Suggestions for Final Projects – Physics 682

- Weyl semimetals. What are they? Discuss the fact that Weyl points have a chirality, and relate to Berry fluxes and Chern numbers [1, 2, 3, 4, 5, 6]. (Note that [1] is a generally nice review of topological materials.)

- Resta’s position operator and localization measure [7, 8]. Discuss how, in the single-particle case, it is related to the spread of the Wannier functions. Also tie into the theory of Souza and co-workers on polarization fluctuations [9].

- Resta’s paper on the Chern number and orbital magnetization as local quantities [10].

- Haldane’s paper on the anomalous Hall conductivity as a Fermi surface property [11].

- Topology of Fermi surfaces, Weyl nodes, and Fermi arcs [12, 13].

- Theory of orbital magnetization (which I will only cover lightly in class) [14, 15, 16, 17, 18, 10, 19].

- Theory of axion magnetoelectric coupling and relation to surface anomalous Hall conductivity [20, 21, 22, 23].

- Semiclassical theory of Niu and co-workers, as an alternative derivation of the theory of polarization, orbital magnetization, magnetoelectric coupling, etc. [24, 25, 26, 27].

- The above is a big subject. A narrower topic could be the density-of-states correction due to Berry curvature discussed by Niu and co-workers, and its consequences [25].

- Quantum anomalous Hall or other topological phases in
  - Cold-atom lattices
  - Photonic crystals
  - Floquet systems

- Berry phases in Josephson junction circuits [28].

- Original Thouless and Niu papers on adiabatic charge transport [29, 30, 31].

- Anomalous Hall conductivity: intrinsic and extrinsic contributions [32].

- Discuss some specific experimentally realized or theoretically proposed topological material. (Especially if there is a tight-binding model that captures its qualitative behavior that you can explore with PythTB.)
References


