Φ – 575 Διάλεξη 16

Φυσική διατάξεων δισδιάστατων ημιαγωγών

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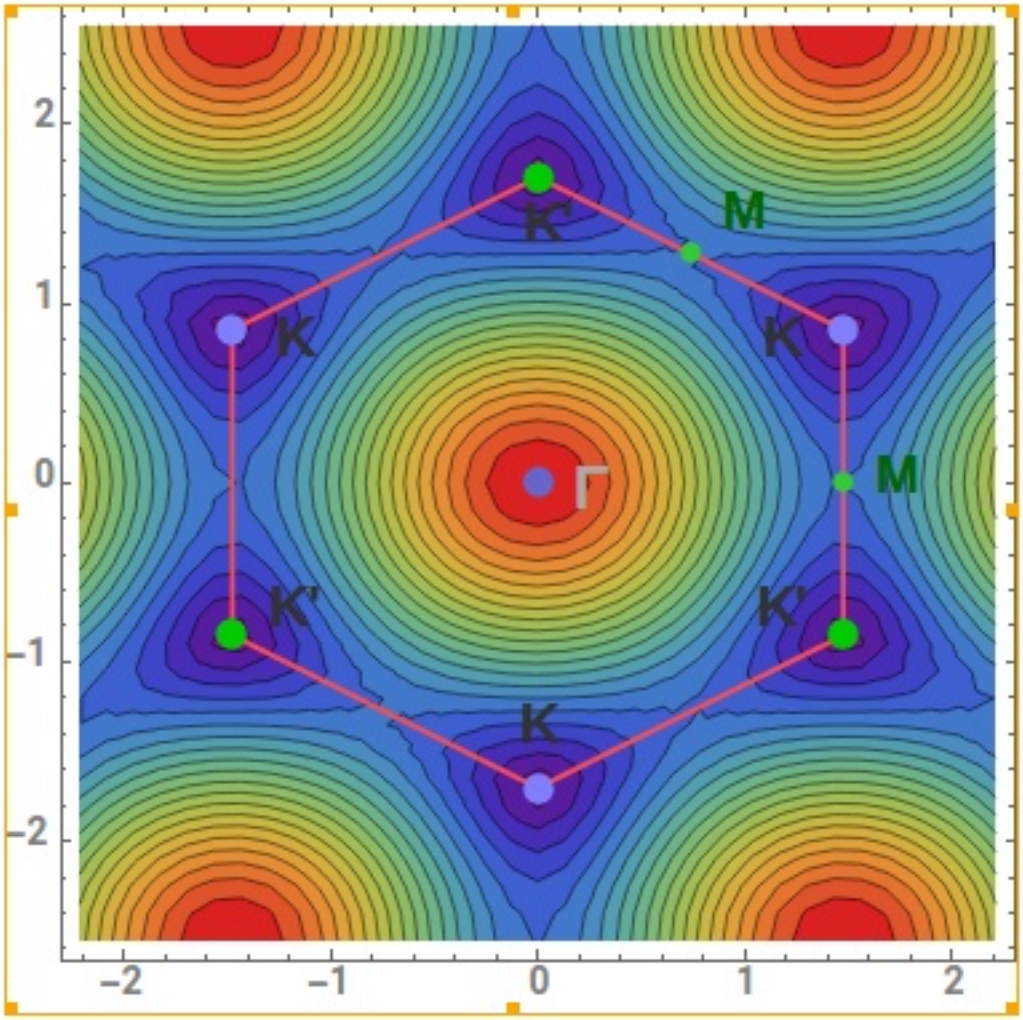
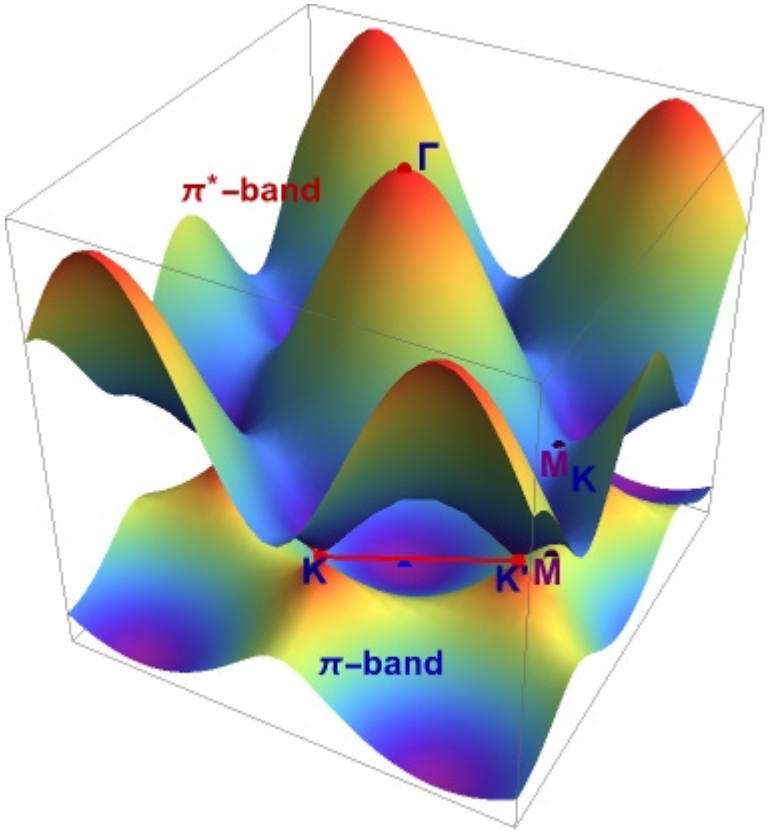
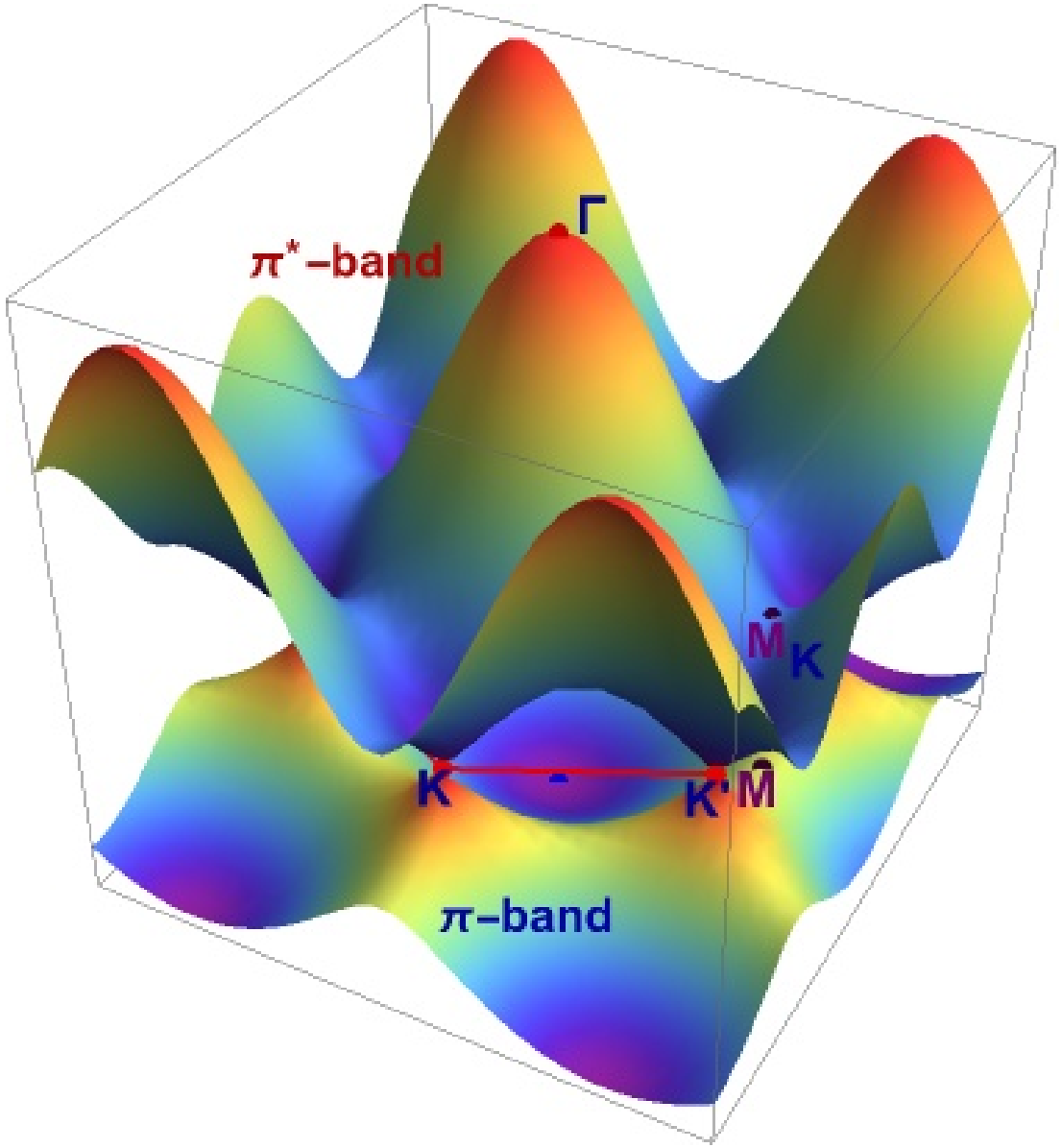
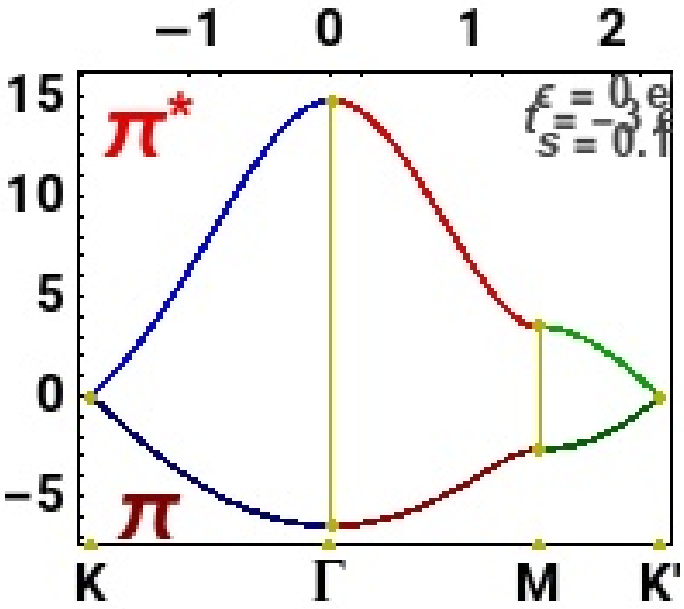
Graphene Brillouin zones / dispersion

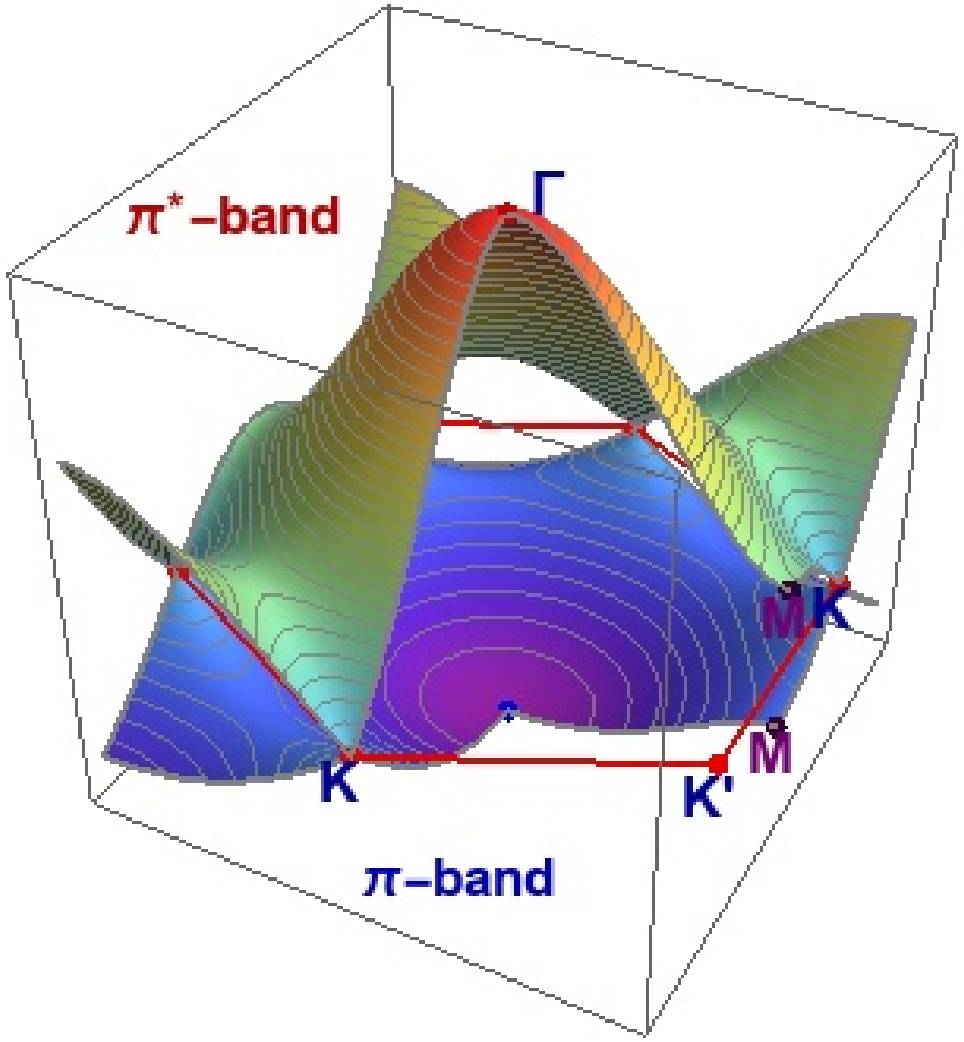




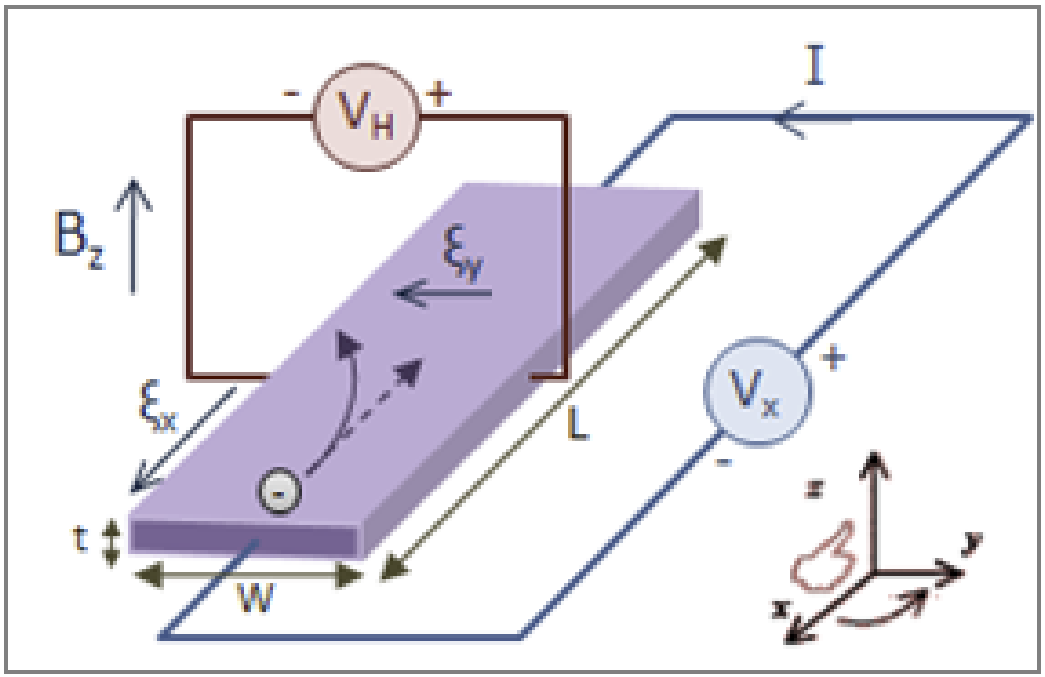
https://demonstrations.wolfram.com/GrapheneBrillouinZoneAndElectronicEnergyDispersion/


π*–band
Γ
M
K
K'
M
π–band


−1
0
1
2
15
10
5
0
−5
π*
π
K
Γ
M
K'

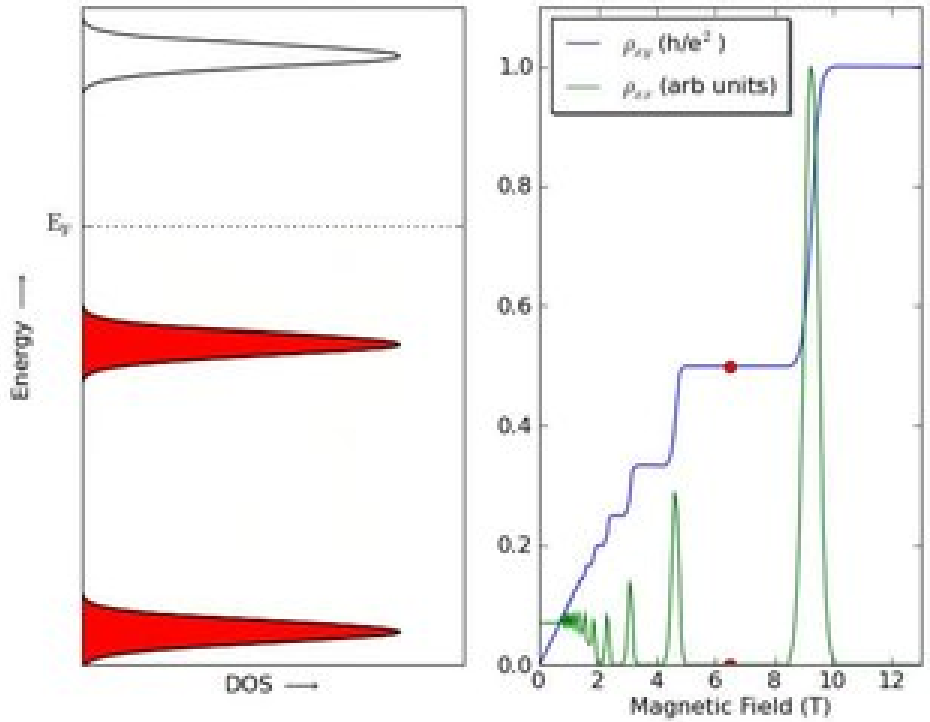

π*–band
Γ
M
K
K'
M'
π–band

Classic Hall effect



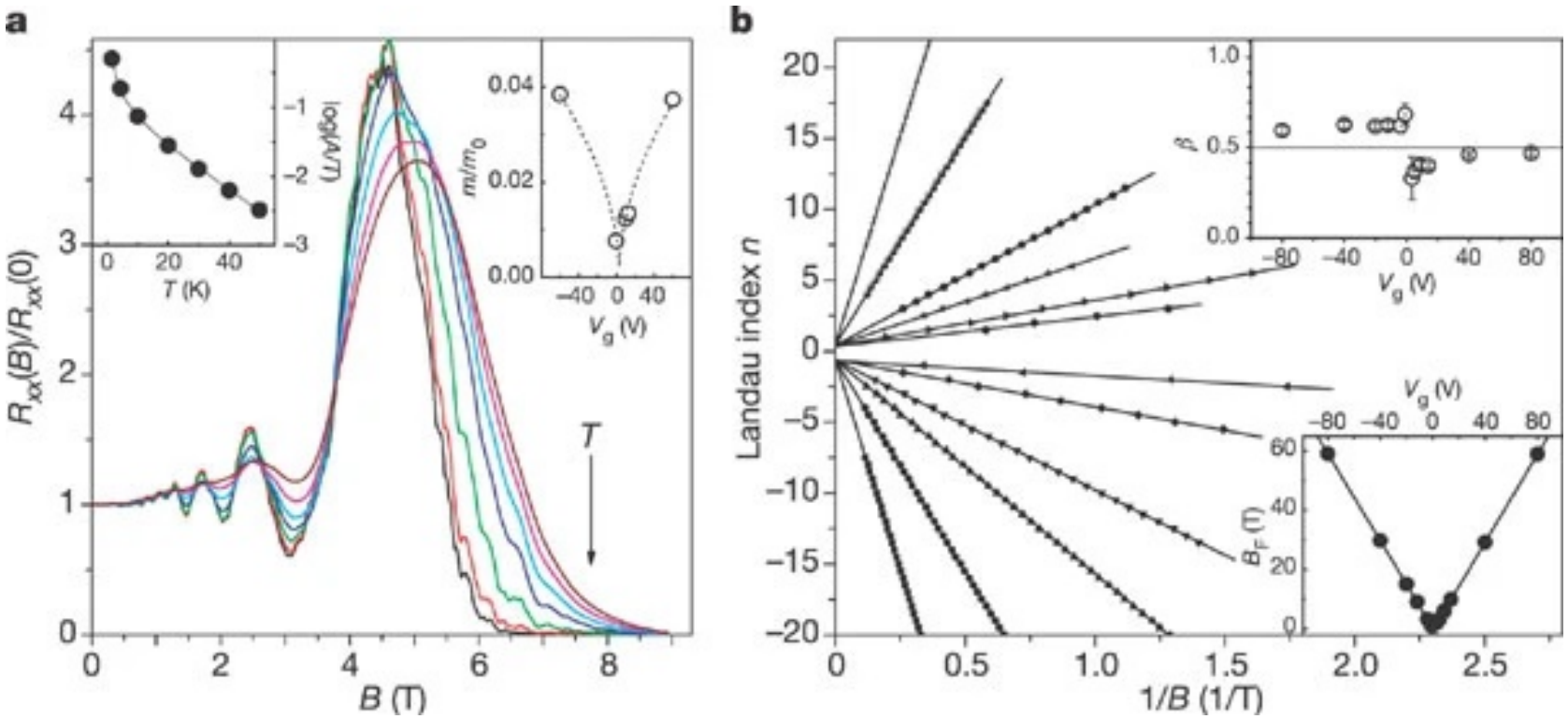
https://en.wikipedia.org/wiki/Hall_effect

Quantum Hall effect



https://en.wikipedia.org/wiki/Landau_quantization
https://en.wikipedia.org/wiki/Quantum_Hall_effect

Subnikov de Haas oscillations



https://www.nature.com/articles/nature04235

Landau levels

Schrödinger electrons

$$H=\frac{1}{2m}(p+eA)^2$$

$$\Psi(x,y)=e^{ik_x x}Y(y)$$

$$\frac{1}{2m}\left(-\hbar^2\frac{d^2}{dy^2}+(eB)^2\left(y-\frac{\hbar k_x}{eB}\right)^2\right)Y=\varepsilon Y$$

$$\omega_c=\frac{eB}{c},\ y_o=\frac{\hbar k}{eB}=k_x l^2,\ l=\sqrt{\frac{\hbar}{eB}}$$

$$E_n=\hbar\omega_c\left(n+\frac{1}{2}\right)$$

Relativistic vs NR LLs

A semiconductor 2DEG is formed by doping electrons into the conduction band.

Fermi in a semiconductor 2DEG is usually "high"

$\omega_c/2$

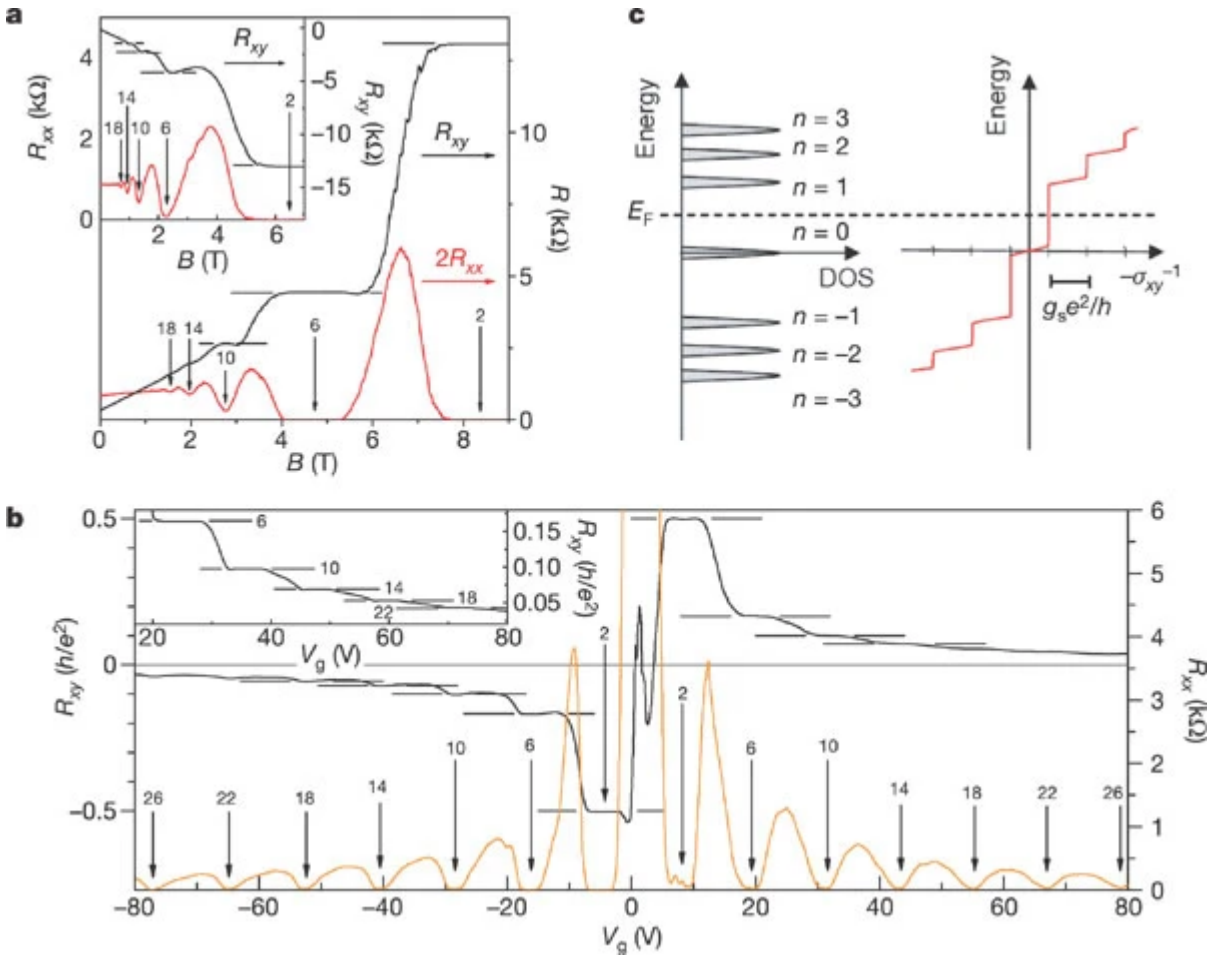
E

0

Fermi level is "in the middle" of 0th LL in undoped graphene

This is because there are a lot of electrons in graphene: 1 per C atom, filling the "negative" energy LLs

Graphene quantized Hall effect



https://www.nature.com/articles/nature04235