Two-band MR

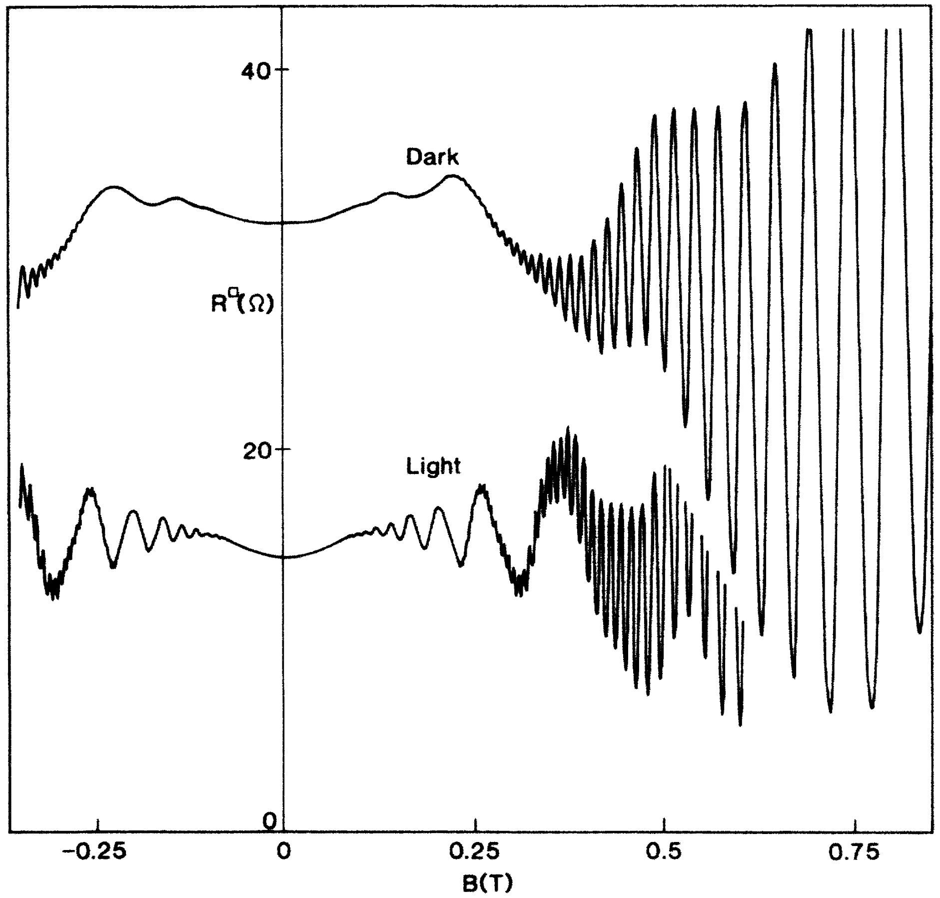


FIG. 1. The resistance per square for a GaAs-$Al_xGa_{1-x}As$ heterostructure with two two-dimensional subbands occupied as a function of magnetic field at 30 mK. Persistent photoconduction is used to change the carrier densities. The fast oscillations pertain to the lowest subband and the slow oscillations to the second subband.

At B=0:

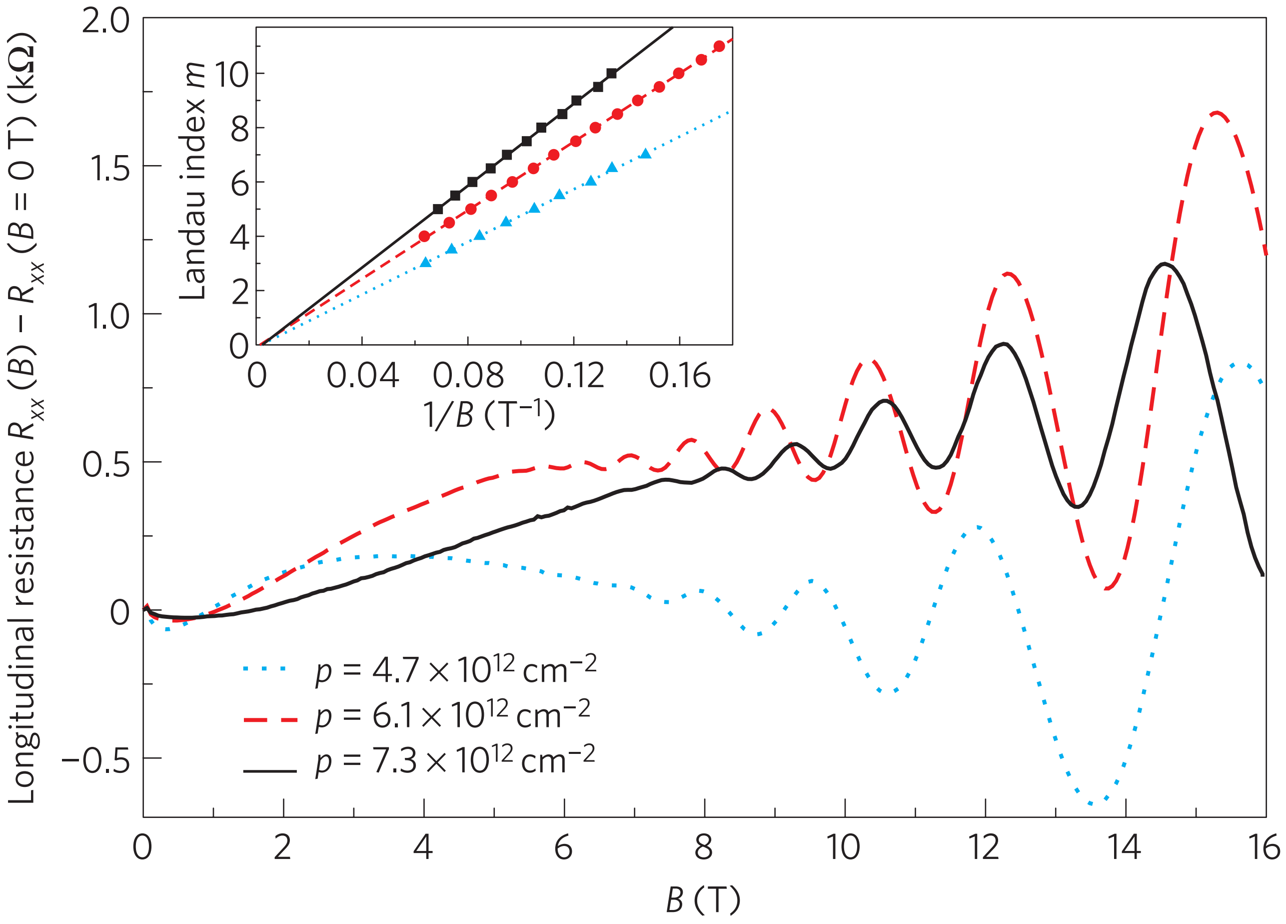
$$\sigma = \sigma_1 + \sigma_2 = en_1\mu_1 + en_2\mu_2$$

Under effect of magnetic field:

$$\sigma(B) = \frac{\sigma_0}{1+x^2}\begin{pmatrix} 1 & x \\ -x & 1 \end{pmatrix}$$

$$x = \mu B$$

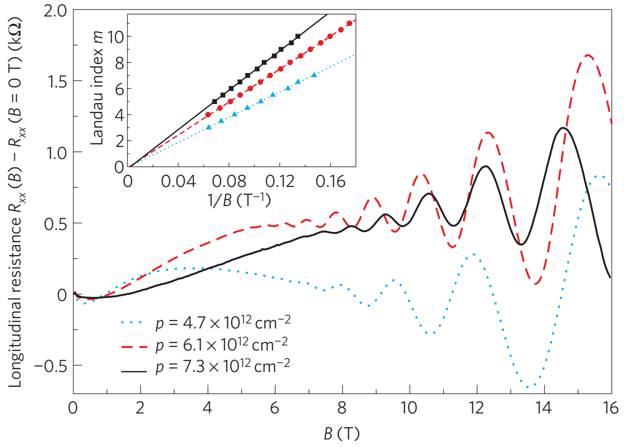
Shubnikov - de Haas oscillations (graphene)



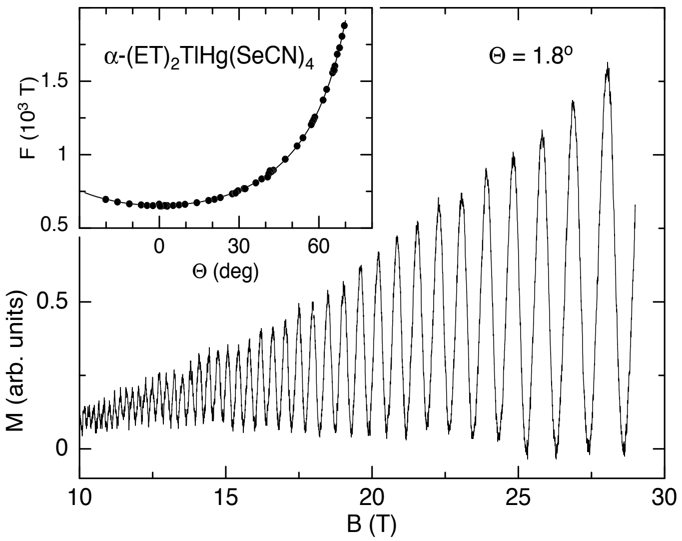
$$\Delta\left(\frac{1}{B}\right) = \frac{2\pi e}{\hbar}\frac{1}{A_e} = \frac{e}{2\pi\hbar}\frac{f}{p}$$

Experimental determination of Fermi surface

Reminder: Shubnikov-de Haas oscillations



de Haas-van Alphen effect



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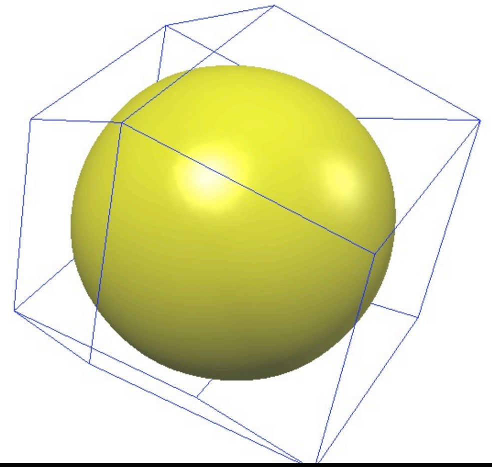
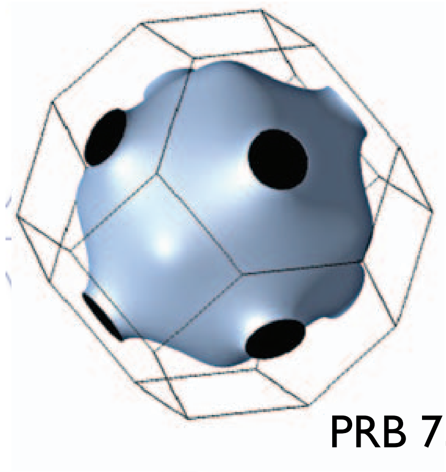
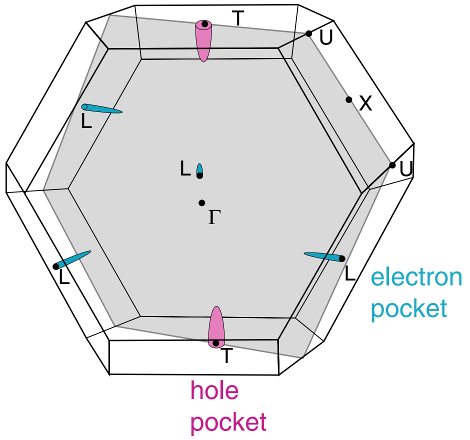
Potassium	Copper
	 PRB 73, 064420
Aluminium	**Bismuth**
	

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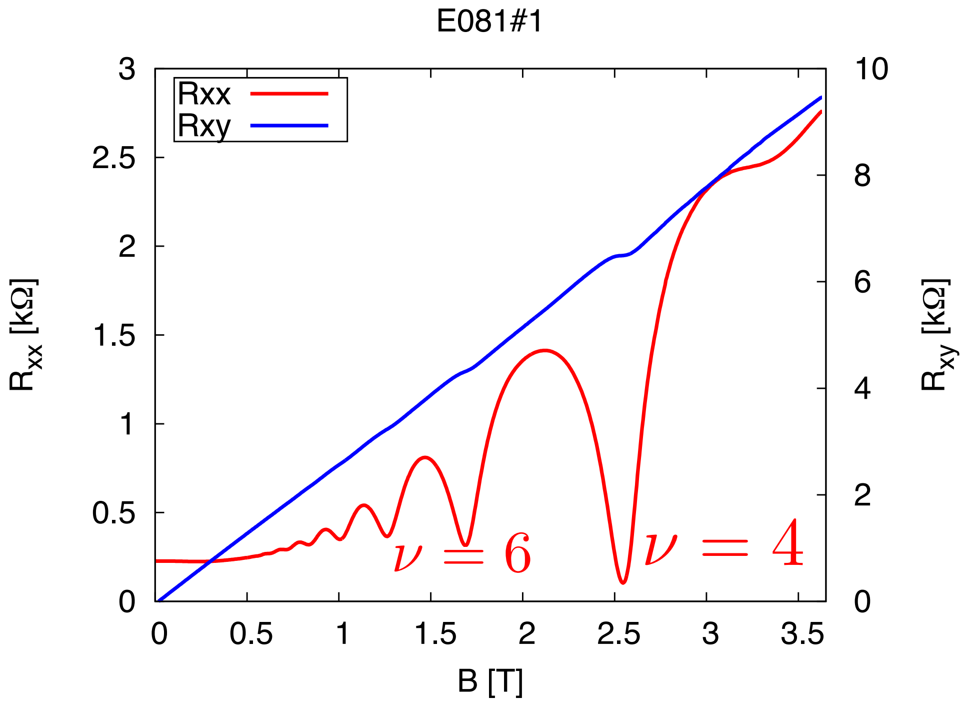
$$\text{Extremal cross section } \perp \vec{B}$$

$$\Delta(1/B) \propto 1/A_e$$

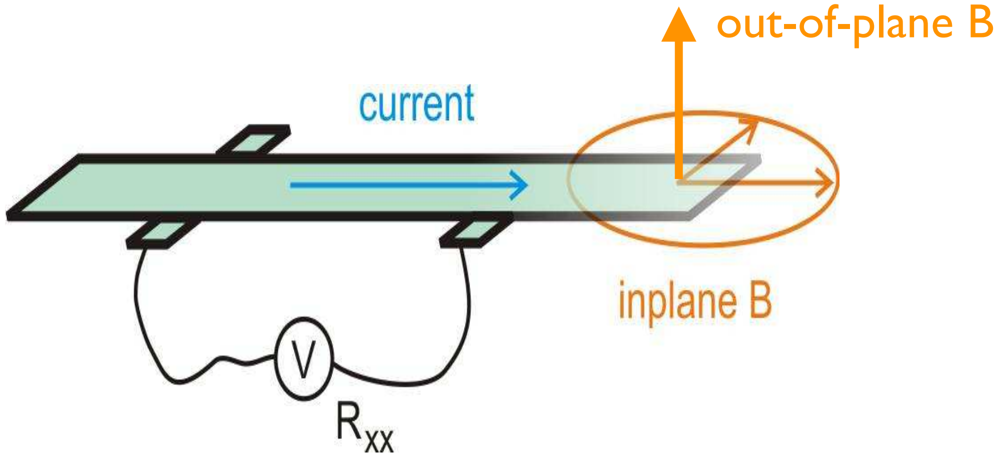
Extreme quantum limit

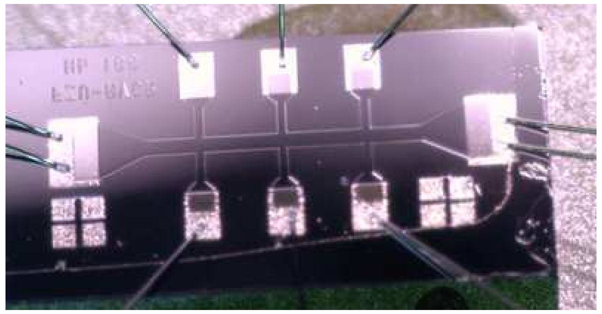
$$\text{SdH} \xrightarrow{\nu \gg 1 \qquad\qquad \nu \approx 1} \text{IQHE}$$

Plain 2DEG



Hall bar geometry

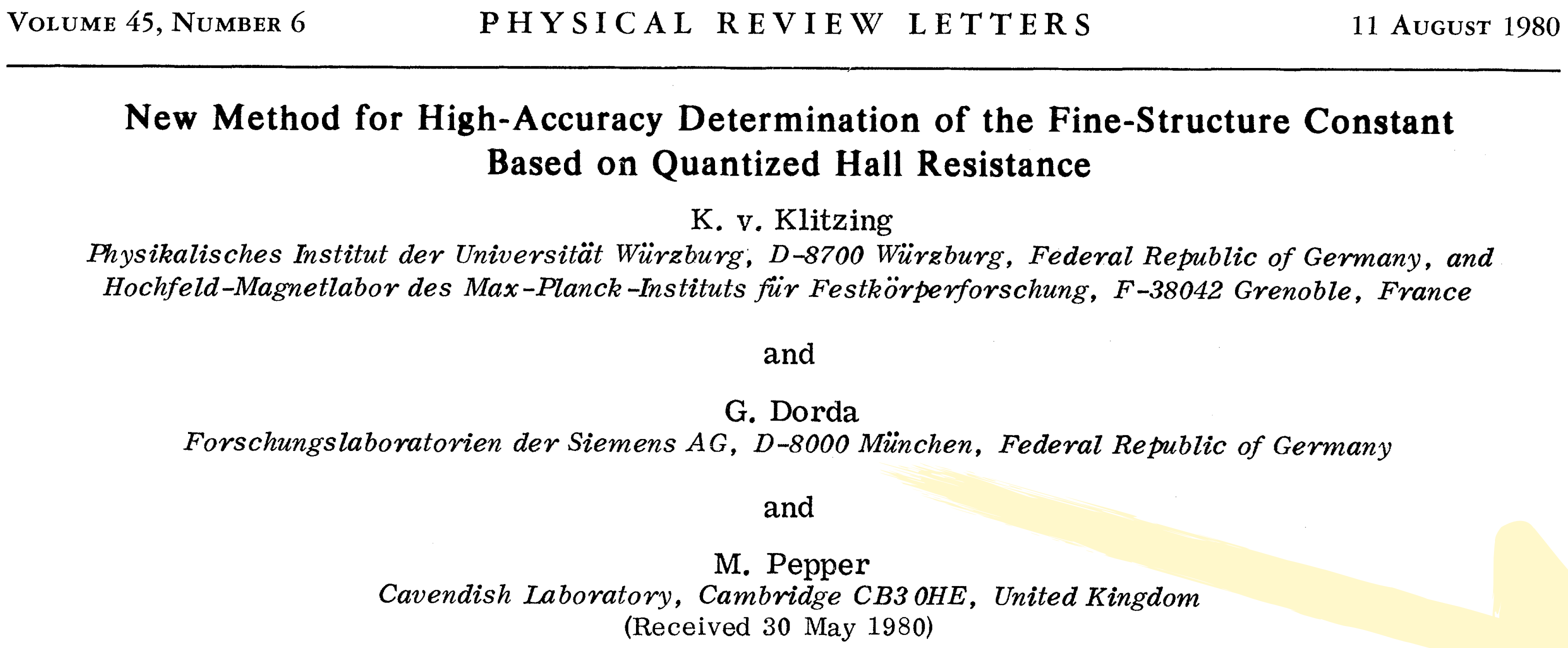




$$\rho_{xy} = \frac{2\pi\hbar}{e^2\nu} \qquad \sigma_{xy} = 2n\frac{e^2}{2\pi\hbar}$$

Courtesy of L. Nádvorník (MFF/FZU AV)

Integer Quantum Hall Effect



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

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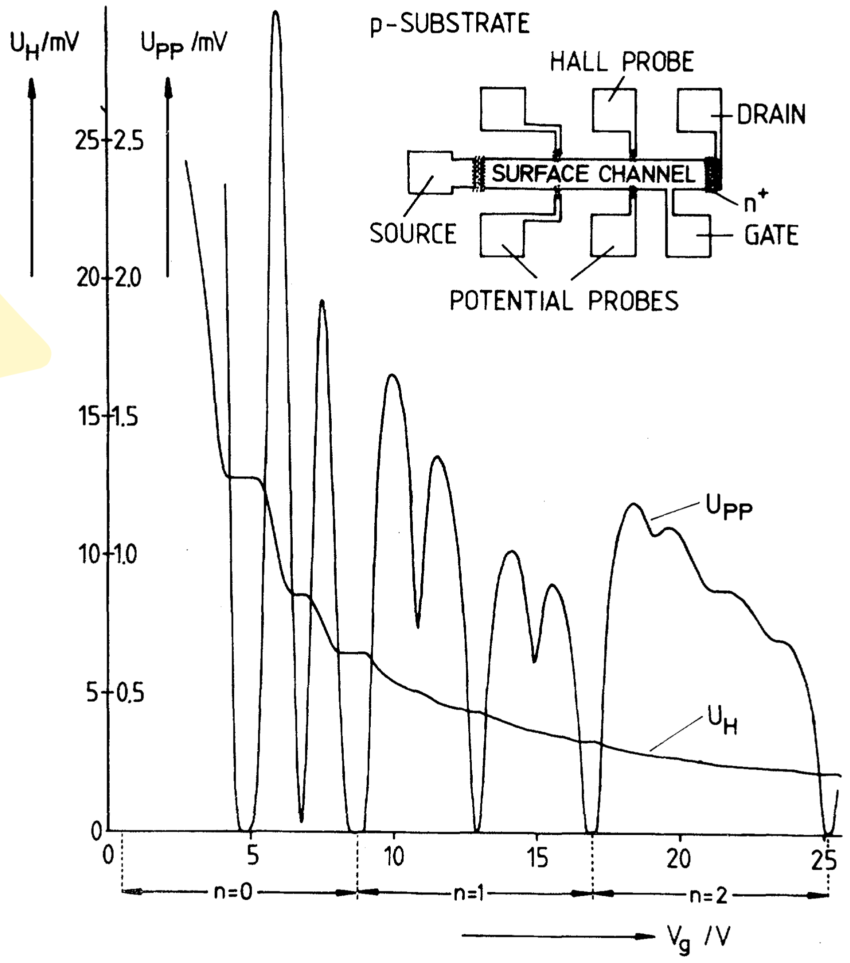
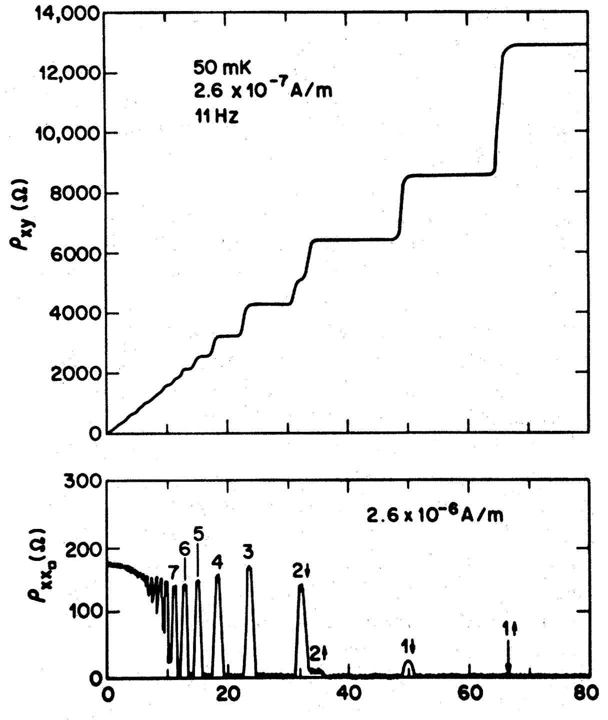


FIG. 1. Recordings of the Hall voltage U_H, and the voltage drop between the potential probes, U_{pp}, as a function of the gate voltage V_g at $T = 1.5$ K. The constant magnetic field (B) is 18 T and the source drain current, I, is 1 μA. The inset shows a top view of the device with a length of $L = 400$ μm, a width of $W = 50$ μm, and a distance between the potential probes of $L_{pp} = 130$ μm.

Paalanen et al., PRB '82
- medium mobility
- very low T



B [kG]