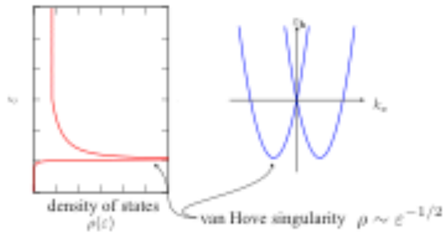
Example Handout

example I: parabolic band

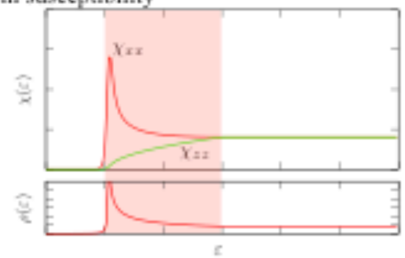
consider a band with Hamiltonian

$$\mathcal{H}_{\mathbf{k}} = (\frac{\mathbf{k}^2}{2m} - \mu)\sigma^0 + \alpha(k_y\sigma^x - k_x\sigma^y)$$



parabolic band

spin susceptibility



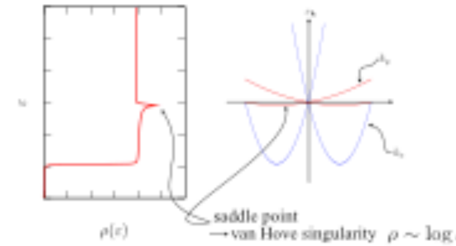
band-edge: $\chi_{xx} > \chi_{zz}$

example II: elliptic band

consider a band with Hamiltonian

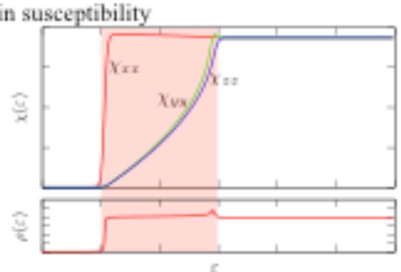
$$\mathcal{H}_{\mathbf{k}} = (\frac{k_x^2}{2m_x} + \frac{k_y^2}{2m_y} - \mu)\sigma^0 + \alpha(\frac{k_y}{m_y}\sigma^x - \frac{k_x}{m_x}\sigma^y)$$

$v_{x,y}$



Elliptic band

spin susceptibility



band-edge: $\chi_{xx} > \chi_{zz}$

ellipticity: $\chi_{xx} > \chi_{yy}$ & peak in DOS

Outline

- Consider Rashba SOC in a one-band model
  - general considerations for a parabolic band
  - explicit examples:
    - parabolic band (cf. d_{xy} band)
    - elliptic band (cf. d_{xz} / d_{yz} bands)
- Generalize to three bands
  - three independent bands
  - add atomic spin-orbit coupling to mix bands
- conclusions and remarks

three-band model

consider band structre given by

- individual dispersions

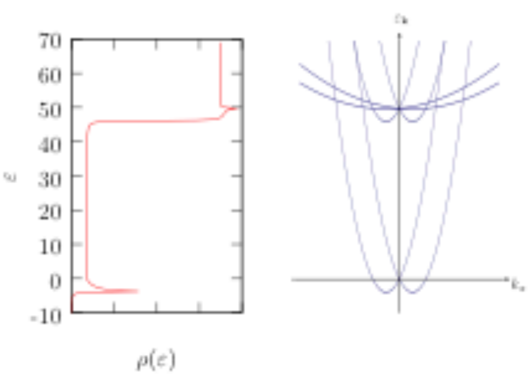
$$\varepsilon_{1\mathbf{k}} = \frac{k_x^2}{2m} + \frac{k_y^2}{2M} - \mu + \delta$$
$$\varepsilon_{2\mathbf{k}} = \frac{k_x^2}{2M} + \frac{k_y^2}{2m} - \mu + \delta$$
$$\varepsilon_{3\mathbf{k}} = \frac{k_x^2 + k_y^2}{2m} - \mu$$

due to interface symmetry breaking

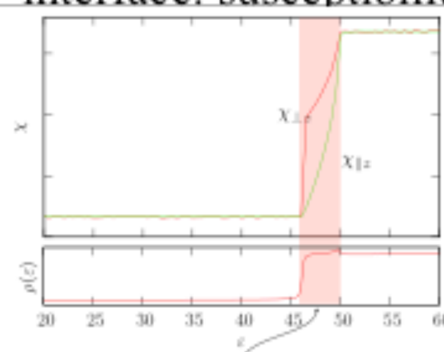
- Rashba spin-orbit coupling

$$\mathcal{H}_{\mathrm{Rashba}} = \sum_{\alpha}\sum_{\mathbf{v}_{\mathbf{k}}^{\alpha}} \frac{E}{c}(\mathbf{v}_{\mathbf{k}}^{\alpha} \times \hat{z}) \cdot \sigma$$

three bands: DOS



interface: susceptibility



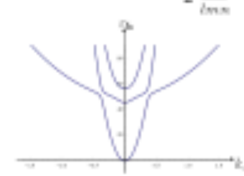
window with anisotropic susceptibility

atomic SOC

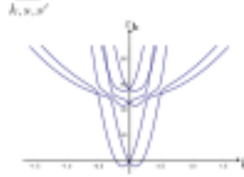
additionally consider atomic SOC

$$\mathcal{H}_{\mathrm{SOC}} = \lambda \sum_i \mathbf{L}_i \cdot \mathbf{S}_i$$

$$\mathcal{H}_{\mathrm{SOC}} = i\frac{\lambda}{2}\sum_{lmn}\epsilon_{lmn}\sum_{k,s,s'} c^{\dagger}_{lks}c_{mks'}\sigma^{n}_{ss'}$$



only atomic SOC



& Rashba SOC