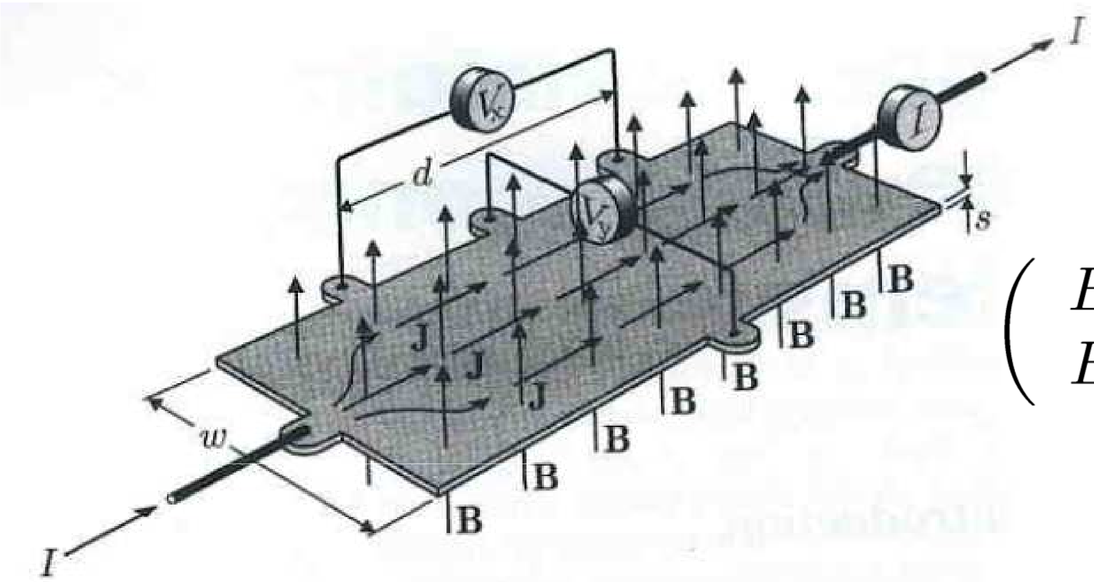
Classical Hall effect: resistivity tensor



$$\mathbf{E} = \rho \cdot \mathbf{J}$$

We have shown that:

$$\begin{pmatrix} E_x \\ E_y \end{pmatrix} = \frac{1}{\sigma_0} \begin{pmatrix} 1 & +\omega_c^e \tau_e \\ -\omega_c^e \tau_e & 1 \end{pmatrix} \begin{pmatrix} J_x \\ J_y \end{pmatrix}$$

$$\rho_{xx} = \rho_0$$

Considering only n-type carriers

Hall Resistivity:

$$\rho_{yx} = -\rho_0 \omega_c^e \tau_e = \frac{B}{(-e)n}$$

Linear in B!

$$\mu_e = \frac{e\tau_e}{m_e^*}$$

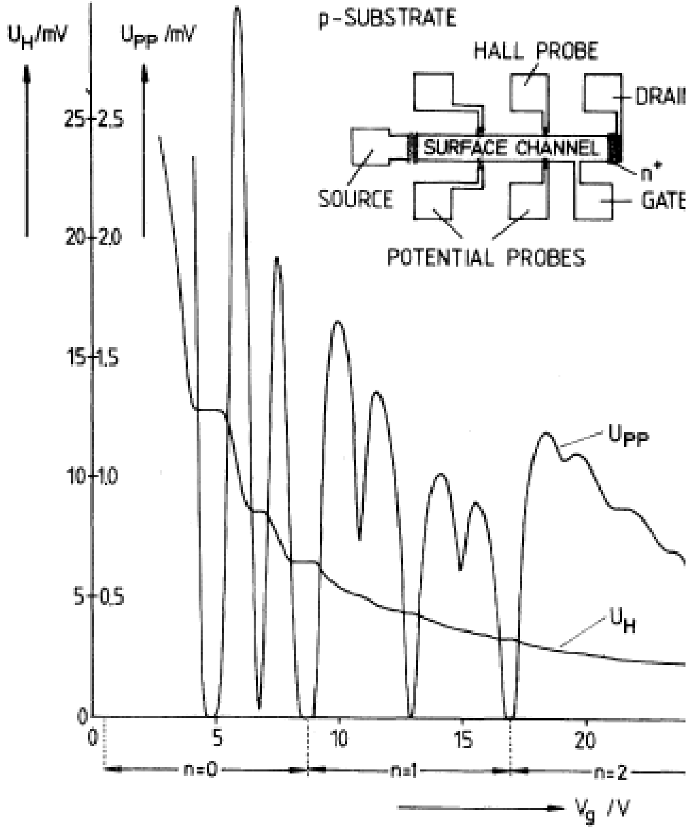
$$\omega_c^e = \frac{e.B}{m_e^*}$$

For $J_y = 0$ we get $\rho_{xx} = \frac{E_x}{J_x}$ $\rho_{yx} = \frac{E_y}{J_x}$

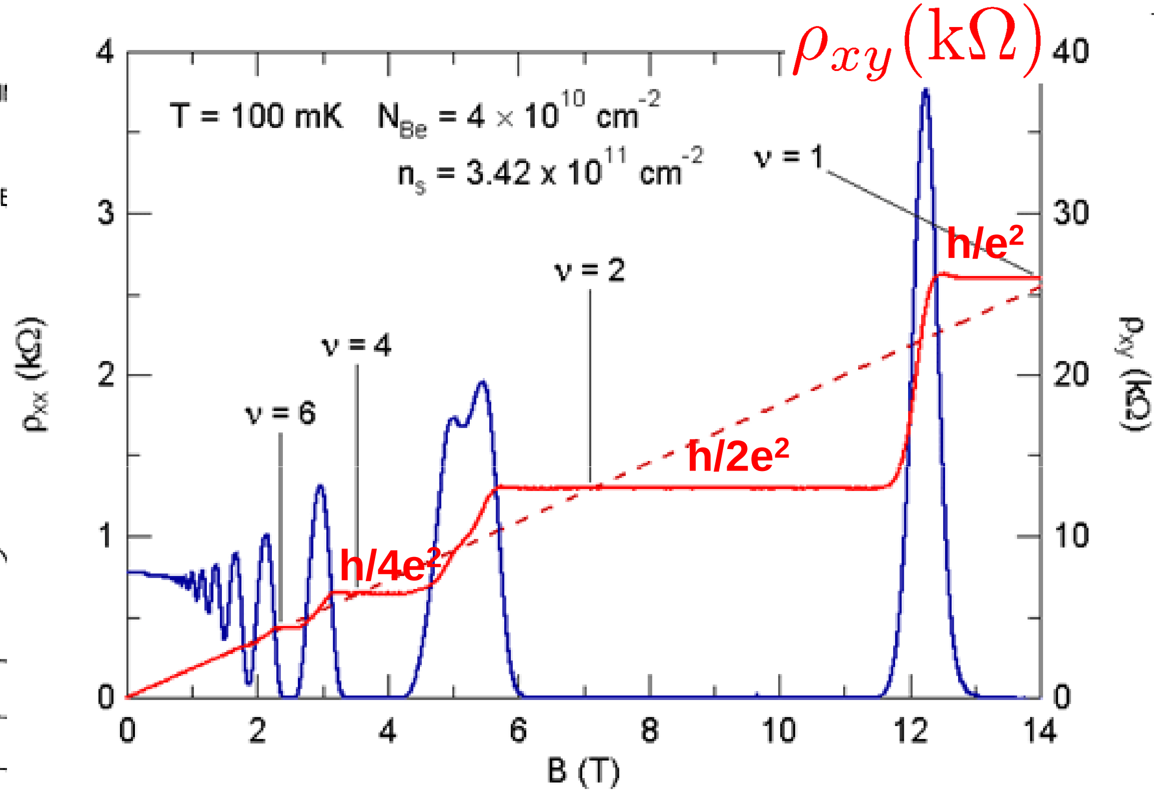
The (integer) quantum Hall effect.

Klaus von Klitzing

1985



K. v. Klitzing, G. Dorda, M. Pepper,
***Phys. Rev. Lett*. 45, 494 (1980)**



Plateaus in ρ_{xy} vs B!

https://www3.physnet.uni-hamburg.de/institute/IAP/Group_N/e/semiconductors/semiconductors_print.html

The (integer) quantum Hall effect.

Klaus von Klitzing

1985

PRL Milestone

Access I

New Method for High-Accuracy Determination of the Fine-Structure Constant Based on Quantized Hall Resistance

K. v. Klitzing, G. Dorda, and M. Pepper

Phys. Rev. Lett. **45**, 494 – Published 11 August 1980

An article within the collection: Letters from the Past - A PRL Retrospective

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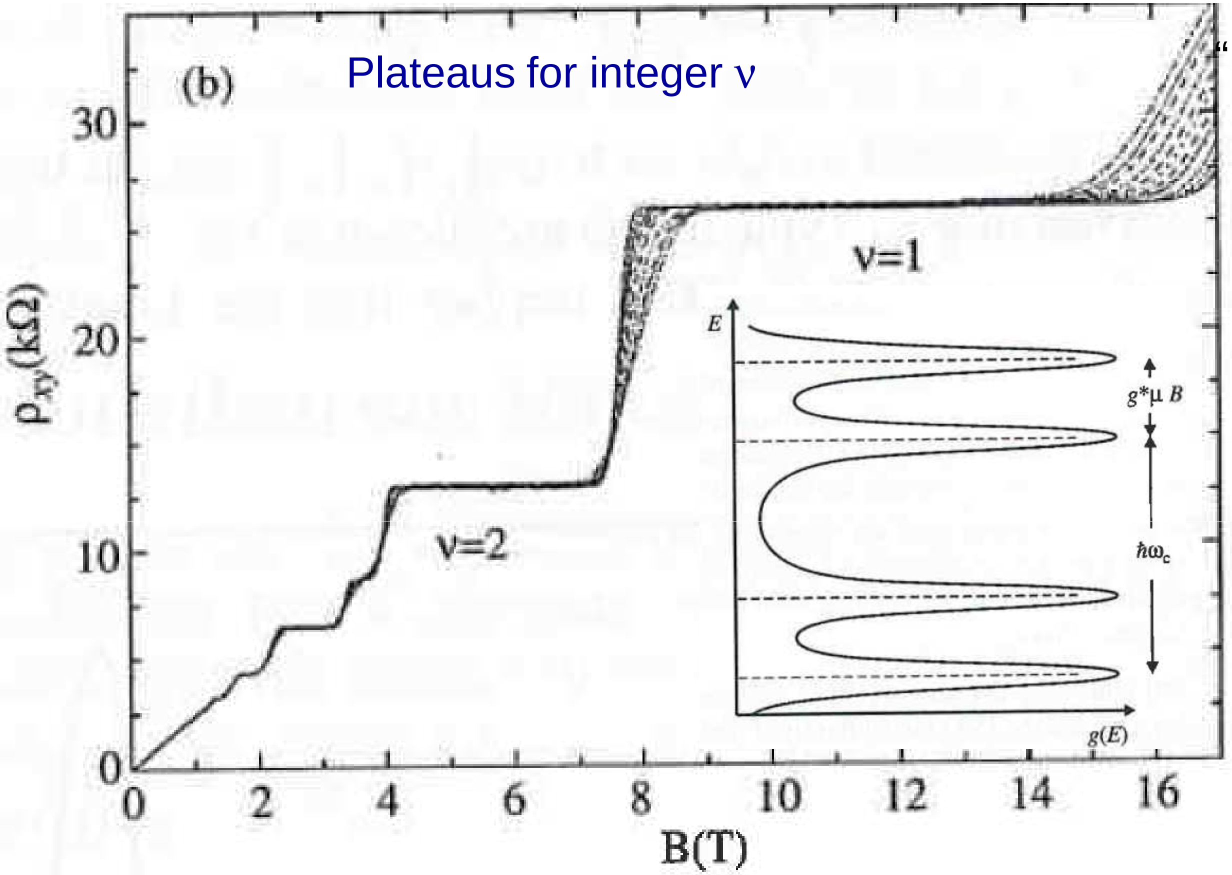
Quantum Hall effect: resistivity plateaus



Zeeman splitting of Landau levels: one spin per state

"Doubly filled" jth Landau level (given density n):

$$n = j_{\max} \frac{2eB}{h}$$

"Filling factor" ν (per spin): $$\nu = \frac{nh}{eB}$$

Hall Resistivity:

$$\rho_{yx} = \frac{B}{(-e)n} = \frac{1}{\nu}\frac{h}{e^2}$$

Resistivity quantization!

$$\frac{h}{e^2} = ???\ \ \Omega$$

e = 1,6 x 10^{-19} Coulomb

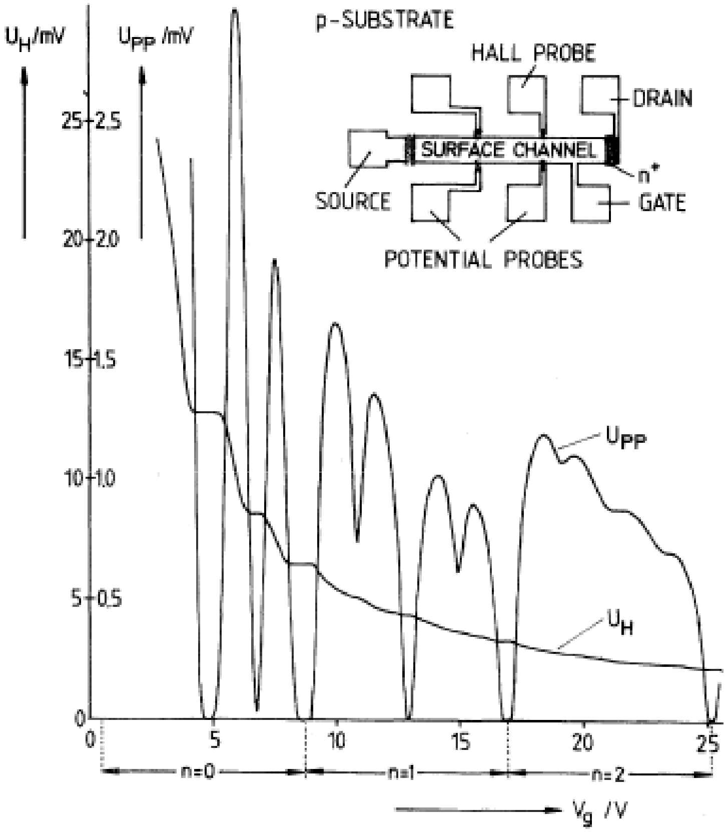
$\hbar$ = 6,58212 x 10^{-16} eV.s

Tarefa 18 (em sala, agora)

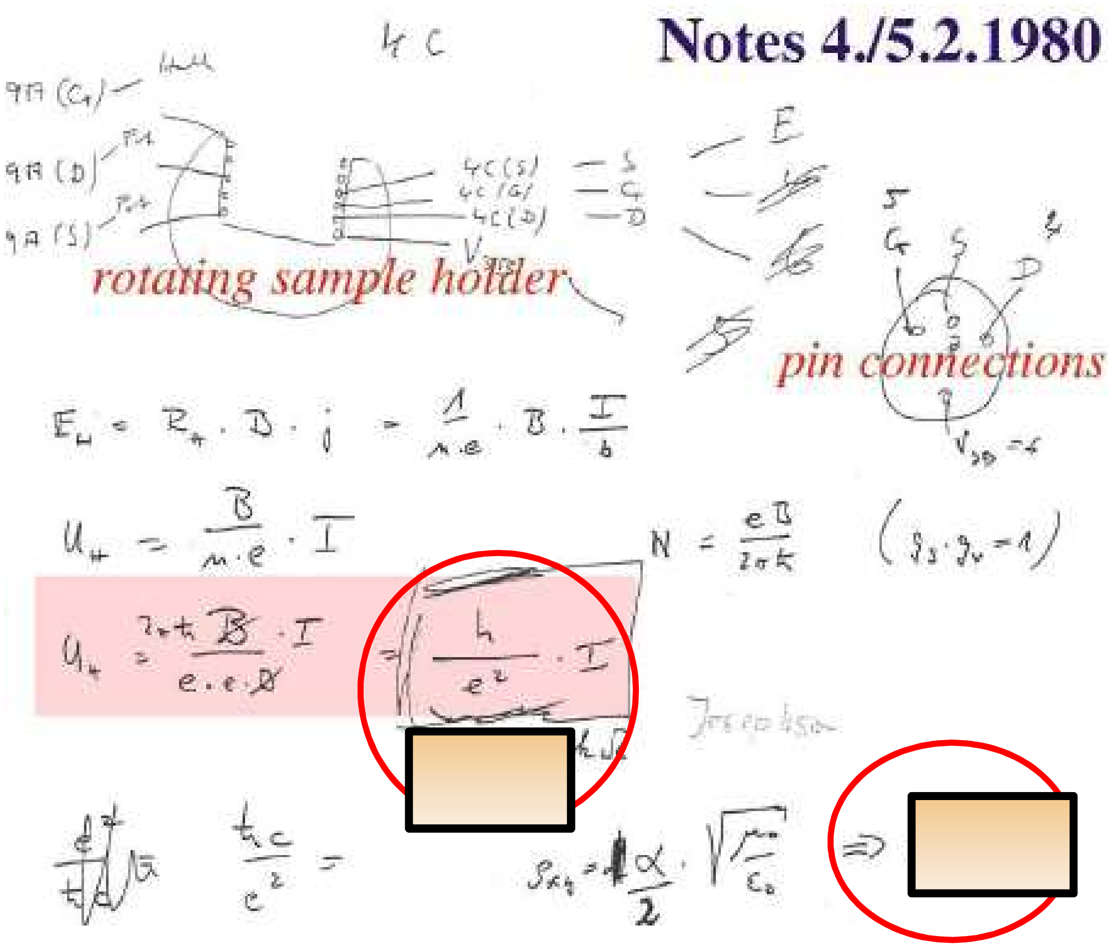
The (integer) quantum Hall effect.

Klaus von Klitzing

1985

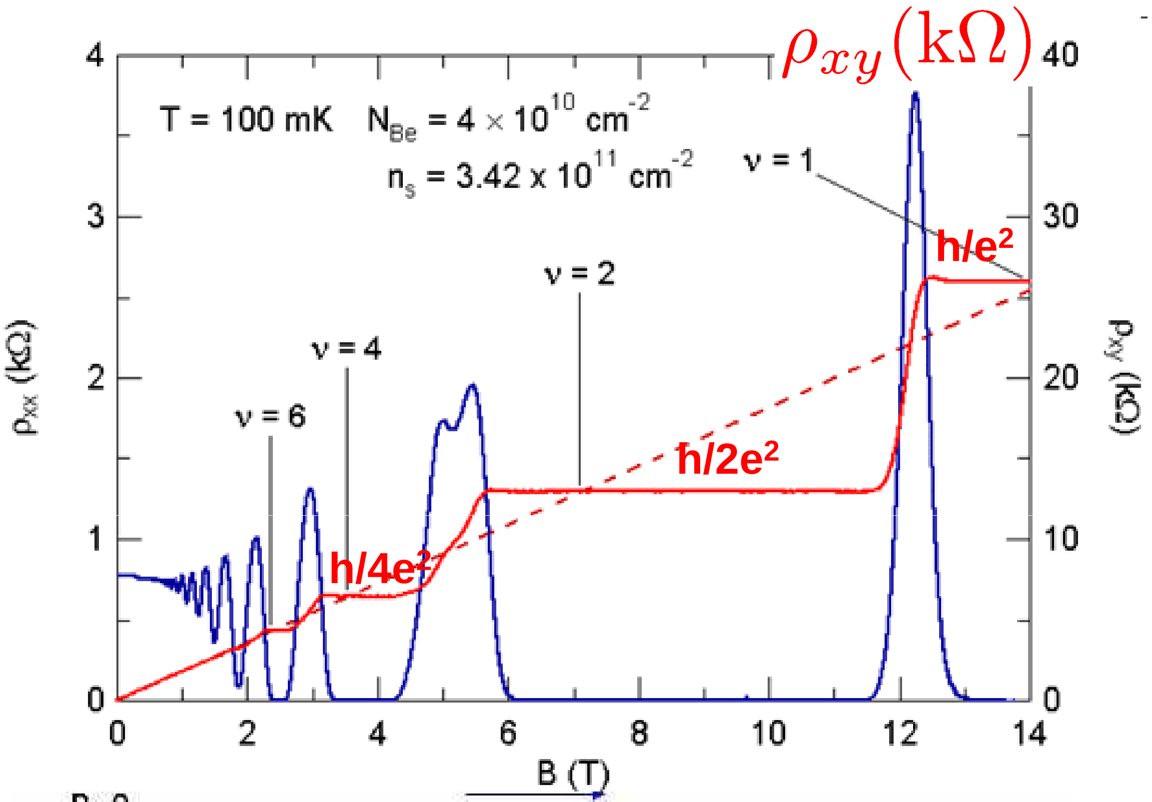


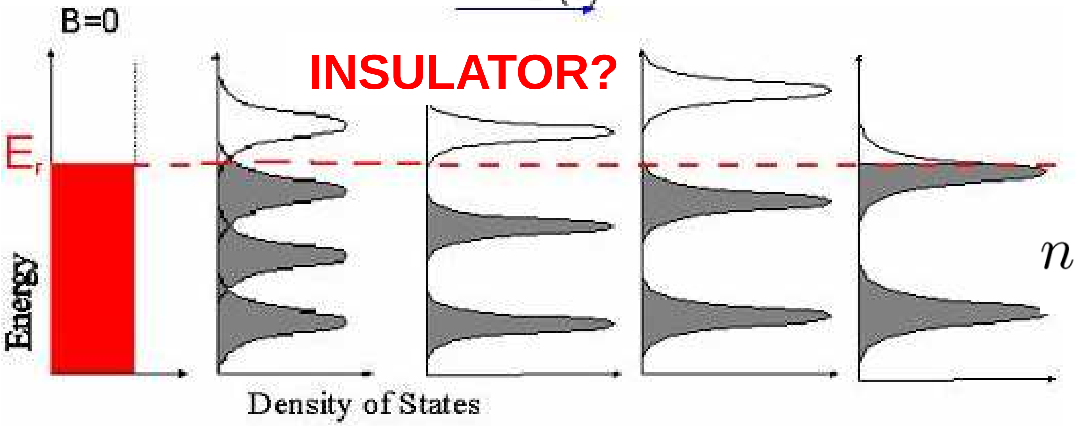
Séminaire Poincaré 2 (2004) 1 – 16



K. v. Klitzing, G. Dorda, M. Pepper,
***Phys. Rev. Lett*. 45, 494 (1980)**

Quantum Hall effect: resistivity plateaus





Plateaus in the Hall resistivity for integer ν

$$\rho_{yx} = \frac{1}{\nu}\frac{h}{e^2}$$

$$\nu = \frac{nh}{eB}$$

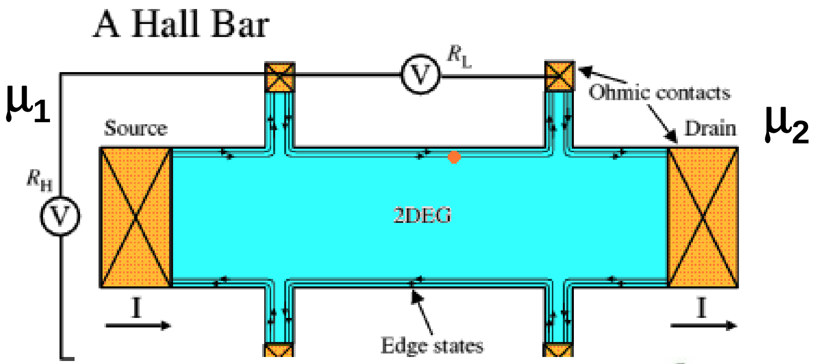
Now, the longitudinal resistivity goes to zero!

$$\rho_{xx} = \frac{\sigma_{xx}}{\sigma_{xx}^2 + \sigma_{xy}^2} \approx \frac{\sigma_{xx}}{\sigma_{xy}^2} \to 0$$

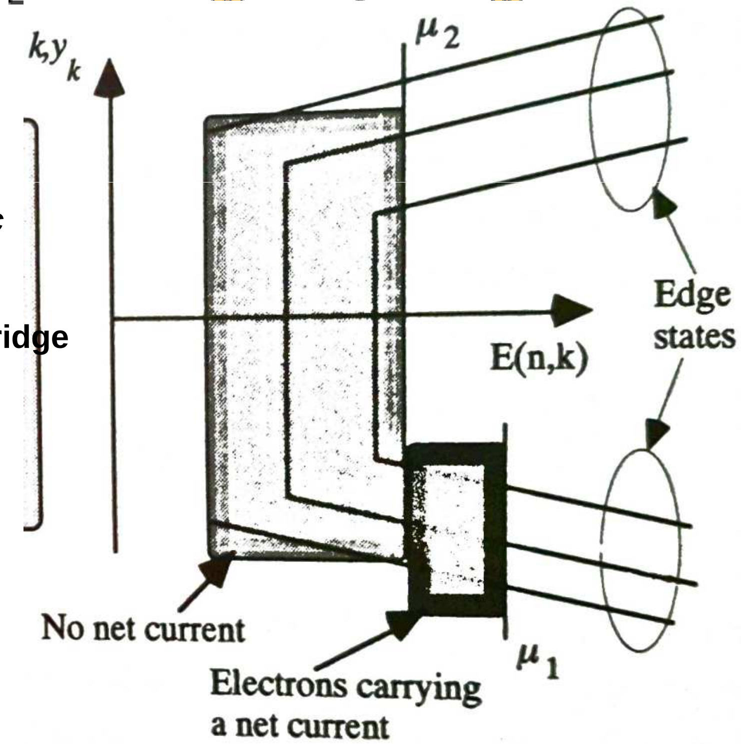
No magnetoresistance for $\omega_c \tau$ large ?!?

$$n = j_{\max}\frac{2eB}{h}$$

Landau edge states



http://www.sp.phy.cam.ac.uk/research/fundamentals-of-low-dimensional-semiconductor-systems/lowD



Datta, *Electronic Transport in Mesoscopic Systems,* Cambridge Press

Potential V(y): edge states

D.R. Leadley, Warwick University 1997

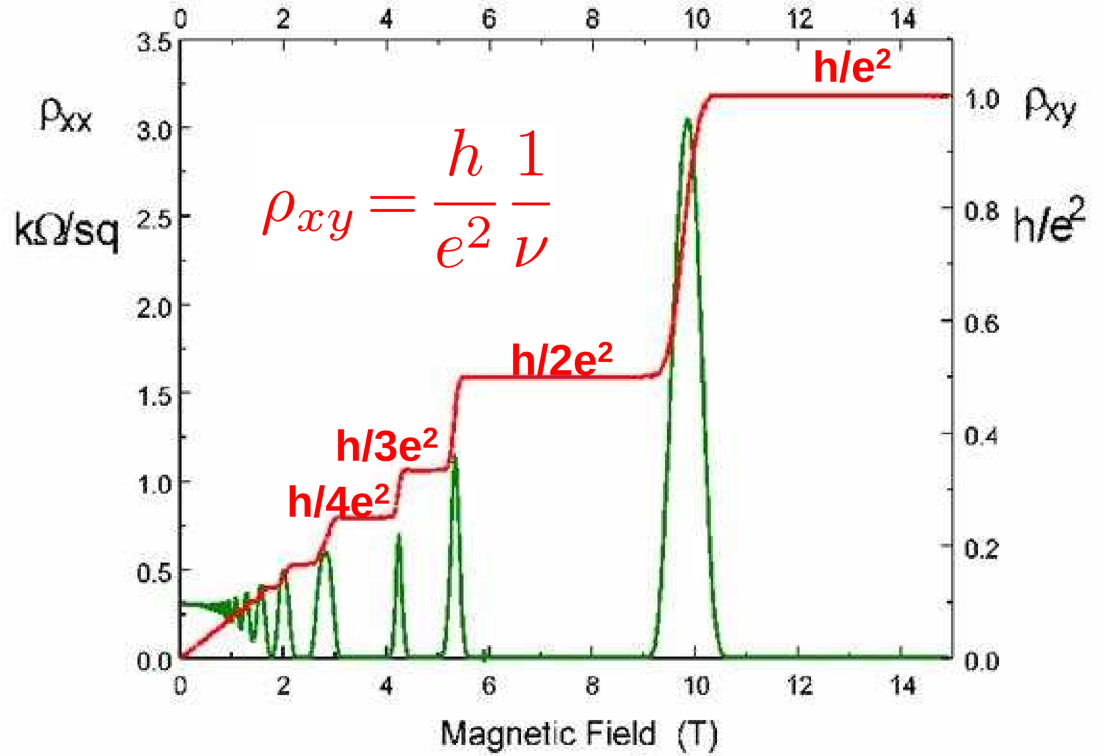
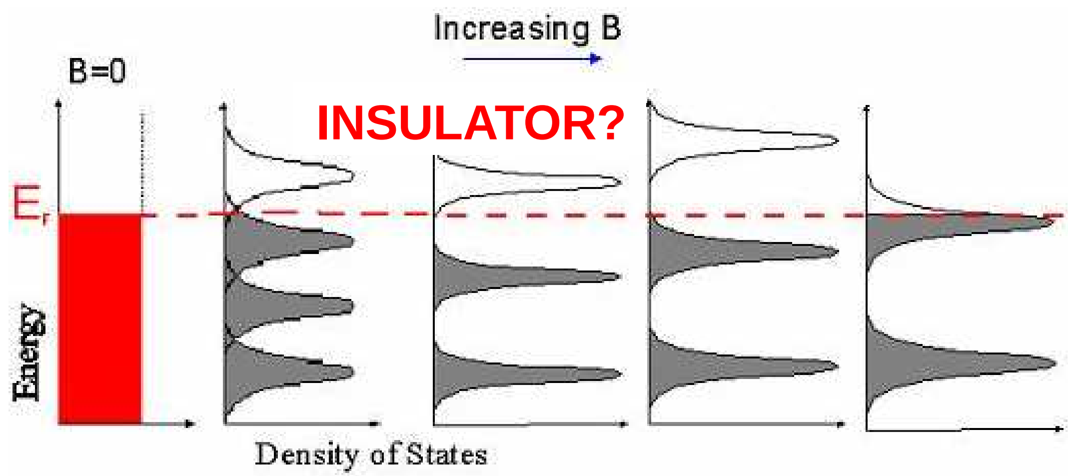


Fig 4: Red is the graph of hall resistance in units of h/e² versus magnetic field in tesla



Fractional Ouantum Hall effect

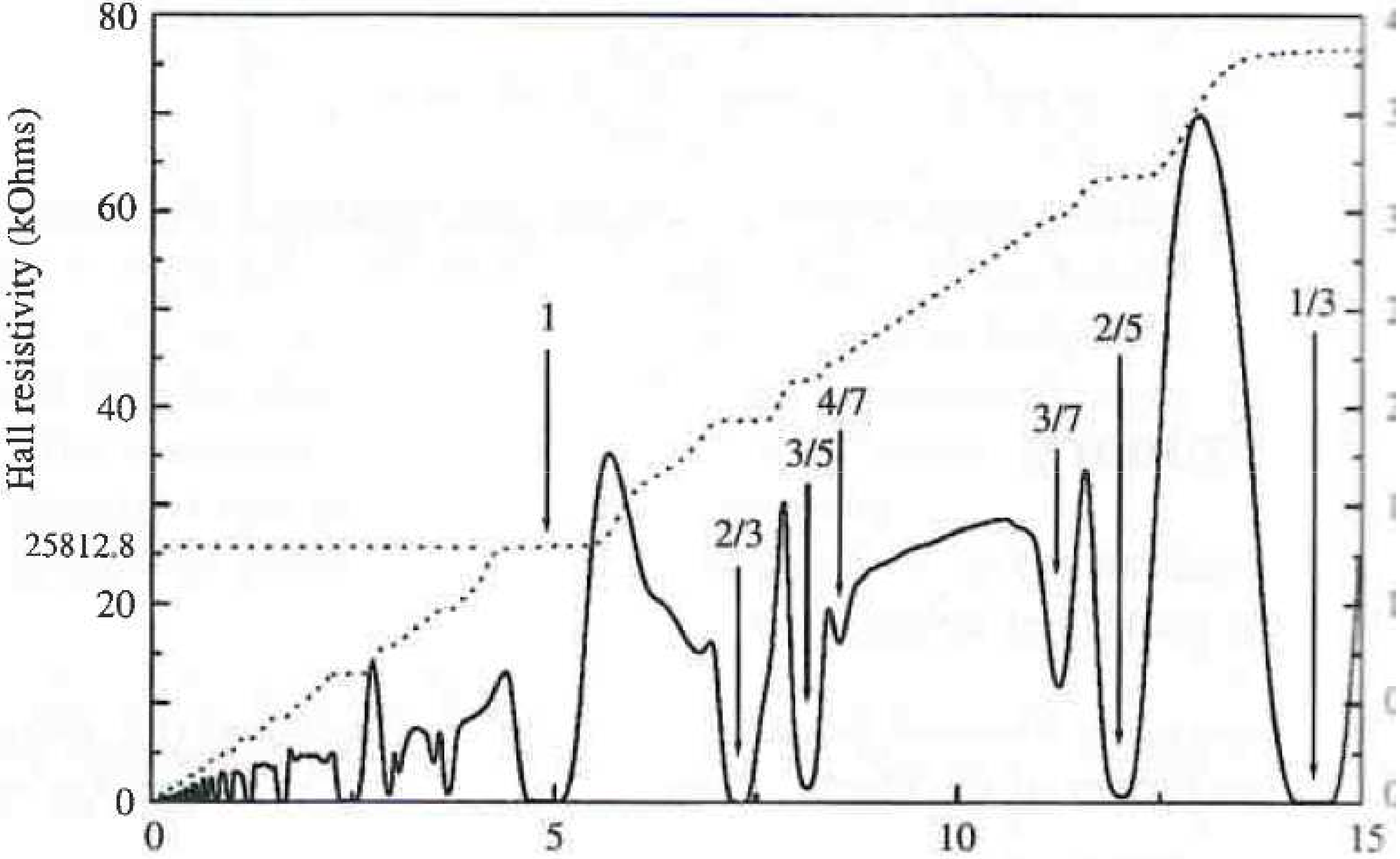


Fig. 11.5 Fractional quantum Hall effect in ρ_{xx} (right-hand scale) and ρ_{xy} (left-hand scale) data for a GaAs-(Ga,Al)As heterojunction ($T = 100$ mK). The filling factors ν are indicated. Data courtesy of Phil Gee, Clarendon Laboratory, Oxford.

$$\rho_{yx} = \frac{1}{p}\frac{h}{e^2}$$

$$p = \frac{1}{3}, \frac{2}{5}, \frac{3}{7}, \frac{2}{3}, \cdots$$