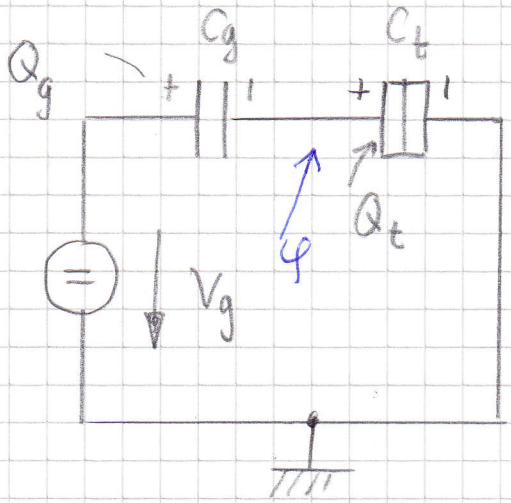
Exercises : Single-Electron Tunneling

1) C of a sphere is $4\pi\varepsilon_0 r$ (r = radius)
How small should r be that single-electron tunneling can be observed at 300K and at 4K ?

2)



$Q_{island} = Q = Q_t - Q_g$

φ = potential of island

free energy $F = \int_0^{-Ne} dQ\, \varphi(Q)$ =

determine $F(N, V_g)$ = ?

a) express φ in terms of V_g and Q

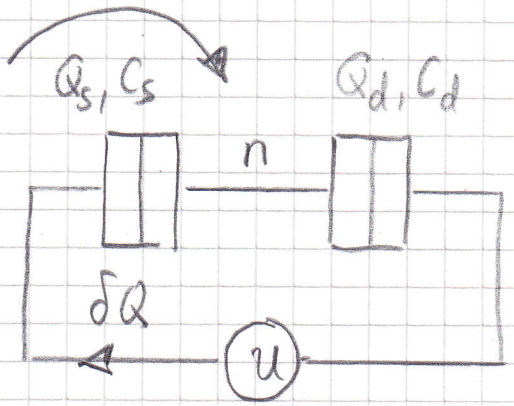
b) integrate and summarize

result : $$F(N, V_g) = E_c (N - C_g V_g/e)^2 - \frac{1}{2}\frac{C_g}{C_\Sigma} C_g V_g^2$$

compare with result given in lecture

3) determine the relaxation charge δQ that is moved through the source when an electron tunnels in a double-barrier tunneling junction

b)



For example if an electron tunnels over the left junction. Then:

initial state: Q_s, n, Q_d

tunneling step $Q_s - e$, $n+1$, Q_d (first moment)

final state δQ_s flows in response onto C_s

$\Rightarrow$ $Q_s(n) - e + \delta Q = Q_s(n+1)$

...

---

4) The slide 19 of lecture notes

---

5) } read paper PRB 44, 5919 (91)
6) } discuss different form of I-V curves!

When is the <u>Coulomb staircase</u> <u>very pronounced</u>?

---

7) 2 island physics
see slide 46 lecture notes

---

8) read <u>Physics Today</u> article Jan 93 from Marc Kastner