Two types of SOI in solids

1) Symmetry-independent:
   exists in all types of crystals
   stem from SOI in atomic orbitals

2) Symmetry-dependent:
   exists only in crystals without inversion symmetry
   a) Dresselhaus interaction (bulk): Bulk-Induced-Assymetry (BIA)
   b) Bychkov-Rashba (surface): Surface-Induced-Asymmetry (SIA)

Additional band splitting in non-centrosymmetric crystals

Kramers theorem: if time-reversal symmetry is not broken, all eigenstates are at least doubly degenerate

if ψ is a solution, ψ^* is also solution

Kramers doublets $\varepsilon_s(\mathbf{k}),\ s=\pm1$ (not necessary spin projection!)

Time reversal symmetry: **k➔-k,**t➔-t $\varepsilon_s(\mathbf{k})=\varepsilon_{-s}(-\mathbf{k})$

No SOI: $\varepsilon(\mathbf{k})=\varepsilon(-\mathbf{k})$ regardless of the inversion symmetry

With SOI: i) If a crystal is centrosymmetric

$$\varepsilon_s(\mathbf{k}) \underbrace{=}_{t\to -t} \varepsilon_{-s}(-\mathbf{k}) \underbrace{=}_{\mathbf{k}\to-\mathbf{k}} \varepsilon_{-s}(\mathbf{k}) \Rightarrow \varepsilon_s(\mathbf{k})=\varepsilon_{-s}(\mathbf{k})$$

ii) If a crystal is non-centrosymmetric,

$\varepsilon_s(\mathbf{k})\neq\varepsilon_{-s}(\mathbf{k})$ B=0 “spin” splitting