

Instead of a final exam, this course will have a 30-minute “journal club talk”, with 20 minutes of presentation and 10 minutes of questions and discussion. The subject matter can be any topic in physics which is related to Phases of Condensed Matter. Since many interesting phenomena are a manifestation of spontaneous symmetry breaking, you have a lot of freedom in your choice of topic, but I need to approve it before you begin.

Your presentation should not duplicate an presentation that you have prepared for another course, nor should it duplicate your research work. The purpose is to give you something fresh to prepare, related to the topic of the course.

Some hints: look at the back of the current *Reviews of Modern Physics* where you will find a listing of topics that have been reviewed in the last ten years or so. These are always a good starting point. Similarly for journals such as *Advances in Physics* and *Reports of Progress in Physics*. Use internet keyword searches on <http://xxx.lanl.gov> archives and search engines such as Google.

In some cases I may be able to give you some advice about the literature, but I would prefer if you search on your own – you may find something completely unexpected that I don’t know about. In other cases I will be as clueless, or more clueless, than you.

Don't be restricted by the topics that we addressed in class. We didn't have time to cover the huge variety of emergent states of matter that arise in the real world. Here is a partial list of subject areas to prompt your thinking:

Exotic superfluidity

- Superfluid phenomena in Helium 3
- Superfluid phenomena in neutron stars
- Superfluid phenomena in nuclei

Exotic superconductivity

- Heavy fermion superconductors
- Unconventional pairing states in cuprate superconductors
- Unconventional pairing states in non-cuprate superconductors
- Iron-based superconductors
- Sr₂RuO₄ superconductivity
- Fluctuation effects in superconductors
- Vortex liquids, glasses and other aspects of the magnetic phase diagram of the cuprates

Liquid crystals

- Analogies between liquid crystals and superconductors
- Smectic phases in liquid crystals

Dynamics of topological defects in liquid crystals
Phase transition kinetics in liquid crystals
Blue phases

Emergent states of matter

Ordered phases in optical lattices (superfluid, Mott insulators, ...)
Quantum hall states of rapidly rotating BECs
Magnetic states of condensed matter (ferromagnets, antiferromagnets, spin glass, ...)
Disordered states of matter (Griffiths phases, random field Ising models, localization, ...)

Nonequilibrium systems

Collective behaviour in animals (herding, flocking, schooling, ...)
Traffic flow (shocks, phase diagram, pedestrians ...)
Reaction-diffusion patterns
Convection effects in fluids
Bioconvection
Emergence of network properties (WWW, metabolic networks, ...)
Evolution
Synchronisation of coupled oscillators

Detailed Directions

The purpose of your presentation is to explain why the problem is interesting, what has been done, and what are the conclusions. Don't go into unnecessary technical details. The amount that you personally chose to work through the technical details is up to you; my goal is that you understand the broad issues. Hopefully you will find your topic sufficiently interesting that you will wish to delve deeper (and perhaps even think for yourself about the subject). You should aim your talk at someone who is like you were before you started thinking about your topic. Every talk must include some sort of discussion of experiment or observations: these can either be the focus of the talk, or at least must be mentioned specifically with regard to how they demonstrate, provide counter-examples to, or otherwise inform theory.

There are two basic suggested formats: a) a "library talk" where you research an area, and try to synthesize the essence of what is interesting; b) a "journal club talk" where you pick a single classic or recent paper in the field and tell us enough about it so that we understand the main point. You are allowed to pick papers that you don't like, and being critical is encouraged!

Your essay must be presented using the computer driven projector, i.e. be written in power point or equivalent presentation software. A pdf file of the presentation should be turned in after the talk.