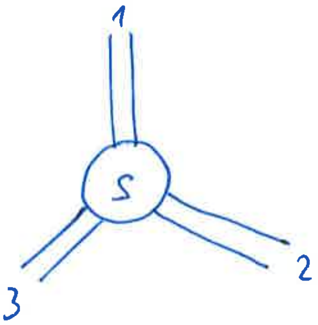
Quantum Transport
Problem sheet 4

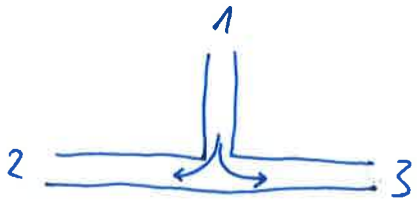
1) Scattering matrix of an ideal, single-mode 3-terminal beam splitter. Hint: assume all elements to be real and S unitary.

a) Assume that all transmission amplitudes from one to another terminal are identical and all backscattering amplitudes, too.



Determine the scattering matrix S (3×3).

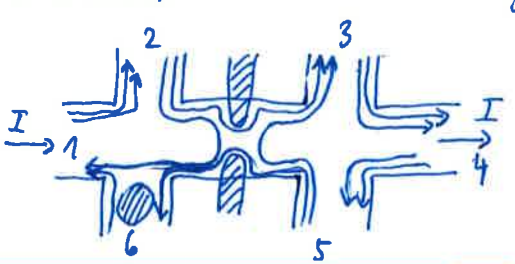
b) T-junction beam splitter:



Assume no backscattering into lead 1, equal probabilities for 1 to 2 and 1 to 3 and symmetric in the leads 2 and 3. Determine the (single-mode) S.

2) Use a six-terminal Hallbar (without disorder) in the quantum Hall effect (QHE) regime → with edge states – to show or illustrate the reciprocity relation $G_{qp}|_{+B} = G_{pq}|_{-B}$.

3) Effect of a non-ideal/disordered contact. Calculate the longitudinal and transverse resistance in a six-terminal Hall bar with a constriction and a voltage probe with a scatterer, which simulates a disordered contact. Assume filling factor $\nu = 4$. Compare your result to the case where all contacts are ideal.



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4) Find, download and read the article Phys. Rev. B 76, 085316 (2007) and answer the following questions:

a) What is measured in all subfigures of Fig. 2?

b) Why is there no (or little) resistance change for integer filling factors $\nu = 2, 4, 6, 8$? Why is there a change for other fillings?

c) explain in few words Fig. 11.

d) How is it possible that the changes in the potential landscape more than 5 μm away lead to changes in the Hall resistance (only qualitatively).