University of California at San Diego – Department of Physics – Prof. John McGreevy

# Physics 211C (239) Quantum phases of matter, Spring 2021

## End-of-Term Project

**Deadlines:** Topic choices are due by week 8.
Papers are due on Thursday, June 10, 2021.

The end of term project for Physics 211C (239) will be a *short* paper explaining a nugget of truthy goodness about topology in physics or something related.

Your goal in deciding what to say should be to try to save the rest of us from having to read the papers. Give some context, say what the crucial point is, say what the implications are.

I plan to post all the papers on the course webpage, so we can all read them. Reading the other papers is part of the assignment.

The paper should be approximately 2 pages in a TeX format for which I'll provide a template. You may include arbitrarily many figures, which need not count toward the page limit. The page limit is not sharp, but keep in mind that I will post all the papers to the course webpage and everyone should read everyone else's paper: you don't want to torture your classmates.

I would prefer a level of detail and technical sophistication comparable to that of my lecture notes. Anything we've covered may be assumed known (though a reference to a specific section of the notes might be helpful). Your paper may contain as much detail as you like, but complicated technical details must be put in a box and labelled, so that the reader may read only the label on the box without losing the narrative thread. Examples of boxes into which you may put details are footnotes, appendices and actual boxes. There is no page limit on appendices.

Please tell me (by email) what topic you plan to study as soon as possible, but not later than week 8. Below are some topic suggestions, involving wildly varying levels of difficulty. The list is certainly not in any sense exhaustive, and I will keep adding to it as I think of more topics. Creative topics are encouraged. As topics are claimed, I will mark them on this document.

## Submission instructions:

I will post an assignment on Canvas by which you can submit your paper. It would help me if you name the file in the following format:

`2021S-211C-YourLastName-YourFirstName.pdf`

## Some topic suggestions:

Anything in blue below is a link to the literature.

Lists of and links to references below are intended as entry points to the literature, and not as complete citations of all good work on the subject. For each paper you should of course always also read all papers that cite it[1][2], as well as all of the papers to which it refers. The order below is not meaningful, though I've tried to group related topics together. I will keep adding to this file as I think of more possible topics.

1. An interesting exception to the classification of defects of ordered phases by homotopy groups. [Start here]
2. Symmetry-enriched topological phases in 2+1 dimensions [Start (and end) here and remember that the paper is supposed to be two (2) pages long]
3. Crystalline topological insulators [Start here maybe]
4. Crystalline SPTs [Start here or here. See also this paper for a perhaps better method] Claimed by Arghadip Koner.
5. Quasicrystalline SPTs [Start here or the talk by Dominic Else here.]
6. What anomaly protects 3+1d topological semimetals? What can they do at strong coupling? [Start here and here] Claimed by Shubham Parashar.
7. Extrinsic defects in topological phases and their statistics [Start here and here] [Claimed by Wei-Ting Kuo]
8. Quantum Hall ferromagnets and skyrmions [Start with sections 1.10-1.12 here]
9. Unkillable non-chiral edge modes [here] Claimed by Ahmed Akhtar.
10. A physical interpretation of the Atiyah-Hirzebruch spectral sequence in terms of decorating defects with SPTs [here and here and here] Claimed by Hung-Hwa Lin.

[1] Am I exaggerating?

[2] For some of the papers listed below, a relatively complete citation list can be found using Spires: http://inspirehep.net.

11. Non-linear sigma model description of topological phases [start here] Claimed by Xiang Li.

12. Anomaly matching in symmetry-broken phases, for discrete symmetries: [here], and/or for continuous symmetries: [here and maybe here and maybe here] Claimed by Dachuan Lu.

13. Anomalies of '(-1)-form symmetries' [here and here. See also this talk.] Claimed by Zhengdi Sun.

14. SPT-LSM theorems: when any short-range entangled groundstate is guaranteed to be a non-trivial SPT. [start here] Claimed by Meng Zeng.

15. Non-abelian nodal-line defects in momentum space of free fermion systems (suggested by Tarun Grover) [start here] Claimed by Hongrui Li.

16. Topological superconductors in $D = 3 + 1$ from axion electrodynamics [here and here]

17. Are non-Fermi liquids stable to Cooper pairing? [start here]

18. The Moore-Read state and CFT. [start here] Claimed by Zipei Zhang.

19. String-net condensation [here and here] Claimed by Wanda Hu.

20. Supersymmetry-protected phases of matter? [start here]

21. Can topological field theories arising from twisted supersymmetric field theories be effective field theories for quantum phases of matter? [start here. Warning: the answer is widely believed to be 'no'.]

22. A physical system whose groundstates compute $\pi_{q\geq 2}$ of the space it's living on? [here, here and most recently and concretely here. Also look for the discussion of Ref 31 of here. Warning: I am really not sure if these models answer the question above.]

23. Anything else we don't get to in lecture that's on the syllabus, or any other related topic.