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Topological semimetals: robustness and tuning of the Fermi arcs

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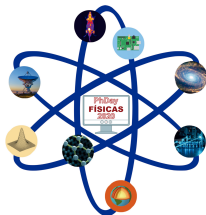
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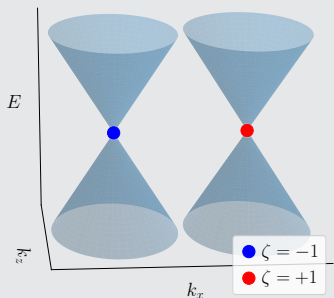
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Introduction: Topological semimetals

Weyl and Dirac Semimetals (WSM/DSM)



- **WSM:** Weyl nodes in pairs [Nielsen-Ninomiya] connected by Fermi arcs → **surface states** protected by **topology**
- **DSM:** two copies of Weyl nodes protected by symmetry

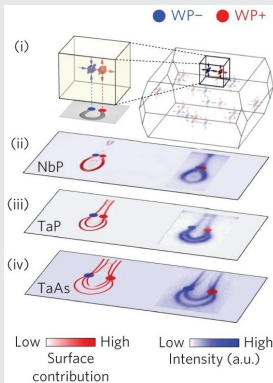


Figure: Projection of the Weyl points and Fermi arcs for TaAs, NbP, TaP. Liu, Z. *et al.*, Nat. Mater. **15**, 27 (2016).

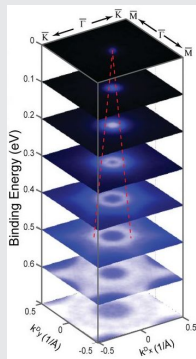


Figure: Dirac cone in Na₃Bi Liu, Z. *et al.*, Science **21**: 846-867 (2014).

Electric field: control of the surf. states

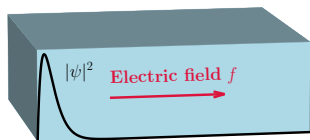


Figure: Set-up:

- Electric field perpendicular to the surface:
 $\mathcal{H}_f = efy\mathbb{1}_2$
- Periodic boundary conditions in x and z

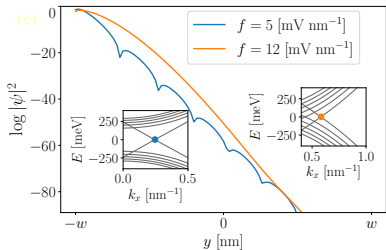


Figure: Type transition induced by the electric field

Y. Baba, A. Díaz-Fernández, E. Díaz, F. Domínguez-Adame, and R. A. Molina, PRB **100**, 165105 (2019).

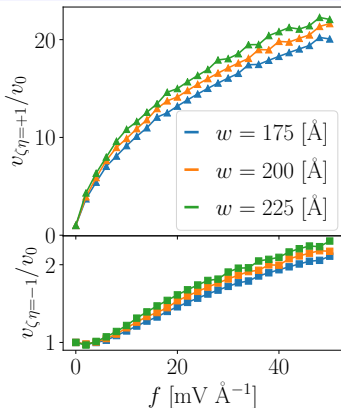


Figure: Breaking of the symmetry between nodes and **chiral** renormalization of the parameters

RSOC: spin-switcher

Y.Baba, F.Domínguez-Adame, G.Platero and R.A.Molina, arXiv:2009.14753 (2020)

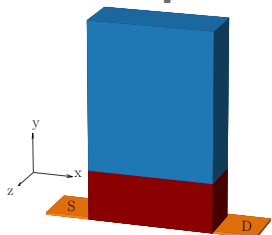


Figure: Schematic view of the device.

Local interaction with a substrate in a slab of DSM:

$$\mathcal{H}_R = \begin{pmatrix} 0 & 0 & -iR_0k_- & 0 \\ 0 & 0 & 0 & 0 \\ iR_0k_+ & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix},$$

where $k_{\pm} \equiv k_z \pm ik_x$.

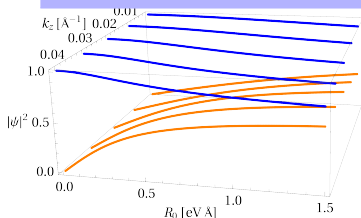


Figure: Absolute value of the upper (blue) and lower (orange) component of the surface state in the chiral basis as a function of R_0 and k_z at fixed $k_x = 0.01 \text{ \AA}^{-1}$.

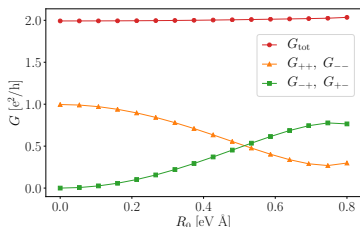
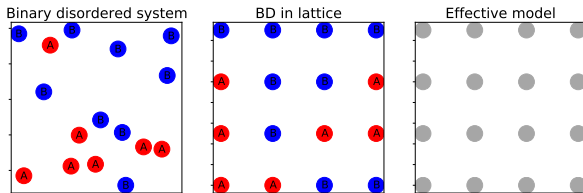


Figure: Na_3Bi slab $150 \times 150 \times 100 \text{ \AA}^3$.

Work in progress: impurities



Effective Green functions
within different approx.:

$$\Sigma_{\text{SCBA}} = \text{---} + \text{---} + \text{---}$$

$$\Sigma_{\text{CPA}} = \text{---} + \text{---} + \text{---} + \dots$$

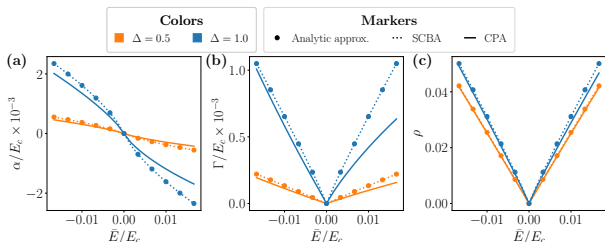


Figure: Real (a) and complex (b) part of the self energy and DOS (c) in a Dirac 2D Hamiltonian.

J.L.Hernando, Y.Baba, E.Díaz and F.Domínguez-Adame, manuscript in prep. (2020)