Using Quantum Hall Effect for the Electrical Characterization of Semiconductors

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Fall 2002

Quantum Hall Effect (QHE)

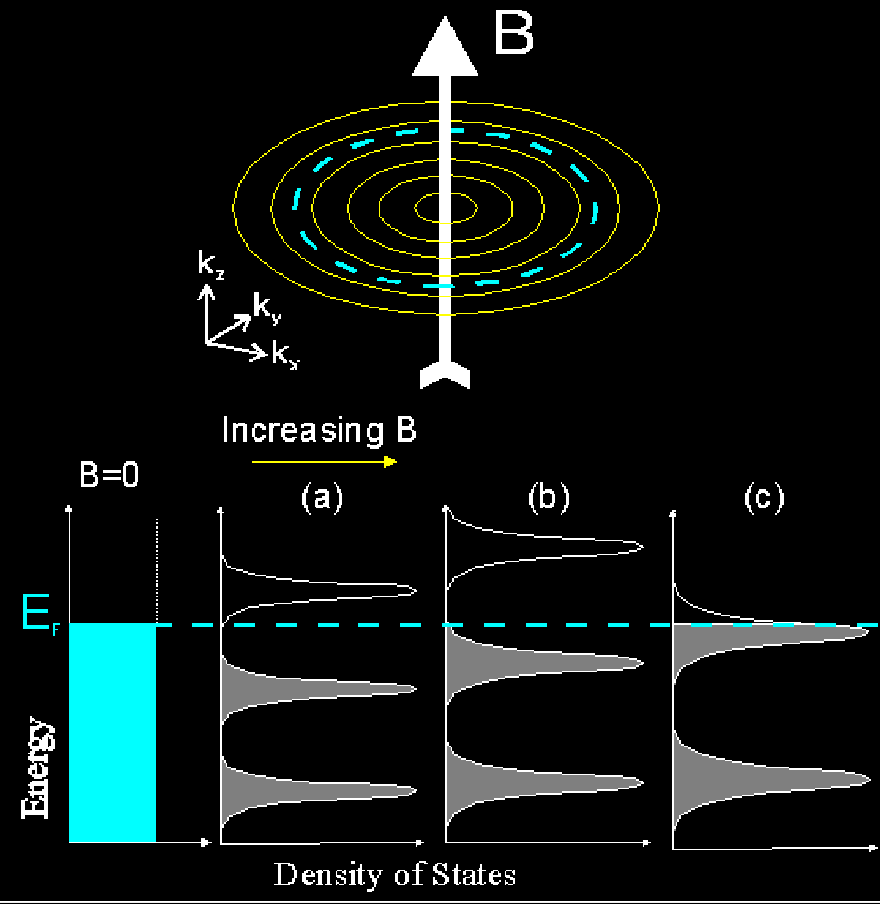
- History
- Basics
- 2-Dimensional Semiconductors
- Experiment Setup
- Measurements
- Conclusion
- Questions

History

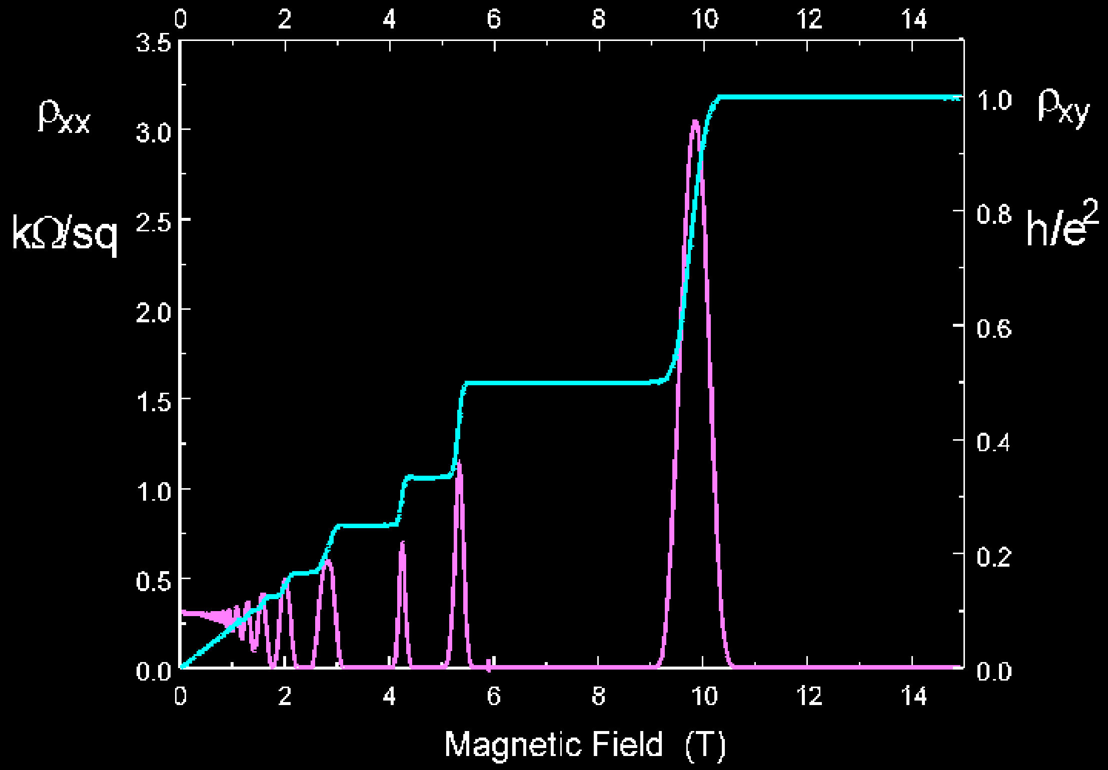
- Discovered on 5^{th} February 1980 by Klaus von Klitzing
- QHE observed on Si-MOSFET device at very low temperature and high magnetic field.
- Nobel Prize awarded in 1985
- Confirmed that quantised Hall resistance was accurate to ten parts in 10^6

Basics

- Classical Hall resistance increases linearly with magnetic field
- At low temperatures a series of steps appear instead of the monotonic increase
- Resistance is quantised: h/e^2i



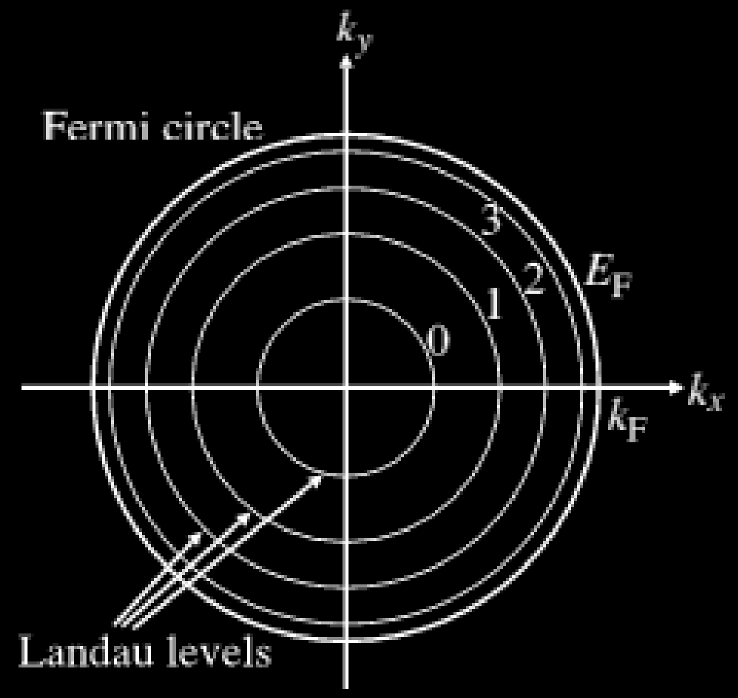
Basics (continued)



Integer quantum Hall effect in a GaAs-GaAlAs heterojunction, recorded at 30mK

Basics (continued)

- At high magnetic field B, density of states become a set of discrete Landau levels
- When voltage is applied the Hall resistance becomes extremely quantised



2-Dimensional Semiconductors

- Two dimensional electron gas (2DEG) at GaAs heterostructure (MBE and CVD growth techniques)

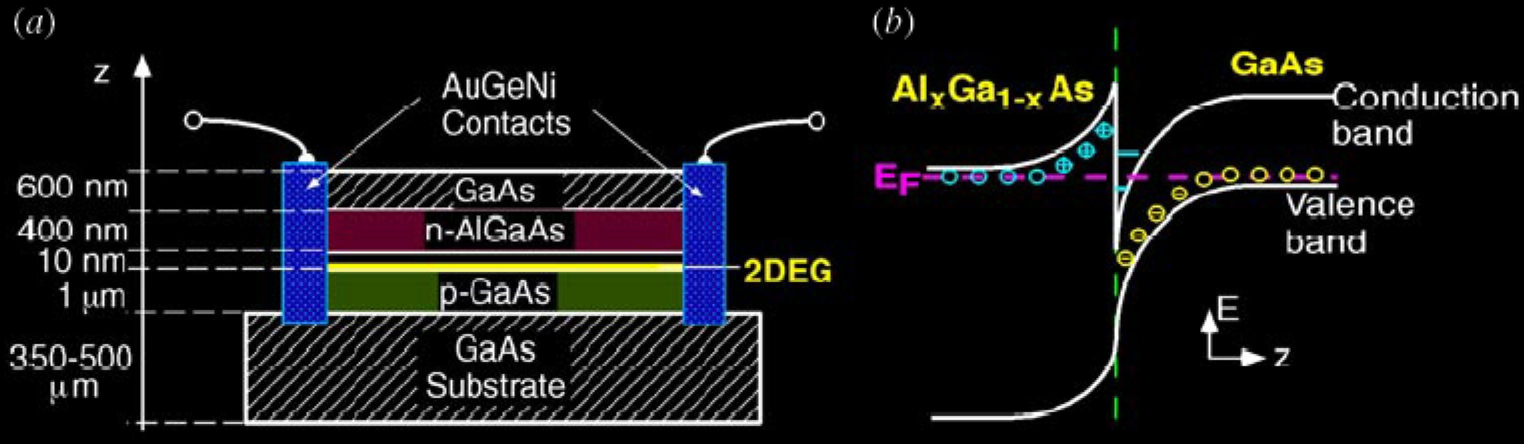
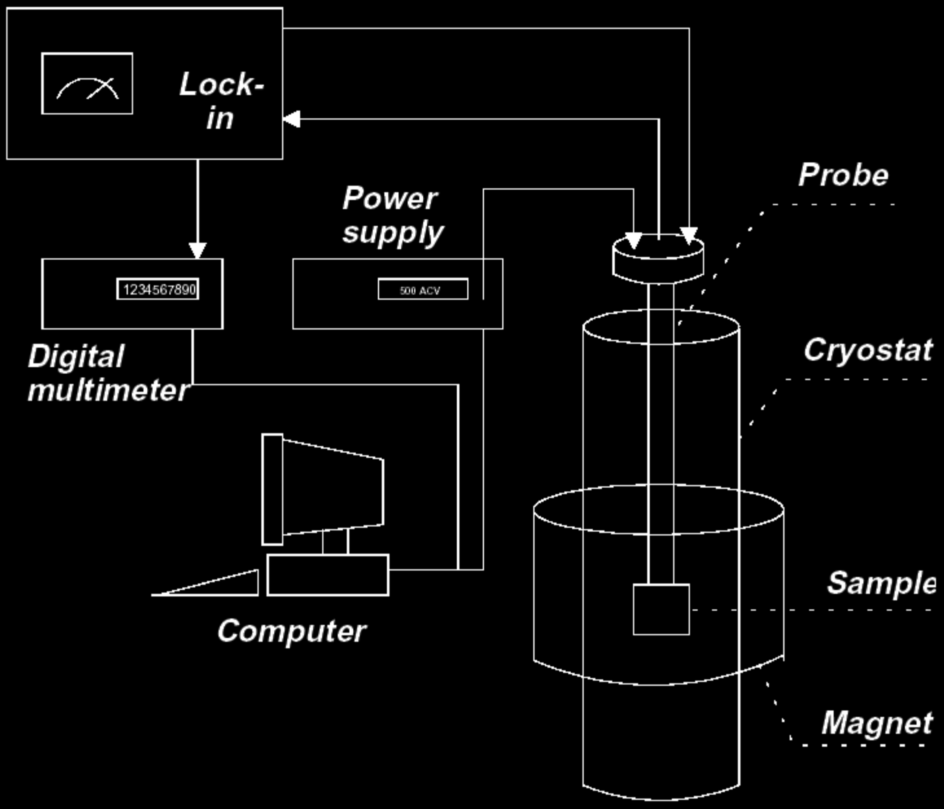
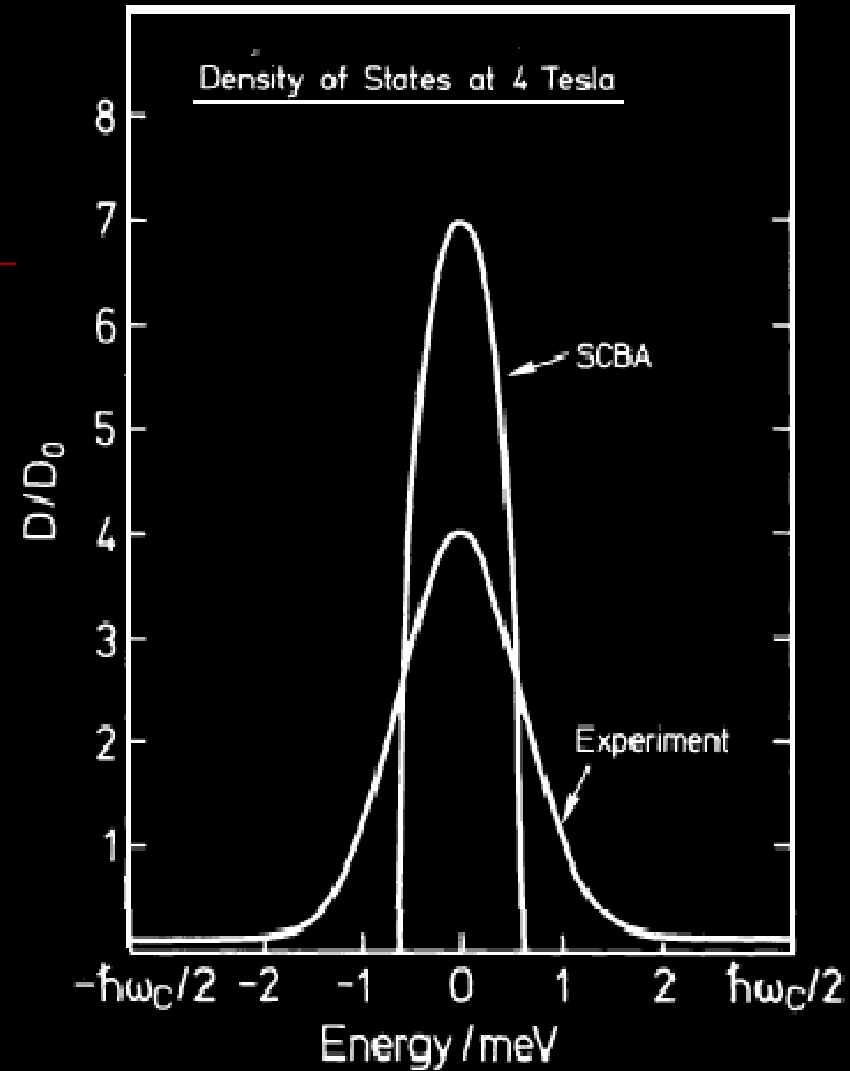


Figure 8. GaAs heterostructure. (*a*) Cross section, (*b*) schematic energy diagram.

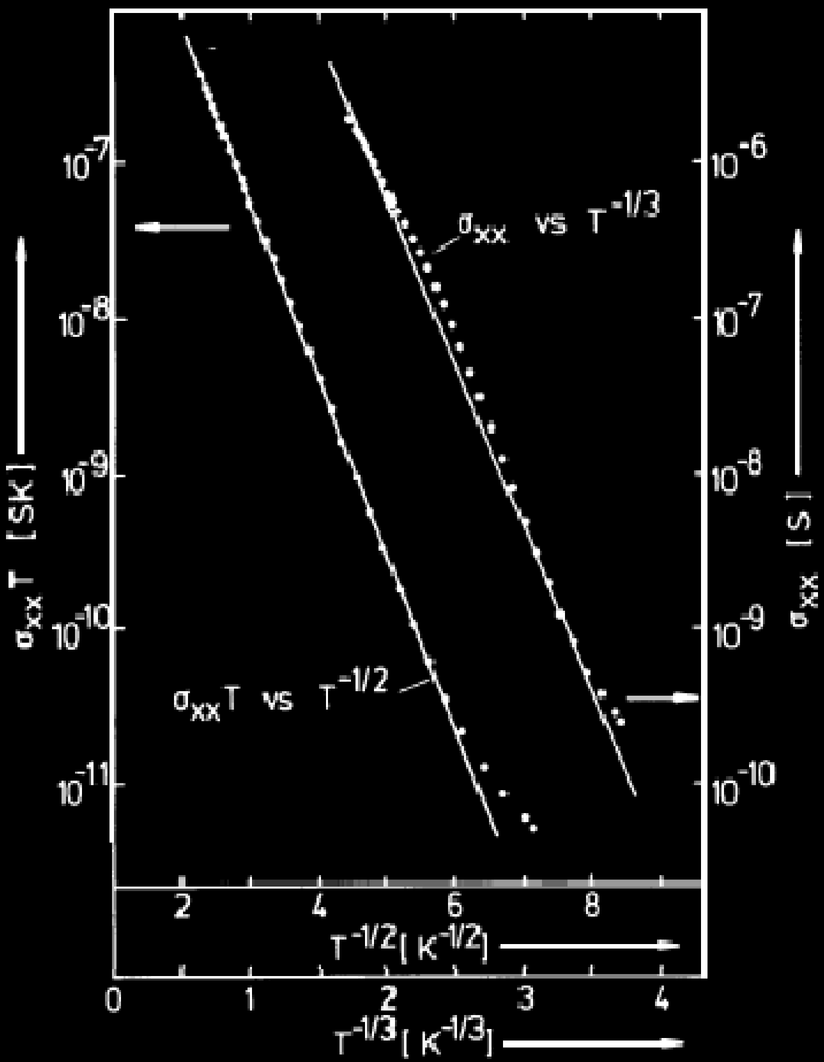
Experiment Setup



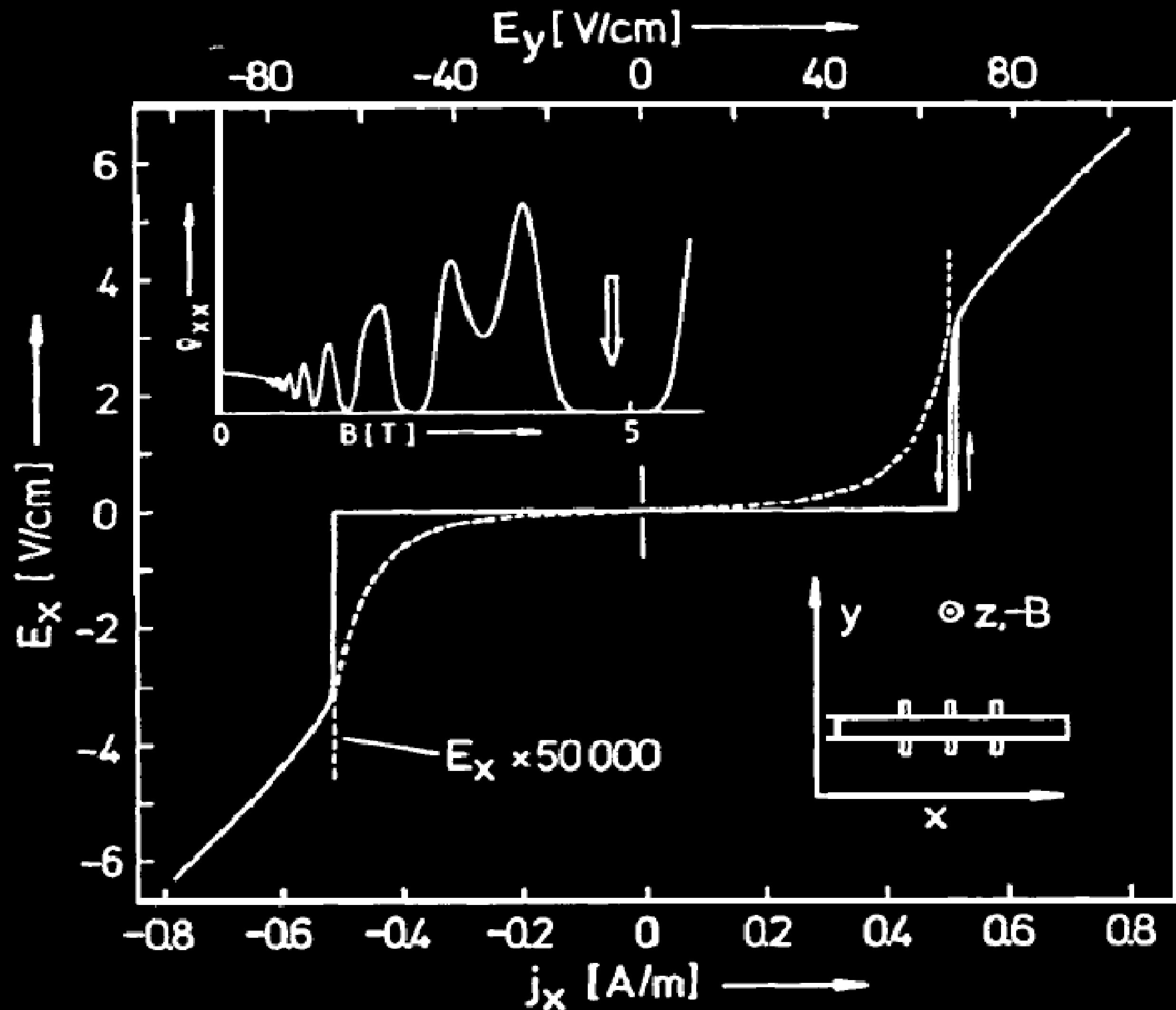
Measurements



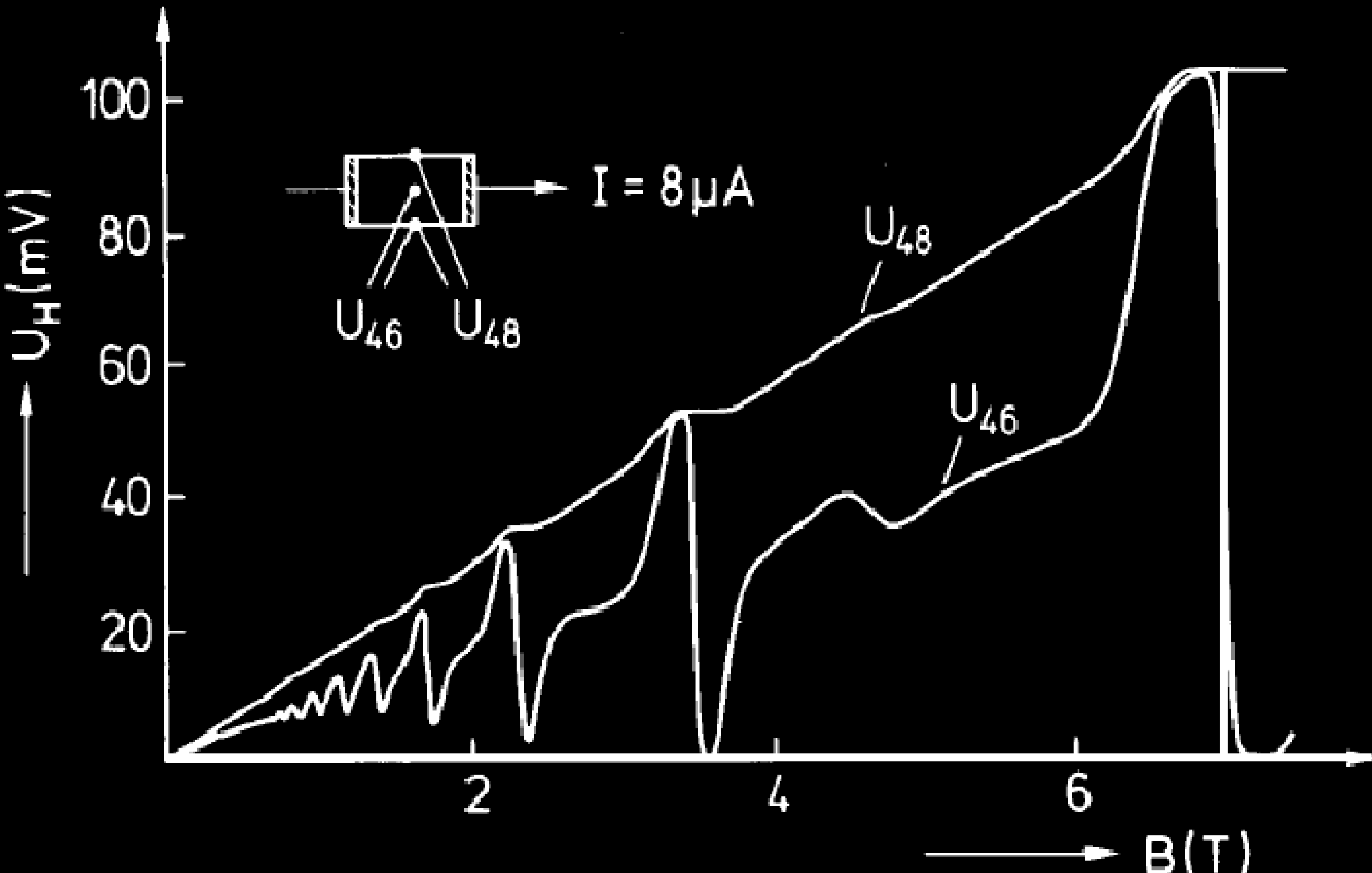
Determination of the Density of States (DOS)



Temperature dependent conductivity of a GaAs heterostructure



Current-voltage characteristic of a GaAs-$Al_xGa_{1-x}As$ heterostructure



Hall potential distribution of a GaAs heterostructure
as a function of the magnetic field

Conclusion

- QHE opened the field of two-dimensional electron systems
- Important for the description of electrical characteristics of semiconductor devices
- Experimental results examined
- QHE as a resistance standard

Questions