

## Problem Set 12

### Theoretical Solid State Physics (SoSe2017)

No due date

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This problem deals with 3D topological insulators according to: Liang Fu, C.L. Kane, E.J. Mele, Topological insulators in three dimensions, Phys. Rev. Lett. **98**, 106803 (2007). Read this paper carefully and discuss the following questions:

#### Problem 1: Gauge invariance

It is stated in the paper that the  $\pi_a$  are not gauge invariant, although products such as  $\pi_1\pi_2$  are. Give an explicit example of a gauge transformation which illustrates this point.

#### Problem 2: Weak and strong topological insulators

- (a) Explain the concept of a time reversal invariant momentum.
- (b) Explain how Fig. 2(b) is constructed.
- (c) Find the analog of Fig. 2(b) for the (100) surface.
- (d) Explain the notions of weak and strong topological insulators.

#### Problem 3: Model Hamiltonian

- (a) Derive the spectrum for the model Hamiltonian in Eq. (6).
- (b) Give the gapless surface Hamiltonian resulting from a sign change in  $m^z = m_z(z)$ , focusing on the vicinity of the  $X^z$  point in the Brillouin zone.