Final Presentations

topics:

- Quantum Hydrodynamics of CFT and connection to Ads/CFT dynamics.
- Strange metal physics/Non-Fermi liquid physics and quantum criticality.

The presentations are 30 minute long plus 30 minute Q & A. Dates will be further discussed but tentatively on Tuesday, April 13.

You can pick up one of these two topics. Here are the lists of references and many other references therein. But you can include more references if needed for your presentation. Contact me if you want my opinions on references not listed here. Good luck with your presentations.

Group 1:

Viscosity in Strongly Interacting Quantum Field Theories from Black Hole Physics
P.Kovtun, D.T.Son, A.O.Starinets, Phys. Rev Lett. 94, 111601 (2005).

Viscosity, Black Holes, and Quantum Field Theory
D. T. Son, A. O. Starinets, Ann. Rev. Nucl. Part. Sci. 57, 95-118(2007) (ArXiV: 0704.0240).

Hydrodynamics of electrons in graphene
Andrew Lucas, Kin Chung Fong, Jour. Phys. Condensed Matter 30, 053051(2018) (ArXiV: 1710.08425)

Imaging viscous flow of the Dirac fluid in graphene, Mark Ku et al., Nature **583**, 537 (2020). ArXiV:1905.1079.

Group 2:

Senthil, Todadri (2008). "Critical Fermi surfaces and non-Fermi liquid metals". *Physical Review B*. **78** (3): 035103. arXiv:0803.4009.

Faulkner, Thomas; Polchinski, Joseph (2010). "Semi-Holographic Fermi Liquids". *Journal of High Energy Physics*. **2011** (6): 12. arXiv:1001.5049.

Strange metals as ersatz Fermi liquids, Dominic V. Else, T. Senthil, ArXiv:2010.10532.

Exactly Solvable Model of Correlated Lattice Electrons in Any Dimensions, Hatsugai, Yasuhiro; Kohmoto, Mahito, Jp. Phys. soc. 61, 2056 (1992).

Simple Exactly Solvable Models of non-Fermi Liquids, Lidsky, Hatsugai and M.Kohmoto, Phys. Rev. B 57, 1340 (1997).

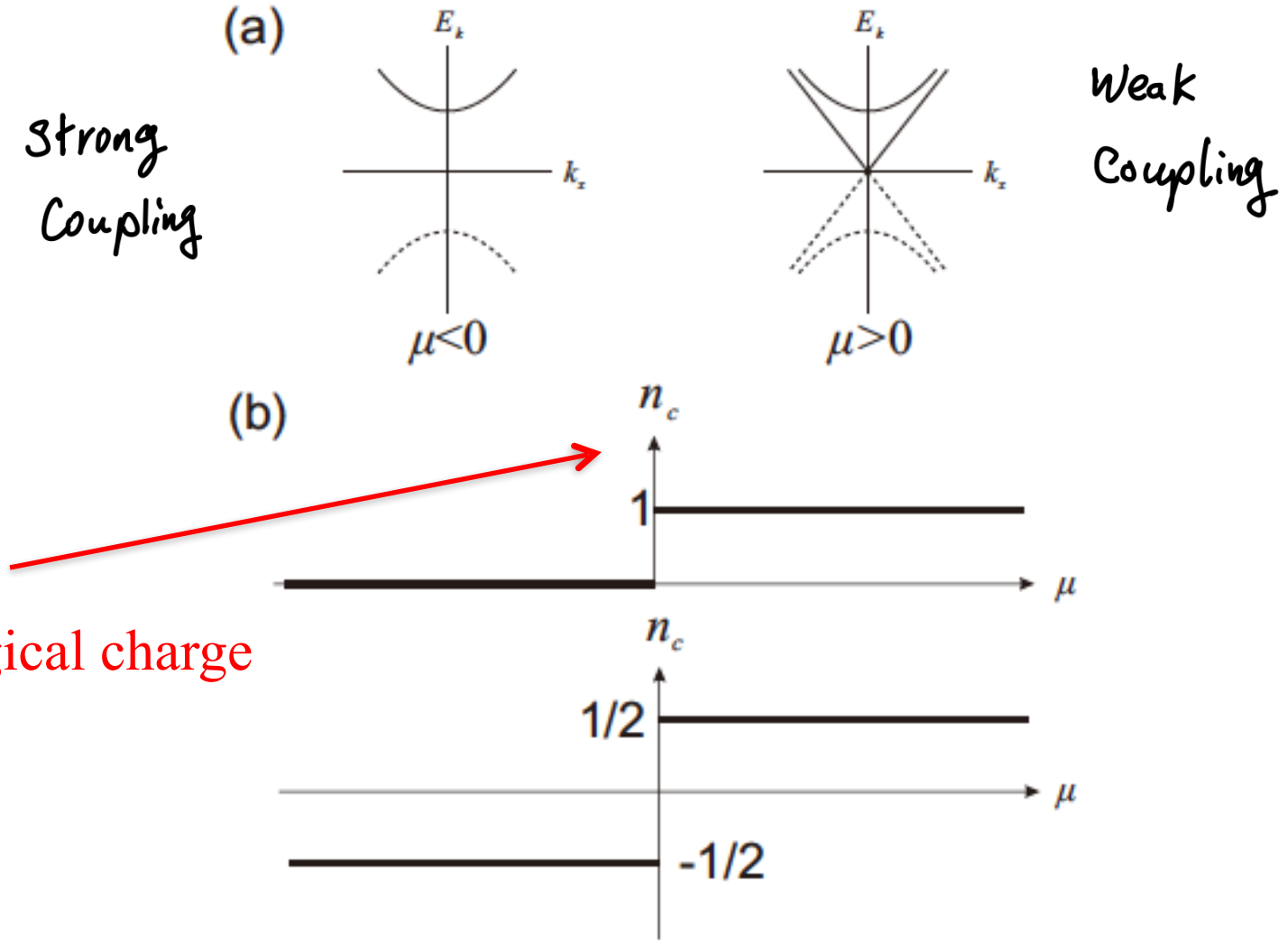
Phys525:
Quantum Condensed Matter Physics: Quantum Criticality
Basics, Dynamics and Topological criticality

Episode 21: QCPs in TSCs/TSFs

Edges and Global Topologies in TSFs
(Read and Green, 00; Kitaev, 2001; also Volovik, 88)

Pfaffian state / $p_x + ip_y$

0 → 1



Topological charge

Modern view 2008 on: global symmetries

Schnyder, Ryu, Furusaki, & Ludwig, Phys. Rev. B 78, 195125 (2008); Kitaev, 2009; Qi, Hughes, Raghu, and Zhang, 2009...

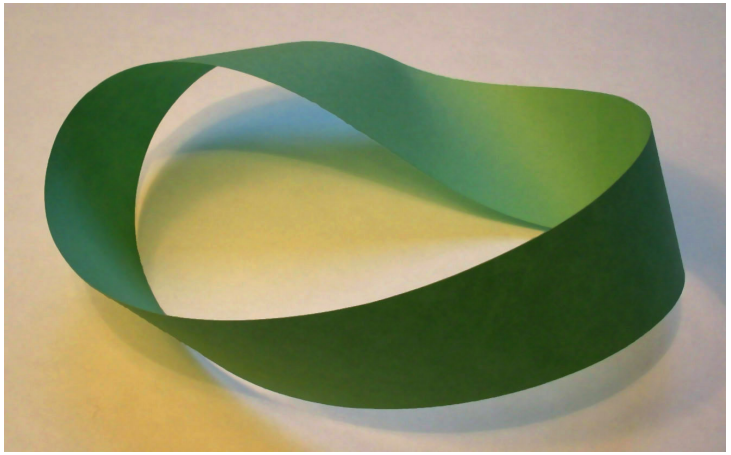
- Time reversal symmetric TSC/TSFs: 2D (z_2) and 3D (z).

Exp: ^{3}He B phase, $Cu_x Bi_2 Se_3$ (?), ...

- Time reversal symmetry breaking TSC/TSFs: 2D (c)

Exp: $Sr_2 Ru O_4$ (?), ^{6}Li, ^{40}K Cold Gases (!)

- All fully gapped with protected edges/helical surfaces.



Towards 3D Z2 TSF and Helical states:
Qi, Hughes, Raghu, Zhang, 2009; Sato, 2009…
Also Kitaev, 2009; Schnyder et al., 2008,

2D p+ip chiral (spinless) TSFs

$$\Delta(\vec{p}) = \vec{p}\cdot\vec{d}\,, \quad \vec{d} = \vec{e}_x + i\vec{e}_y$$

2D Z2 (Spinfull) TSFs

$$\hat{\Delta}_{\alpha\beta} = \left[i\sigma_y\left(\sigma_x p_x + \sigma_y p_y\right)\right]_{\alpha\beta}, \quad \alpha = \uparrow, \downarrow$$

3D Z2 (spinfull) TSFs (isomorphic to B phase of He)

$$\hat{\Delta}_{\alpha\beta} = \left[i\sigma_y\ \vec{\sigma}\cdot\vec{p}\ \right]_{\alpha\beta}, \quad \alpha = \uparrow, \downarrow$$

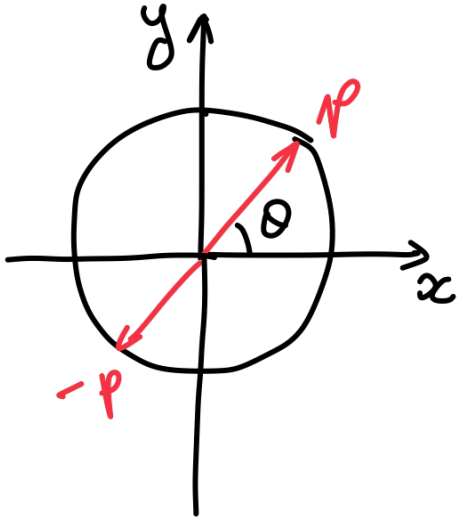
Topological transitions in SFs with/without TRS
(Yang, Jiang and FZ, Phys. Rev. B, 2019)

Two Remarks

↙ 2D TSC ($\mathbb{Z}_2$)

1) $\hat{\Delta}_{\alpha\beta} = i\sigma_y (\sigma_x p_x + \sigma_y p_y)$

$\alpha, \beta = \uparrow, \downarrow \longrightarrow \begin{bmatrix} p_x + i p_y & 0 \\ 0 & p_x - i p_y \end{bmatrix}$



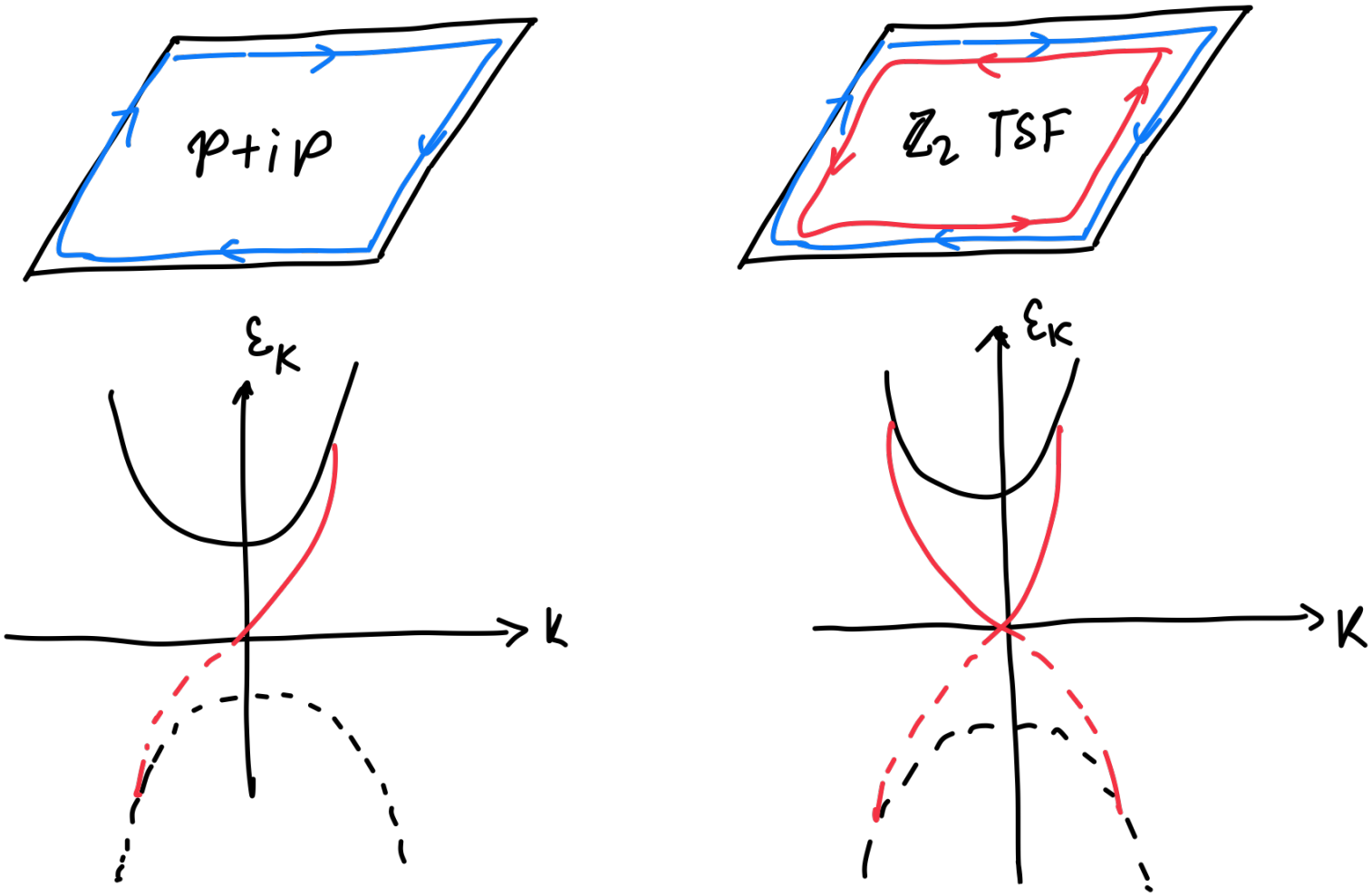
2) $\hat{\Delta} = \sum_{i,j=}^{x,y,z} i\sigma_y \sigma_i p_j O_{ij}$,

↙ General Structure p_wave Pairing

$O_{ij} = 3 \times 3$ Complex matrix

$i, j = x, y, z$

Cartoon Picture of edge / boundary states



Surface states of TSC (3D)

$B < B_c$ $B > B_c$