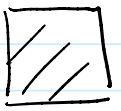
Nanofizika QD

nedelja, 05. april 2020 15:20

# Kvantne pike in Coulombska blokada

$\frac{e^2}{4\pi\varepsilon_0 r \varepsilon}$



majhni kvantni sistemi

Coulombska energija

$r \sim 1\,\text{nm}$

$E_C = \frac{e^2}{4\pi\varepsilon_0 r} = \frac{e^2}{4\pi\varepsilon_0 \hbar c} \cdot \frac{\hbar c}{r} = \frac{1}{137} \cdot \frac{1240\,\text{eV nm}}{2\pi r}$

$\sim \frac{\text{eV nm}}{r}$

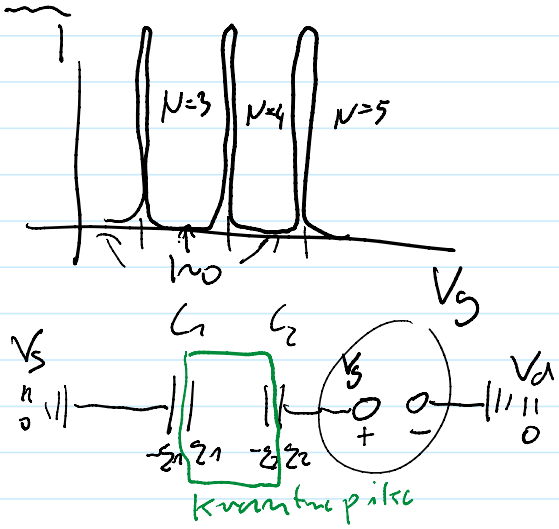
$\frac{1}{137}$

diskretni nivoji

$\frac{-\hbar^2}{2m}\frac{\partial^2}{\partial x^2}$

$\frac{\hbar^2}{2m\ell^2} = \frac{\hbar^2 c^2}{2mc^2\ell^2} = \frac{1000^2\,\text{eV}^2\,\text{nm}^2}{10^6\,\text{MeV}\,\ell^2}$

$= \text{eV}\frac{\text{nm}^2}{\ell^2}$




kvantna pika

$q_1 - q_2 = eN$ ← cel

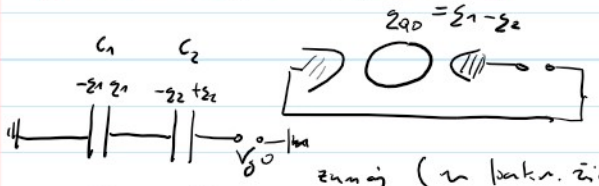
$V_1 = \frac{q_1}{C_1}$ $V_2 = \frac{q_2}{C_2}$ $\mathcal{H} = E + pV$

$V_G = V_1 + V_2$

$\mathcal{H} = \frac{q_1^2}{2C_1} + \frac{q_2^2}{2C_2} - q_2 V_G$

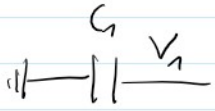
$V_g = V_1 + V_2$

$$\mathcal{H} = \frac{q_1^2}{2C_1} + \frac{q_2^2}{2C_2} - q_2 V_g$$




znamo (v lokal. žici) je $\vec{E} = 0$

$V_1$ $V_2$




$$E = \frac{C_1 V_1^2}{2}$$

$q_1 - q_2 = eN$

$V_1 = \frac{q_1}{C_1}$ $V_2 = \frac{-q_2}{C_2}$

$V_g = V_1 + V_2$ $V = \frac{q}{C}$

Entalpija: $Vde = \frac{q_1^2}{2C_1}$

$$\mathcal{H} = q_1^2/2C_1 + q_2^2/2C_2 - q_2 V_g$$

$\mathcal{H} =$

$V_g = q_1/C_1 + q_2/C_2$

$V_g C_1 = q_1 + q_2 C_1/C_2$

$q_1 = V_g C_1 - q_2 \frac{C_1}{C_2}$

$q_1 - q_2 = eN$

$q_2 (-1 - C_1/C_2) + V_g C_1 = eN$

$q_2 = \frac{eN - V_g C_1}{1 + C_1/C_2}$

$q_2 = \frac{V_g C_1 - eN}{1 + C_1/C_2}$

$q_1 = eN + q_2 = \frac{V_g C_1 - eN + eN C_1/C_2}{1 + C_1/C_2}$

$\mathcal{H} = q_1^2/2C_1 + q_2^2/2C_2 - q_2 V_g$

$$\mathcal{H} = \frac{(eN C_1/C_2 + V_g C_1)^2}{2C_1 (1 + C_1/C_2)^2} + \frac{(V_g C_1 - eN)^2}{2C_2 (1 + C_1/C_2)^2} - \frac{V_g C_1 + eN}{1 + C_1/C_2} V_g$$

$$\mathcal{H} = \frac{C_2}{C_1}\frac{(eN C_1/C_2 + V_g C_1)^2}{2C_2 (1 + C_1/C_2)^2} + \frac{(V_g C_1 - eN)^2}{2C_2 (1 + C_1/C_2)^2} - \frac{V_g C_1 + eN}{1 + C_1/C_2} V_g$$

$$= \frac{1}{2C_2(1+C_1/C_2)^2}\Big[e^2N^2\left(1+\frac{C_1}{C_2}\right) + eNV_gC_1\left(2-2/\right.$$

$$+ \underbrace{V_g^2C_1^2\left(\frac{C_2}{C_1}+1\right)}\Big] - \frac{V_gC_1+eN}{1+C_1/C_2}V_g$$

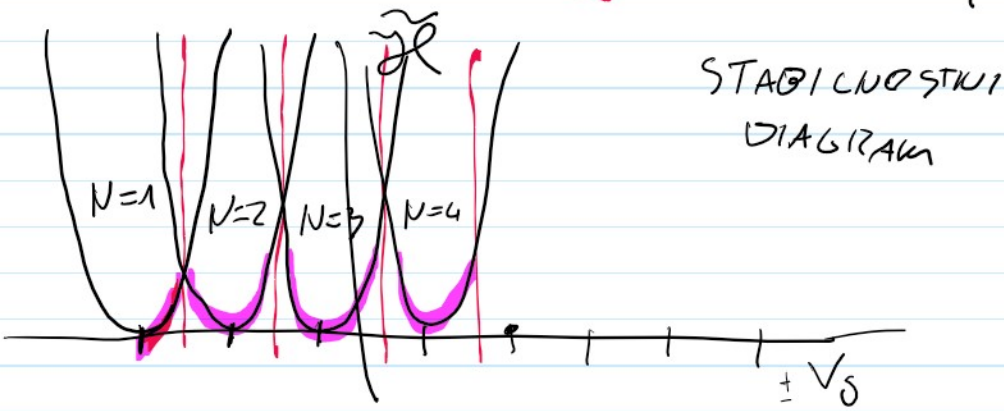
$$\underbrace{V_g^2C_2C_1\left(\frac{C_1}{C_2}+1\right)}$$

$$= \frac{1}{2C_2(1+C_1/C_2)}\Big[e^2N^2 + V_g^2C_2C_1\Big] + \frac{-2V_g^2C_2C_1 + eNV_gC_2 2}{2(C_1+C_2)}$$

$$= \frac{1}{2(C_2+C_1)}\Big[\underbrace{e^2N^2}_{eN} + 2eNV_gC_2 - V_g^2C_1C_2\Big]$$

$$= \frac{1}{2(C_2+C_1)}\Big[(eN+V_gC_2)^2 - V_g^2C_2(C_2+C_1)\Big]$$

$$\mathcal{H} = \frac{1}{2(C_2+C_1)}\Big[(eN+V_gC_2)^2 - \frac{V_g^2C_2}{2}\Big]$$




STABILNOSTNI DIJAGRAM

$$\tilde{\mathcal{H}} = \mathcal{H} + \frac{V_g^2C_2}{2}$$