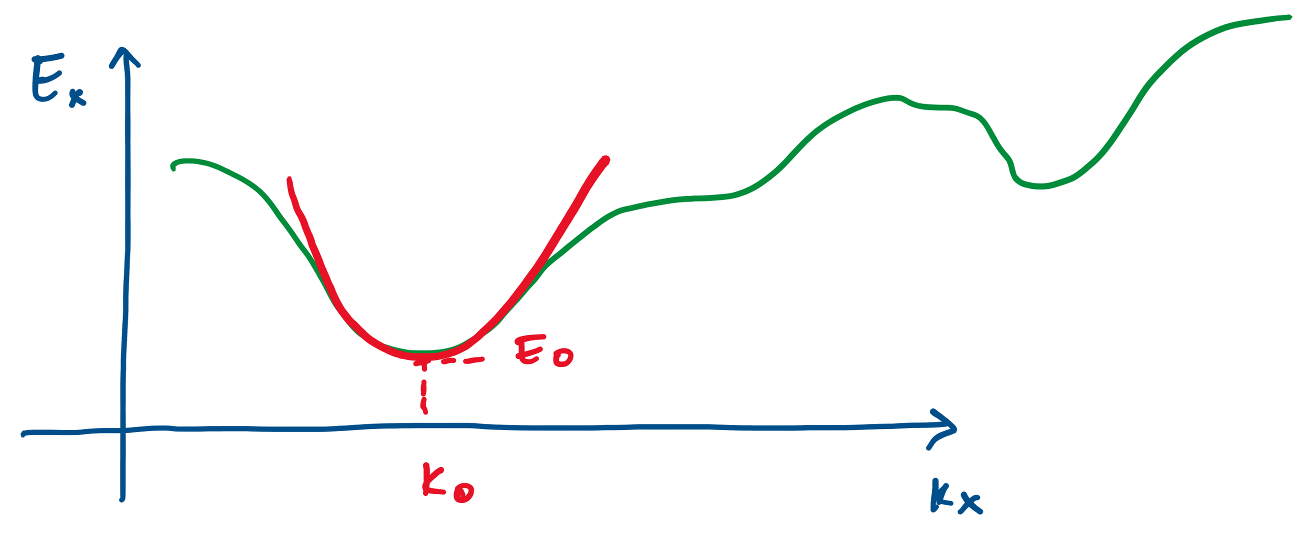
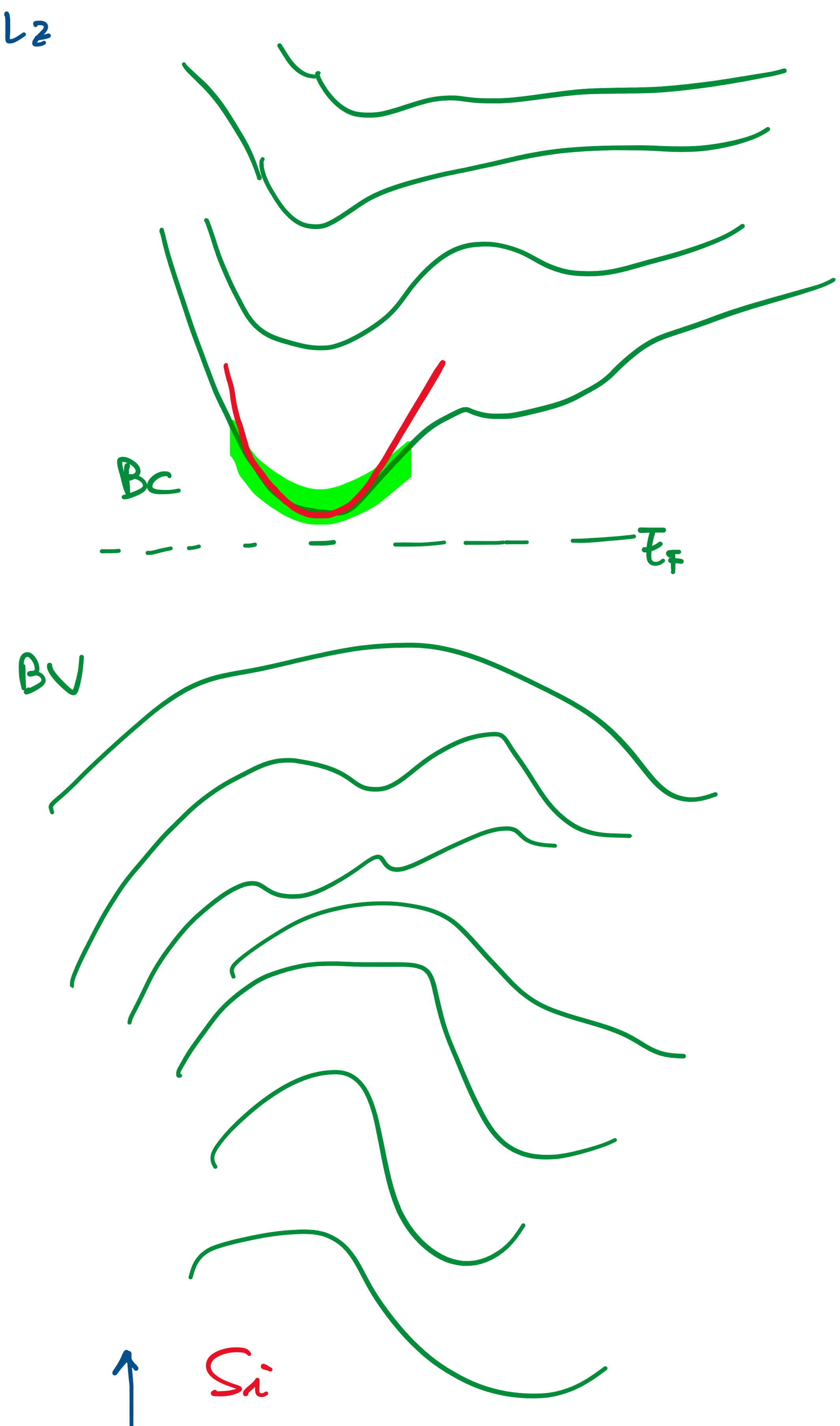
# 1D CONFINEMENT

Friday, 15 November 2019 09:45

$$\Psi_{i,k_y,k_z}(x,y,z) = \varphi_i(x,y,z)\,\frac{e^{jk_y y}}{\sqrt{L_y}}\cdot\frac{e^{jk_z\cdot z}}{\sqrt{L_z}}$$

$$n(x,y,z) = \sum_{i,k_y,k_z} \left|\Psi_{i,k_y,k_z}\right|^2 f\left(E_{i,k_y,k_z}\right)$$



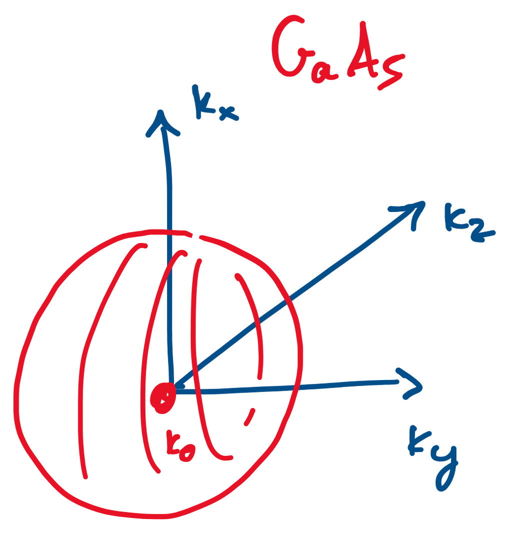




$$E(k)\Big|_{k_0} = E_0 + \underbrace{\frac{\delta E}{\delta k}(k-k_x)\Big|_{k_0}}_{=0} + \frac{1}{2}\underbrace{\frac{\delta^2 E}{\delta k^2}}_{\frac{\hbar^2}{2m_x}}(k-k_0)^2$$

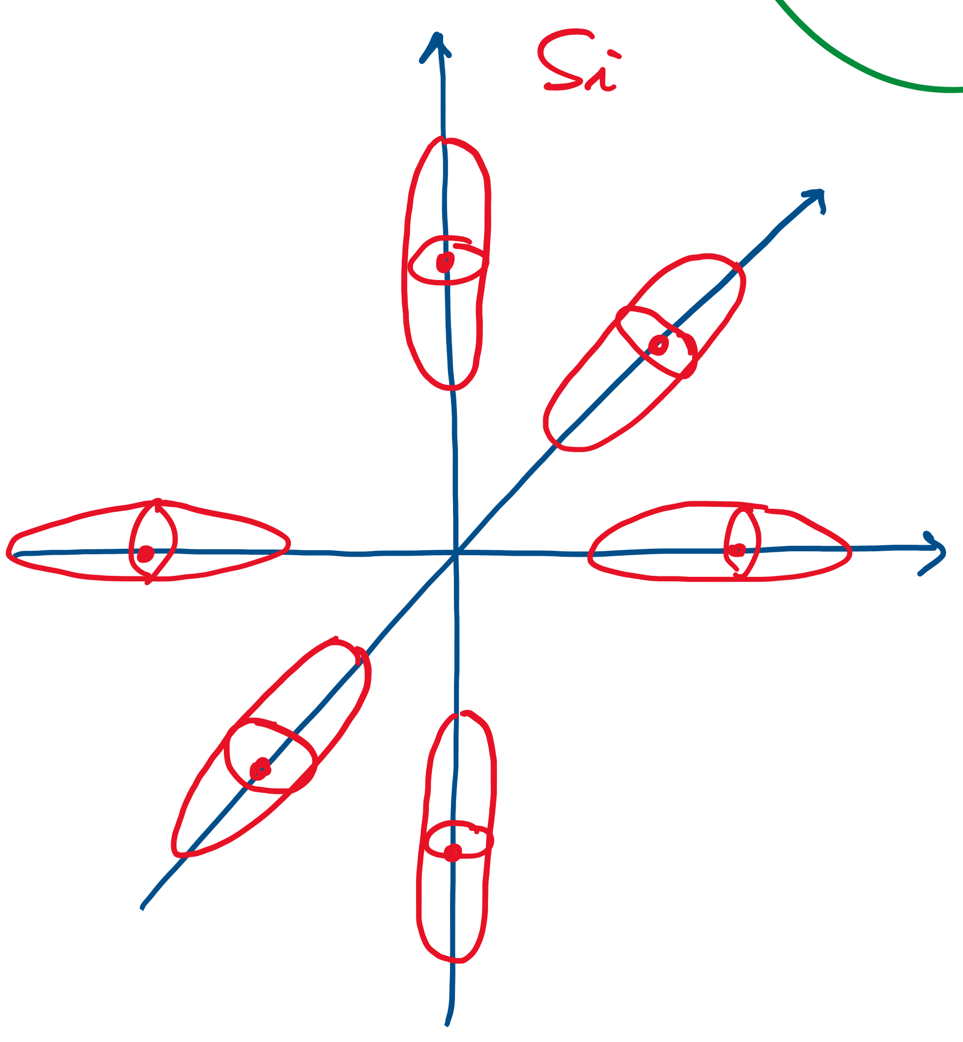
$$E(k)\Big|_{k_0} = E_0 + \frac{\hbar^2}{2m_x}(k-k_0)^2$$

$$m_x = \frac{\hbar^2}{\left(\frac{\delta^2 E}{\delta k^2}\right)_{k_0}}$$

GaAs




Si



$$E_{i,k_y,k_z} = \mathcal{E}_i + \frac{\hbar^2 k_y^2}{2m_y} + \frac{\hbar^2 k_z^2}{2m_z} \Bigg\}\ \text{2D Subbands}$$

$$n(x,y,z) = \sum_i \sigma_i \left|\varphi_i(x,y,z)\right|^2, \quad \sigma_i \triangleq \sum_{k_y,k_z} \frac{f(E_i,k_y,k_z)}{L_y L_z}$$

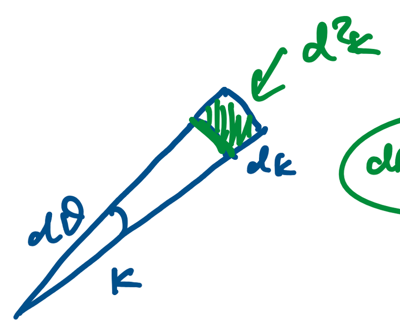
$$\sum_{k_y,k_z} \longrightarrow \frac{2L_yL_z}{(2\pi)^2}\int d^2k$$

$$\boxed{k_y' = \frac{k_y}{\sqrt{2m_y}}\ ;\quad k_z' = \frac{k_z}{\sqrt{2m_z}}}$$

$$d^2k = dk_y\cdot dk_z = 2\sqrt{m_y m_z}\,dk_y'\cdot dk_z'$$

$$E_{i,k_y',k_z'} = \mathcal{E}_i + \hbar^2 k_y'^2 + \hbar^2 k_z'^2 = \mathcal{E}_i + \hbar^2 k'^2 \qquad k'^2 = k_y'^2 + k_z'^2$$

$$d^2k = k\,dk\,d\theta$$

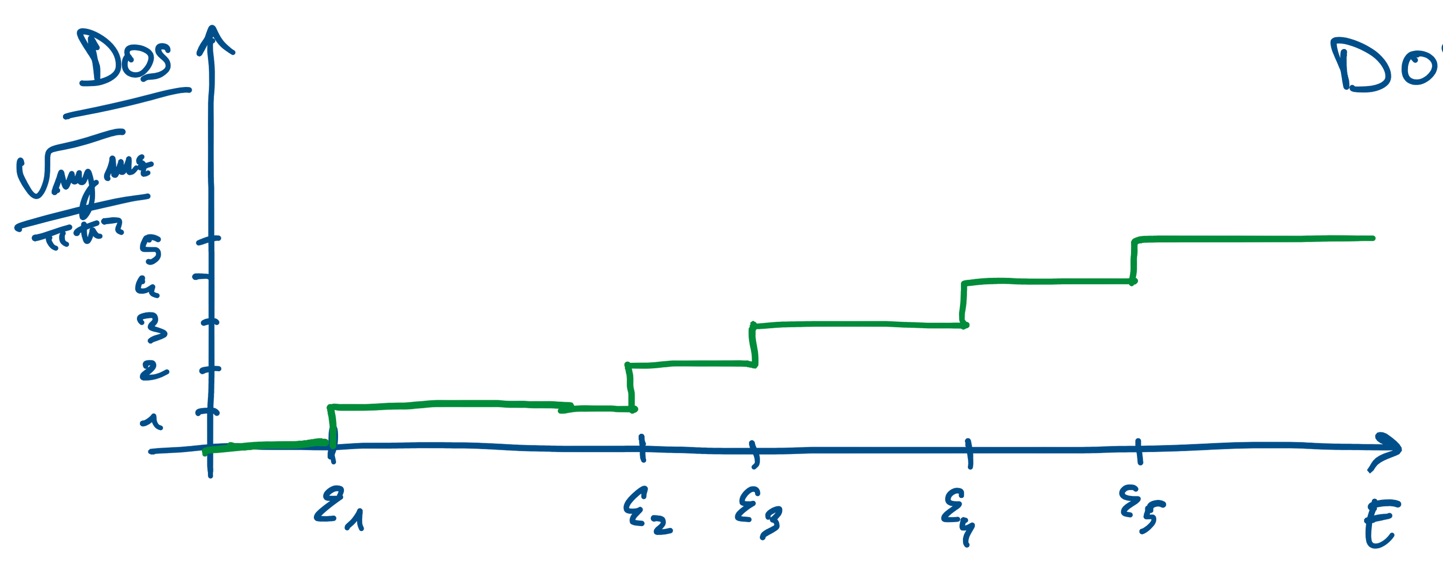


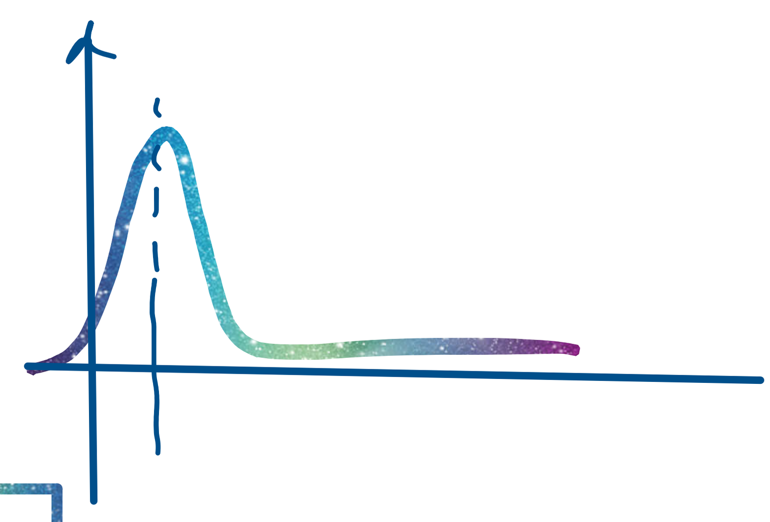

$$\frac{2L_y\cdot L_z}{4\pi^2}\,2\sqrt{m_y m_z}\int_0^{2\pi} d\theta \int_0^{+\infty} k'dk'$$

$$\sigma_i = \int_0^{2\pi} d\theta \int_0^{+\infty} \frac{\sqrt{m_y m_z}}{\pi^2}\,k'dk'\,f(E_i,k_y',k_z') = 2\cancel{\pi}\int_0^{+\infty}\frac{\sqrt{m_y m_z}}{\pi^{\cancel{2}}}\,k'dk'\,f(E_i,k_y',k_z')$$

$$dE_{i,k_y',k_z'} = 2\hbar^2 k'dk' \Rightarrow \sigma_i = \int_{\mathcal{E}_i}^{+\infty} \boxed{\frac{\sqrt{m_y m_z}}{\pi\hbar^2}}\, f(E_i,k_y,k_z)\,dE_{i,k_y,k_z}$$

DOS dell' i-th subband



$$\sigma_i = \frac{\sqrt{m_y m_z}}{\pi\hbar^2}\,k_BT\,\ln\left[1+\exp\left(-\frac{\mathcal{E}_i - E_F}{k_BT}\right)\right]$$

$$\boxed{n_{2DEG} = \sum_i |\varphi_i|^2 \frac{\sqrt{m_y m_z}}{\pi\hbar^2}\,k_BT\,\ln\left[1+\exp\left(-\frac{\mathcal{E}_i - E_F}{k_BT}\right)\right]}$$