Problem Set 9
Theoretical Solid State Physics (SoSe2017)

Due: Due Thursday, June 22, 2017; **at the beginning of class**

Problem 1: Low energy theory of the Su Schrieffer Heeger (SSH) model

(a) In the lecture, we discussed the low energy theory of the SSH model. We sketched the derivation for the uniform hopping term and simply stated the result for the staggered hopping term. Complete the derivation explicitly.

(b) Same as (a), but for the staggered on-site energy as discussed in connection with the Goldstone-Wilczek current.

(c) Show that next nearest-neighbor hopping gives a term which violates the chiral and particle-hole symmetries of the model.

Problem 2: Spinful SSH model

In the lecture, we discussed the fractional charge supported by a domain wall in the SSH model. Discuss how this result gets modified when spin is taken into account. Show that even though there is no longer a fractional charge, there is still an anomalous relation between spin and charge.

Problem 3: Peierls instability

In the class we argued that for a half-filled lattice, the electronic energy gain due to dimerization is larger than the elastic energy which is incurred by the lattice deformation. Make this argument more precise by explicitly computing the electronic energy gain due to dimerizing the hopping compared to a uniform tight binding chain. This can be done by simply computing the energy of the filled lower band of the dimerized chain and subtract from this the energy of the half filled band for a non-dimerized chain.

If necessary, you can work to leading nontrivial order for a small dimerization gap.