Topological Mott transition in a Weyl-Hubbard model with dynamical mean-field theory

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arXiv:2011.05100

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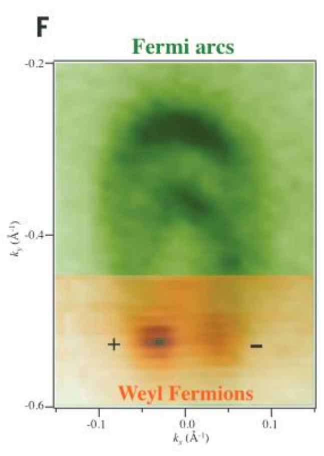
Weyl semimetals…

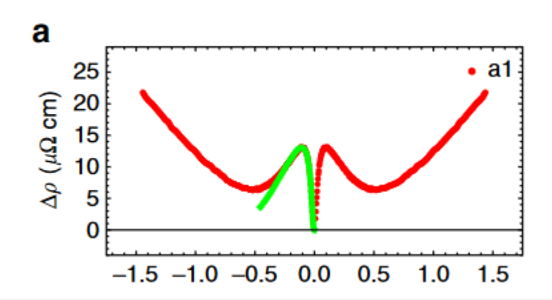
Armitage et al., RMP 90, 15001 (2018)

Fermi arcs…



Xu et al., Science 349, 613 (2015)

…and chiral anomaly in TaAs

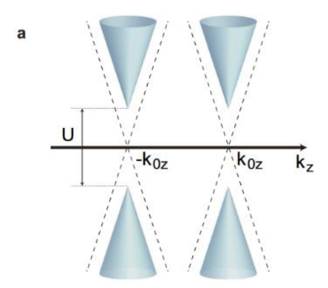


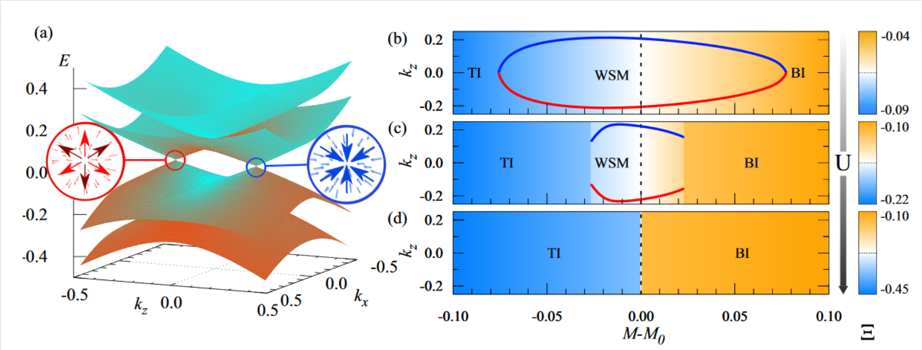
Zhang et al., Nat. Commun. 7, 10735 (2016)

…with interactions

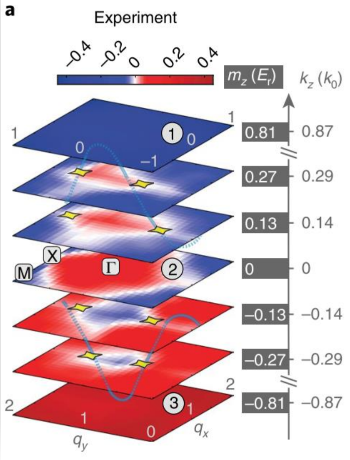
Morimoto and Nagaosa, Sci. Rep. 6, 19853 (2016)

$$\sum_k \frac{U}{2}(\hat{n}_k - 1)^2$$





Crippa et al., PRR 2, 012023 (2020)



Song et al., Nat. Phys. 15, 911 (2019)

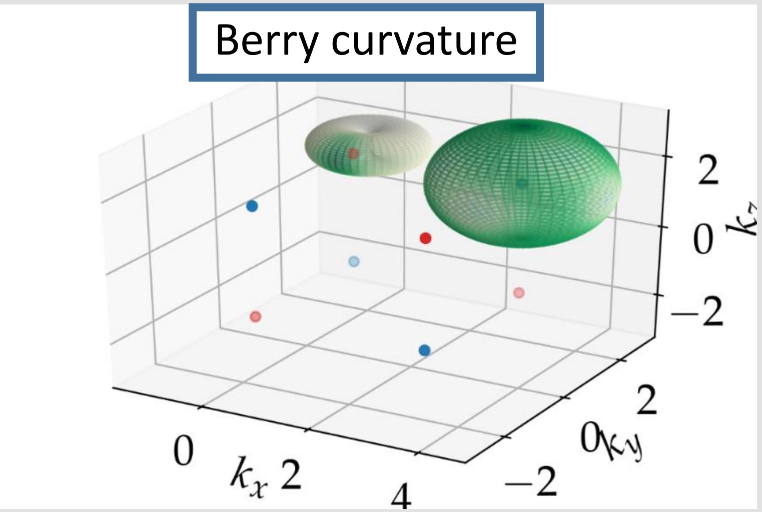
Nodal-line semimetal with cold atoms

Dubcek model, noninteracting...

Dubcek et al., PRL 114, 225301 (2015)

Coupled 2d Hofstadter layers

$J_y = K_x = K_z = 1$



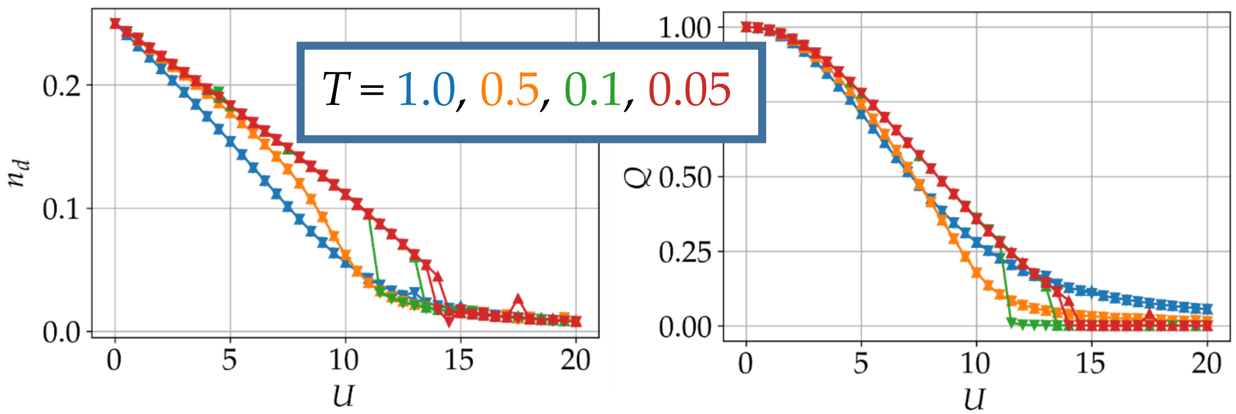
$$\hat{H}_{\mathrm{Dubcek}} = -\sum_j \left[(-1)^{x+y} K_x \hat{c}^\dagger_{j+\hat{x}} \hat{c}_j + J_y \hat{c}^\dagger_{j+\hat{y}} \hat{c}_j + (-1)^{x+y} K_z \hat{c}^\dagger_{j+\hat{z}} \hat{c}_j + \mathrm{h.c.}\right]$$

Suppressed double occupancy

$$n_d = \langle \hat{n}_{j\uparrow} \hat{n}_{j\downarrow} \rangle_j$$

Vanishing quasiparticle weight

$$Q = \frac{m}{m^*}$$



... and interacting

paramagnetic solutions of

$$\hat{H}_{\mathrm{int}} = \begin{pmatrix} \hat{H}_{\mathrm{Dubcek}} & 0 \\ 0 & \hat{H}_{\mathrm{Dubcek}} \end{pmatrix} + U \sum_j \hat{n}_{j\uparrow} \hat{n}_{j\downarrow}$$

3d topological states with dynamical mean-field theory (DMFT)

Amaricci et al., PRB 93, 235112 (2016)

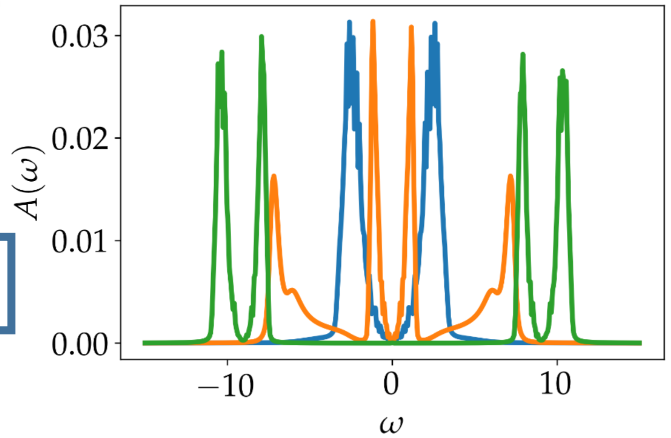
Irsigler et al., PRR 2, 013299 (2020)

-> momentum-independent selfenergy

$\Sigma(\omega, \boldsymbol{k}) = \Sigma(\omega)$

Density of states

U = 1, 10, 20



Topological invariants in the interacting case

$$C_{\rm IM} = \frac{\epsilon^{\mu\nu\rho}}{24\pi^2} \int dk \mathrm{Tr} \left[G\partial_\mu G^{-1}\right] \left[G\partial_\nu G^{-1}\right] \left[G\partial_\rho G^{-1}\right] \quad k = (i\omega_n, k_x, k_y)$$

Ishikawa and Matsuyama, Z. Phys. C 33, 41 (1986)

Semi-analytically: Zheng et al., PRB 99, 125138 (2019)

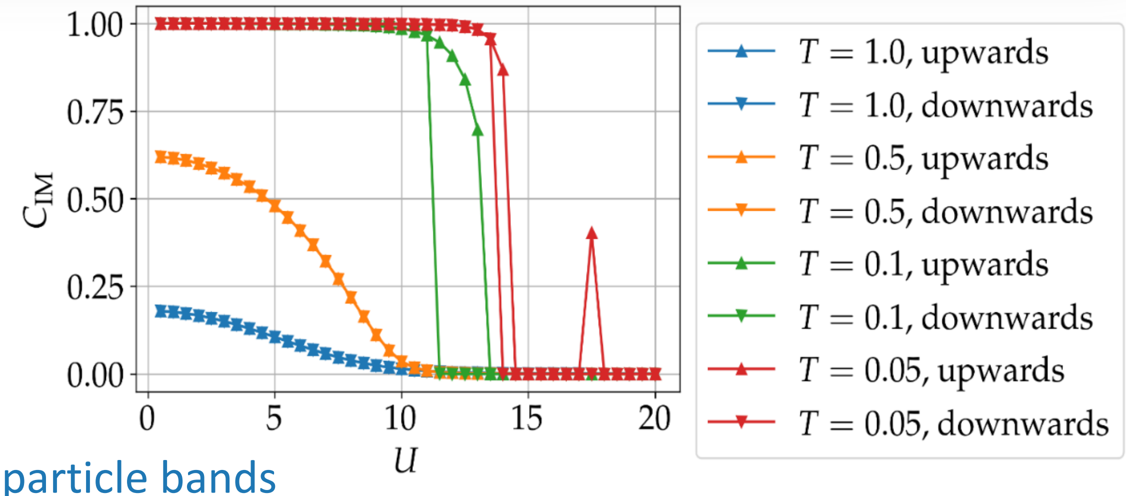
Single-particle Green's function (GF)

$$G = \left[i\omega_n - H(\boldsymbol{k}) - \Sigma(i\omega_n) + \mu\right]^{-1}$$

$$\partial_{k_0} G^{-1} = 1 - \partial_{k_0}\Sigma = 1 - \partial_{i\omega_n}\Sigma = 1 + i\partial_{\omega_n}\Sigma$$

$$\partial_{k_\nu} G^{-1} = \partial_{k_\nu} H(\boldsymbol{k}) = j_\nu$$

$$\partial_{\omega_n}\Sigma(i\omega_n) \approx \frac{\Sigma(i\omega_{n+1}) - \Sigma(i\omega_n)}{2\pi T}$$



Effective band structure

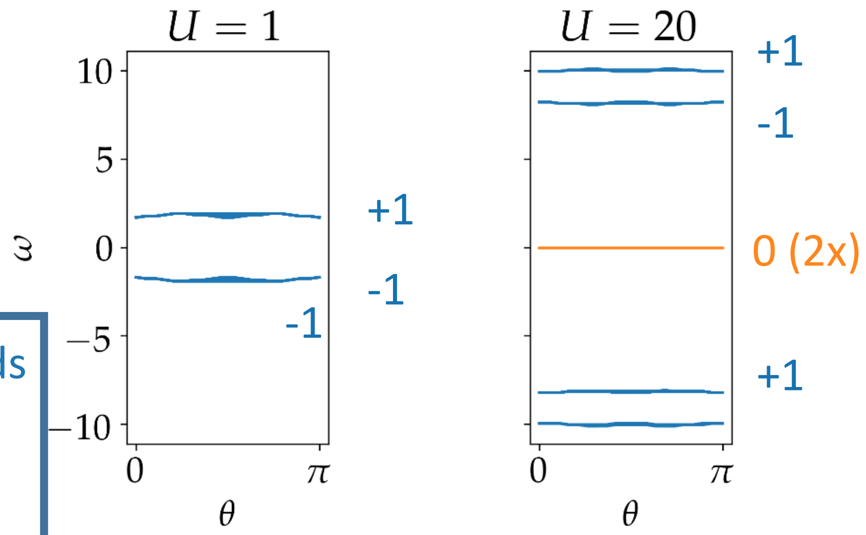
$$\mathrm{Ch}_A = \sum_{j=1}^{n} \frac{\varepsilon^{\alpha\beta}}{2\pi i} \int d^2k \langle \partial_\alpha \psi_j^A(\mathbf{k}) | \partial_\beta \psi_j^A(\mathbf{k}) \rangle - \sum_{j=1}^{n-m} \frac{\varepsilon^{\alpha\beta}}{2\pi i} \int d^2k \langle \partial_\alpha \phi_j^A(\mathbf{k}) | \partial_\beta \phi_j^A(\mathbf{k}) \rangle$$

Zheng and Hofstetter, PRB 97, 195434 (2018)

Poles of GF -> quasiparticle bands
Zeros of GF -> blind bands

Blind bands may also exhibit Chern number

Gurarie, PRB 83, 085426 (2011)



Conservation of: #quasiparticle bands
- #blind bands

Topological phase transition from energy bands only