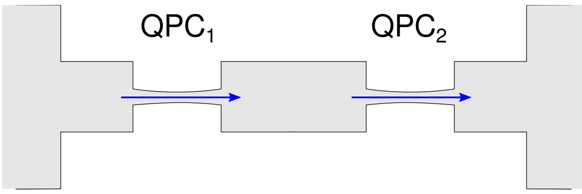
EXERCISE / HOMEWORK SET 04
ÚFV/TRANS/18 - Transport Properties of Solids
lecture by Martin Gmitra
Summer Semester 2020/2021

Exercise:

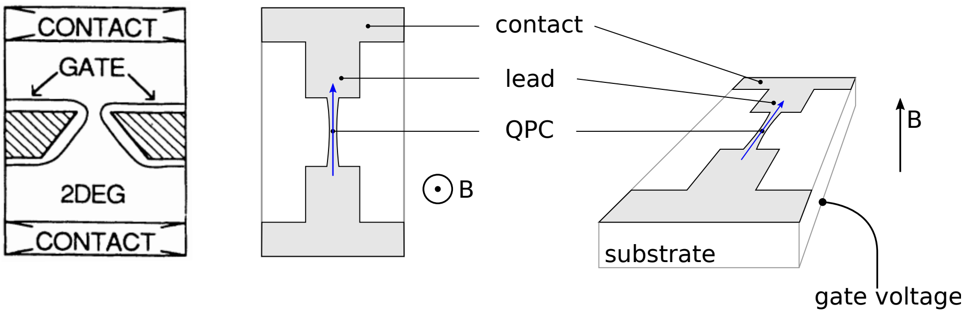
1. Plot and analyze so called Fock-Darwin spectrum of the electronic confinement in two-dimensional symmetric parabolic potential, $U(x, y) = \frac{m^*\omega_0^2}{2}(x^2 + y^2)$, modeling a quantum dot up to quantum numbers equal to 6.

Homework:

1. *[2 points]* Consider two identical point contacts in series and that there is no scattering in the region between the point contacts, as shows figure below. What is the conductance of the system? Is Ohm's law valid? What would happen if the point contacts were not identical?



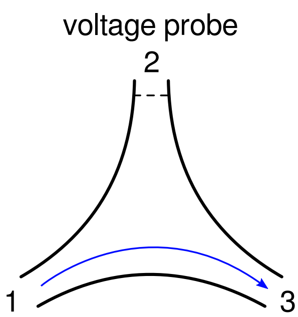
2. *[3 points]* Consider a quantum point contact (QPC) in a transverse magnetic field B applied to the plane of the two-dimensional electron gas (2DEG). For $B = 0$ the conductance decreases in steps with negative gate voltage (connected to semiconducting substrate) which squeezes the constriction region of QPC. What happens with for $B \neq 0$? What is the step height and modes degeneracy? Consult your answer with experimental results published by B.J. van Wees et al. Phys. Rev. B 38, 3625 (1988) or discussion in Sec. 13(b) C.W.J. Beerakker, H. van Houten, Solid State Phys. 44, p. 1-228 (1991).



3. For a three-terminal system with one voltage probe as shown in the figure

a) *[2 points]* show that voltages at the terminals are equal

$$V_1 = \frac{(G_{31} + G_{32})I_1 + G_{13}I_3}{G_{12}G_{31} + G_{12}G_{32} + G_{13}G_{32}}$$
$$V_2 = 0$$
$$V_3 = \frac{(G_{12} + G_{13})I_3 + G_{31}I_1}{G_{12}G_{31} + G_{12}G_{32} + G_{13}G_{32}}$$



b) *[2 points]* calculate $R_{12,13}$ and $R_{13,12}$, and show using Onsager's relations the reciprocity relation $R_{12,13}(B) = R_{13,12}(-B)$.

c) *[1 point]* show that $R_{12,12}(B) = R_{12,12}(-B)$ (two-terminal resistance) is invariant with respect to the sign change of the magnetic field.