Two-band MR

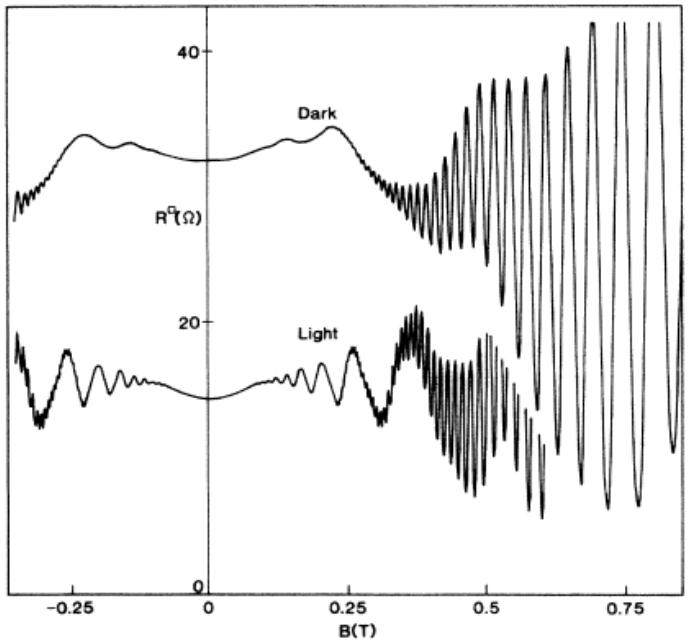


FIG. 1. The resistance per square for a GaAs-$Al_xGa_{1-x}As$ heterostructure with two two-dimensional subbands occupied as a function of magnetic field at 30 mK. Persistent photoconduction is used to change the carrier densities. The fast oscillations pertain to the lowest subband and the slow oscillations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

At B=0:

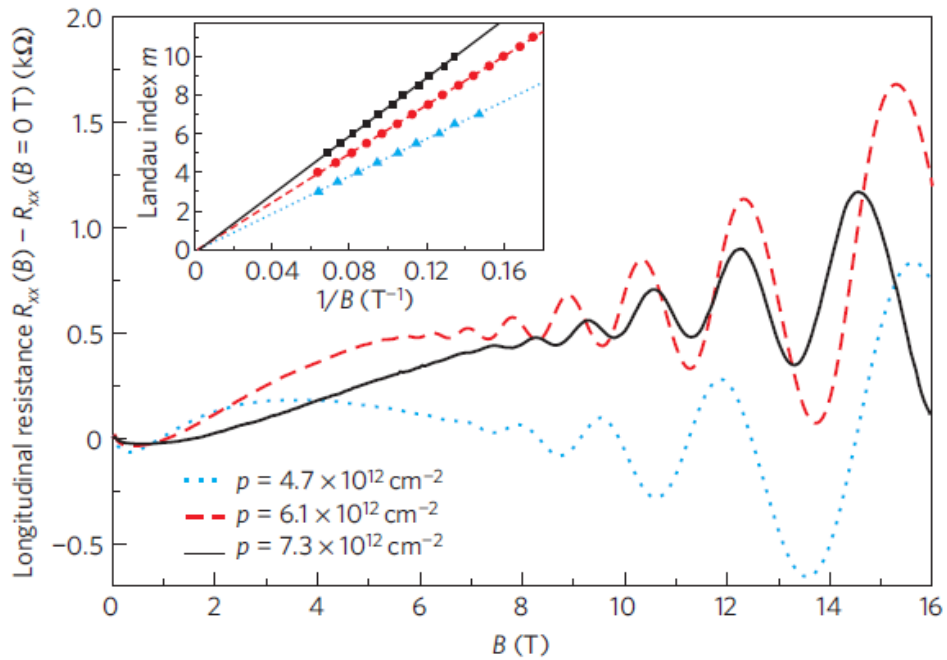
$$\sigma = \sigma_1 + \sigma_2 = en_1\mu_1 + en_2\mu_2$$

Under effect of magnetic field:

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

$$x = \mu B$$

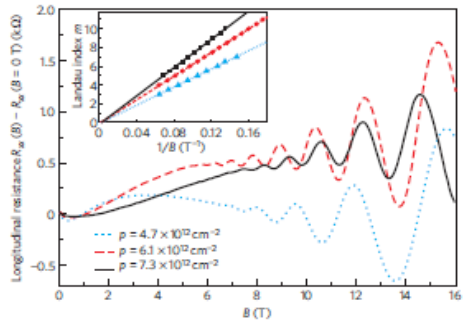
Shubnikov - de Haas oscillations (graphene)



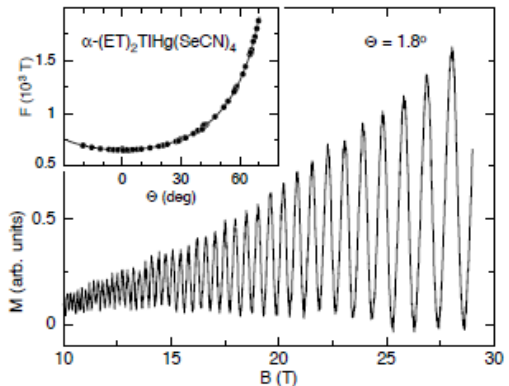
$$\Delta\left(\frac{1}{B}\right) = \frac{2\pi e}{\hbar}\frac{1}{A_e} = \frac{e}{2\pi\hbar}\frac{f}{p}$$

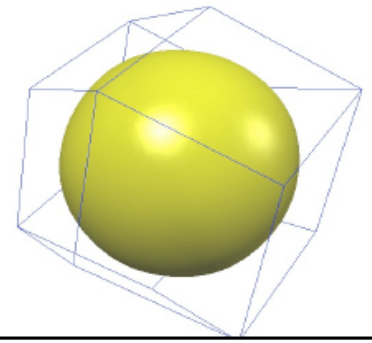
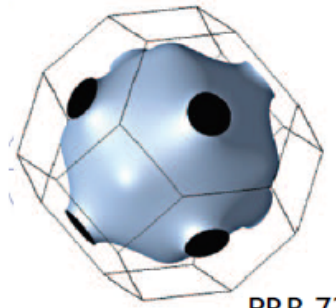
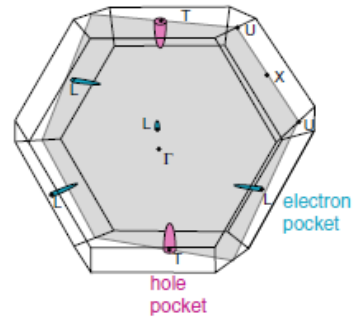
Experimental determination of Fermi surface

Reminder: Shubnikov-de Haas oscillations



de Haas-van Alphen effect



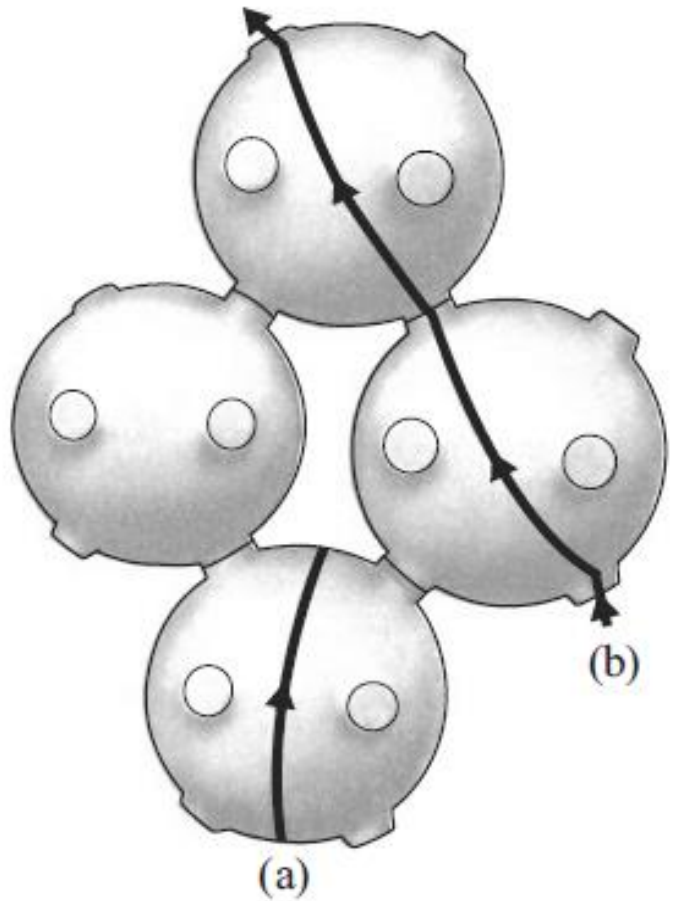
Potassium	Copper
	 PRB 73, 064420
Aluminium	**Bismuth**
	

Prog Surf Sci 81, 191 (2006)

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

EPL 35, 37 (1996)

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



S. Fujita, K. Ito, Quantum Theory of Conducting Matter, Springer (2007), pp. 154 – Figure 12.2

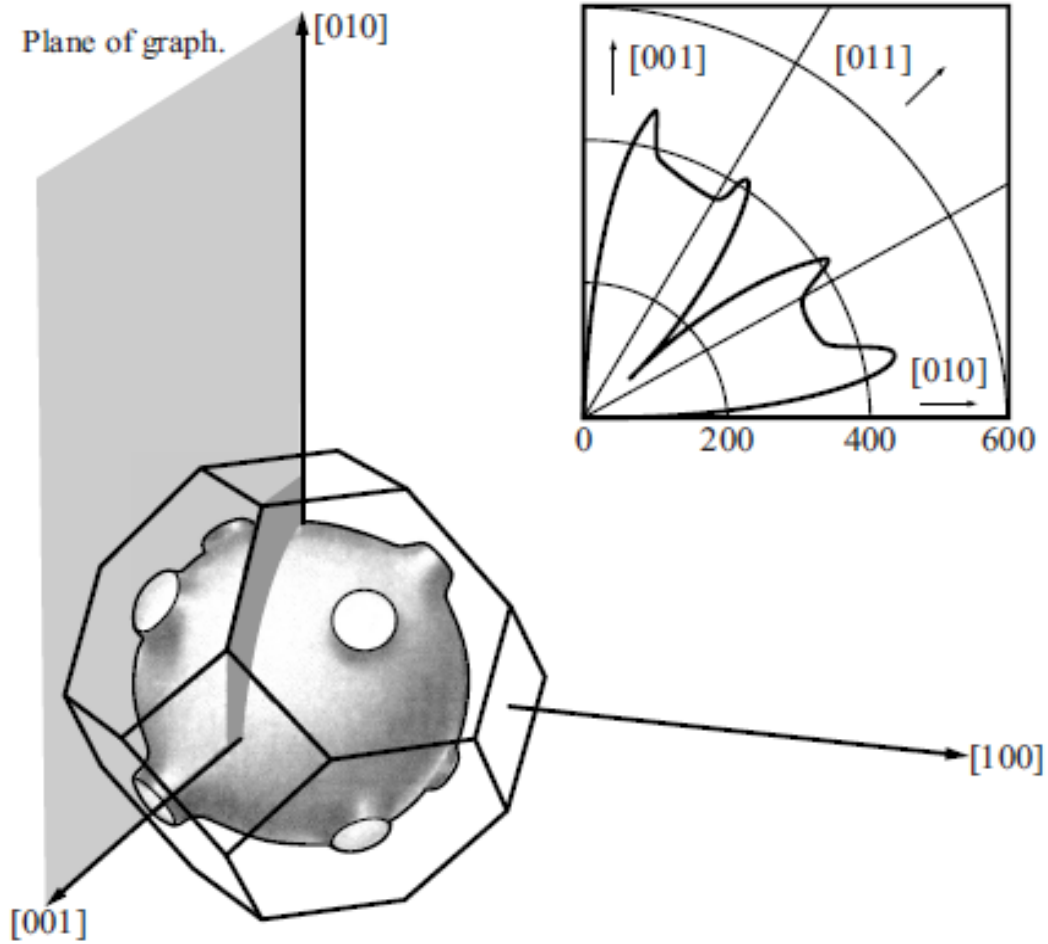
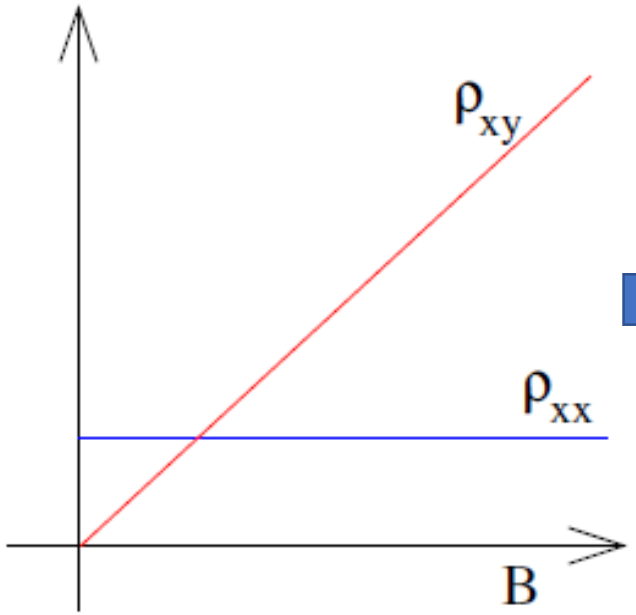
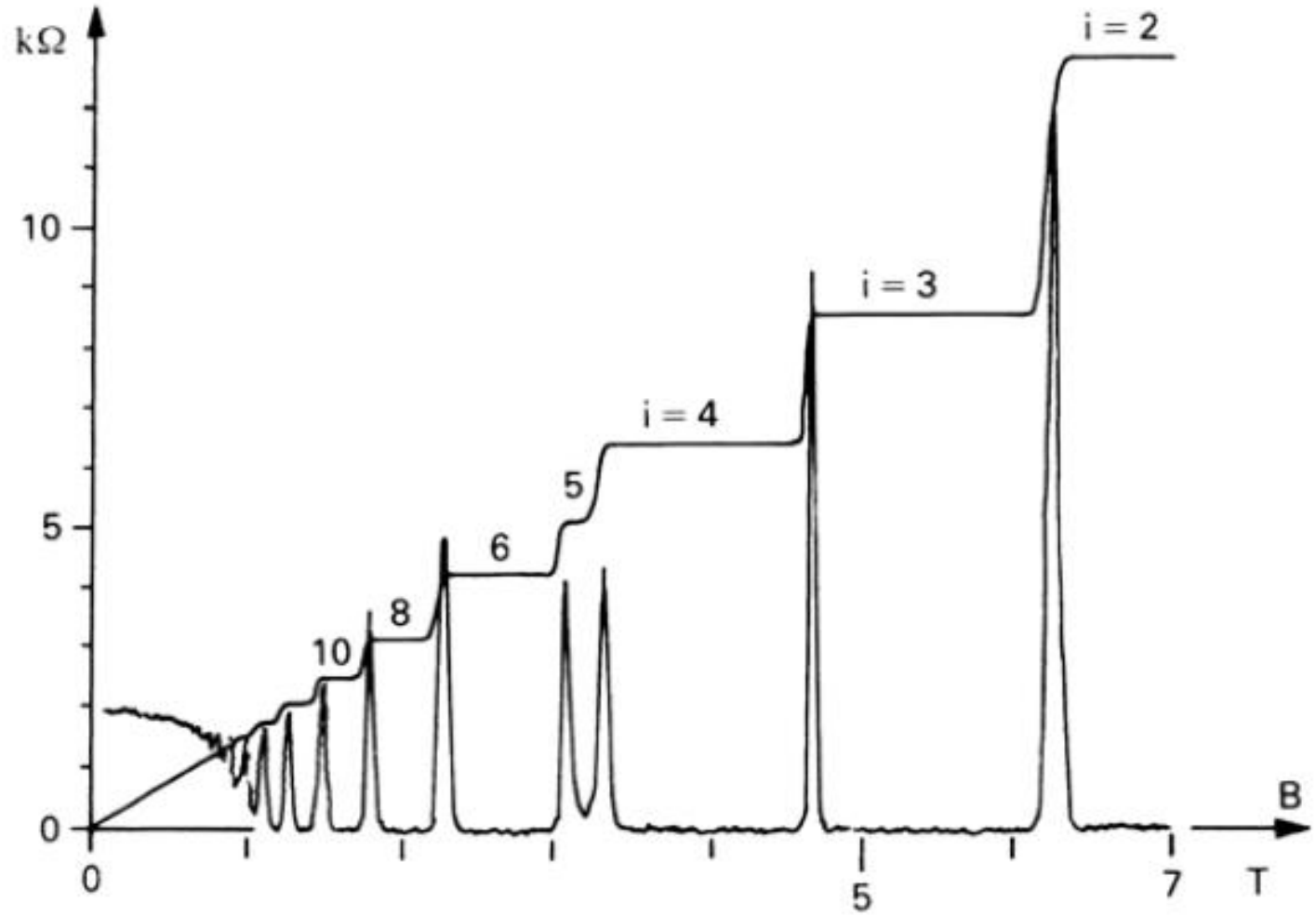


Figure 12.3: The striking anisotropy of the MR $\Delta\rho$ in Cu after Klauder and Kunzler [2]. The [001] and [010] directions of the copper crystal are shown, and the current flows in the [100] direction perpendicular to the graph. The magnetic field is in the plane of the graph. Its magnitude is fixed at 18 kilogauss, and its direction varied continuously from [001] to [010].

S. Fujita, K. Ito, Quantum Theory of Conducting Matter, Springer (2007), pp. 155 – Figure 12.3





D. Tong, The Quantum Hall Effect, TIFR Infosys Lectures, http://www.damtp.cam.ac.uk/user/tong/qhe.html

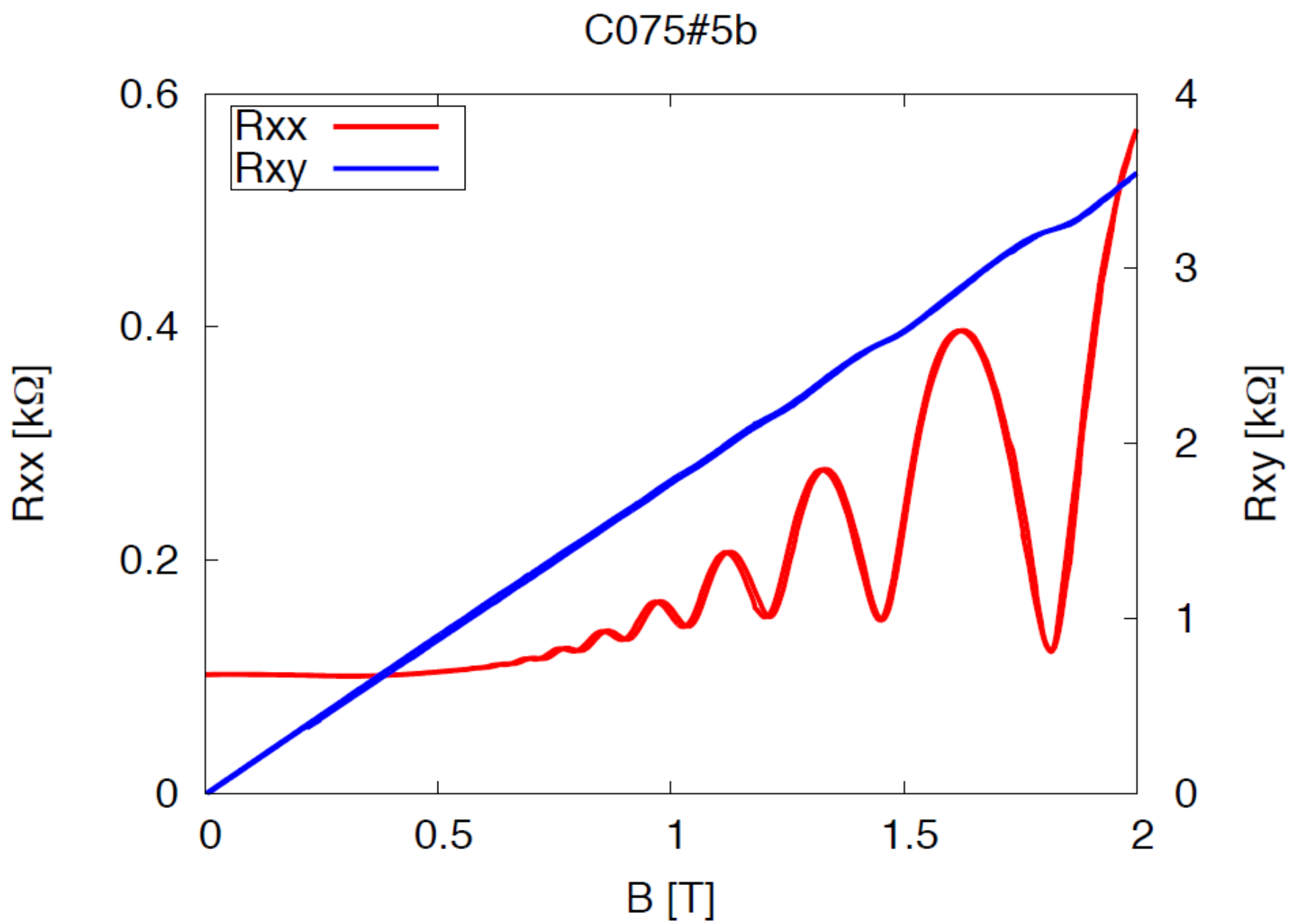


Figure 1: Shubnikov-de Haas oscillations in a GaAs/AlGaAs Hall bar containing 2DEG. (Measured by L. Nádvorník.)

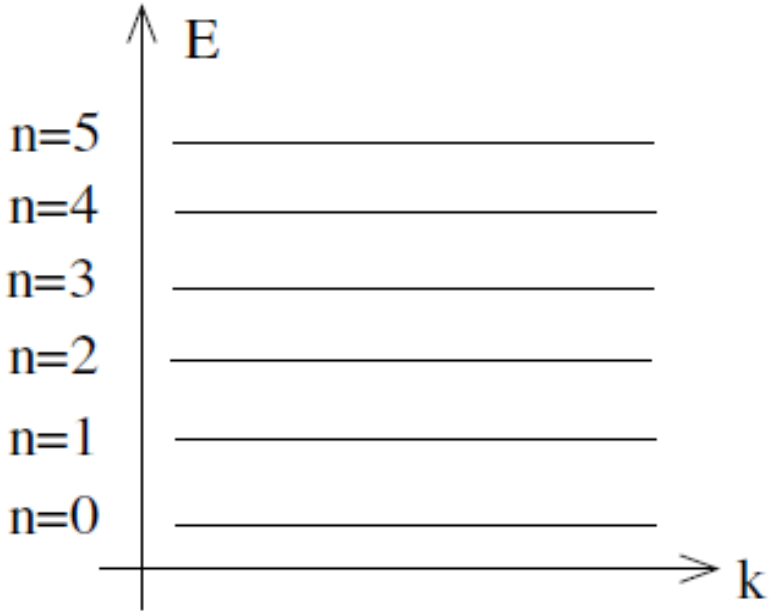


Figure 4: Landau Levels

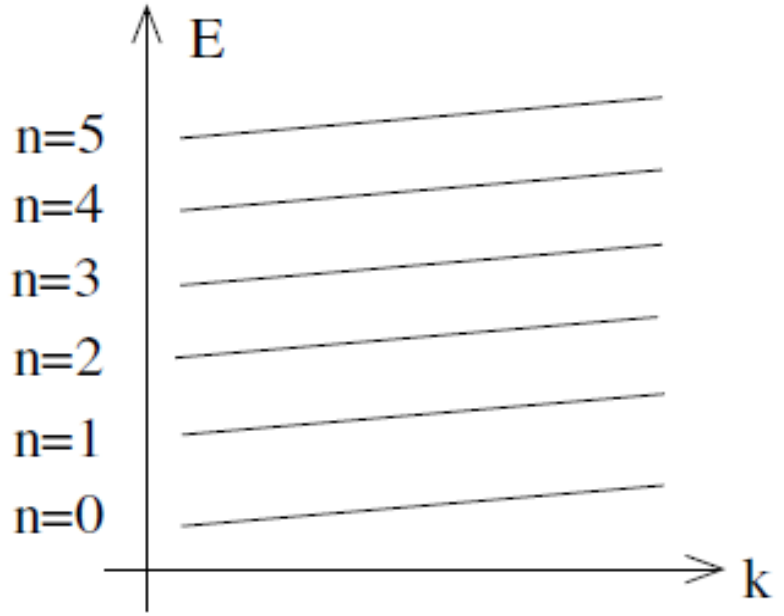


Figure 5: Landau Levels in an electric field

D. Tong, The Quantum Hall Effect, TIFR Infosys Lectures, http://www.damtp.cam.ac.uk/user/tong/qhe.html