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

Physics 230 Quantum phases of matter, Spring 2024

End-of-Term Project

Deadlines: Topic choices are due by week 8.
Papers are due on Thursday, June 13, 2024.

The end of term project for Physics 230 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:

`2024S-230-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. 2+1d topological order, 1+1-dimensional conformal field theory and category theory [One place to start is this recent paper]. Claimed by Eric Yang.
2. IQHE on the sphere as a regulator for 2+1d CFT [Start here]. Claimed by Haoran Sun.
3. Gapped boundaries for topological orders in 3+1 dimensions [here]. Claimed by Deepak Aryal.
4. What happens when Cooper pairs of composite fermions form a boson IQH state? Daughter states of incompressible quantum Hall states with even denominators [Start with these new papers, here and here].
5. An interesting exception to the classification of defects of ordered phases by homotopy groups. [Start here]
6. 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]
7. Crystalline topological insulators [Start here maybe]
8. Quasicrystalline SPTs [Start here or the talk by Dominic Else here.]
9. Quantum Hall ferromagnets and skyrmions [Start with sections 1.10-1.12 here]
10. A physical interpretation of the Atiyah-Hirzebruch spectral sequence in terms of decorating defects with SPTs [here and here and here]

[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. Topological superconductors in $D = 3 + 1$ from axion electrodynamics [here and here] Claimed by Shuhan Zhang.

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

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

14. 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'.]

15. 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.]

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