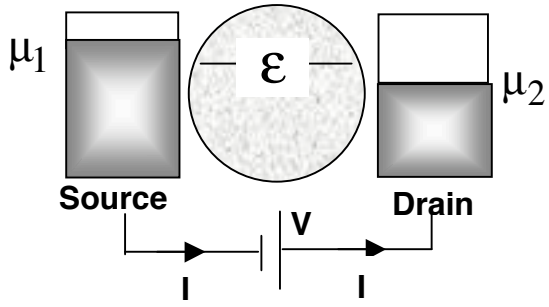
ECE 495N, Fall'09 GRIS 280 MWF 1130A-1220P

Fundamentals of Nanoelectronics

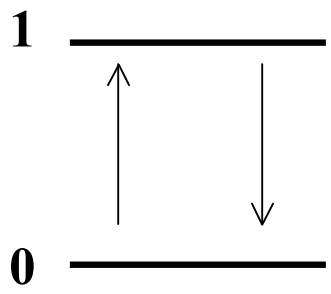
HW#3: Due Monday Sept. 28 in class.

Problem 1: We wish to calculate the current, I through a single discrete energy level ε and the average number of electrons, N using the ***multielectron*** picture where we have two levels '0' and '1' corresponding to the one-electron level being empty or full respectively.

One-electron picture



Multi-electron picture



Your answers to all questions below should be in terms of the Fermi functions in the two contacts and the couplings γ_1 and γ_2 for the two contacts.

(a) Equate the rate of transition from '0' to '1'and that from '1' to '0' to obtain an expression relating the probabilities P_0 and P_1.

(b) From your result in (a), find an expression for the average number of electrons, N

(c) Obtain an expression for the current I from the rates of transition from '1' to '0' and from '0' to '1'.

Problem 2: Consider the structure in Problem 1 with two energy levels both with the same energy ε (in the one-electron picture). Note that the corresponding multielectron picture is different from Problem 1.

(a) Assume that the interaction energy is so high that no more than one of these levels can be occupied at the same time. What is the average number of electrons in the channel if both contacts have the same electrochemical potential μ and temperature T? Your answer should be in terms of ε, μ and T.

(b) Repeat part (a) assuming that the interaction energy is zero.

Problem 3: Consider the same structure as in Problem 2, but now under bias with two different electrochemical potentials in the two contacts. Assume that the temperature is very low (--> 0K).

(a) What is the maximum current under bias assuming (as in Problem 2a) that no more than one of the levels can be occupied at the same time. Your answer should be in terms of γ_1 and γ_2.

(b) Repeat part (a) assuming that the interaction energy is zero.