

Physics 525 Advanced Condensed Matter Physics:

Emergent phenomena in Condensed Matter Physics

Instructor: Prof. Fei Zhou, Tues, Thur 12:30-2:00pm, Buchanan D228

Course website

Part I: General Discussions on Emergent phenomena

- 1) Emergent space-time symmetries: Galilean symmetry (i.e. non-relativistic), Lorentz symmetry (i.e. relativistic) in quantum crystals
- 2) Emergent particles and/or fractionalized particles
- 3) Emergent scale symmetry and/or conformal symmetry in strong coupling states
- 4) Other emergent symmetries
- 5)* General ideas of Effective field theory (EFT) approaches to emergent phenomena in strongly interacting systems

Part II: Emergent symmetries in Topological matter

- 1) Topological states of free fermions: ten-fold way classifications
- 2) Emergent symmetries/pseudo symmetries vs fundamental symmetries in topological states
- 3)**EFT approaches to ten-fold way topological states
- 4) Topological surface dynamics and symmetry breaking phenomena

Part III: More recent applications: TQCPs in Quantum topological Matter

- 1) Beyond-Landau-paradigm quantum phase transitions driven by global topologies
- 2) QCPs in Topological superfluids and superconductors
- 3) Bulk signatures of QCPs and what happens to surface states
- 4) Strong coupling topological QCPs
- 5) Emergent SUSY in topological QCPs and the order of phase transitions

Part IV: Classification of Strongly Interacting topological phases

- 1) What happens in 1D topological states?
- 2) What happens in 3D topological states—-emergent surface anyons and topological order

General References:

- 1) *Quantum Phase Transitions*, Subir Sachdev (Cambridge University Press, 2nd ed., 2011).
- 2) *An introduction to Quantum field theory*, Michael Peskin and Daniel Schroeder (CRC press, Taylor and Francis, 1995)

Important:

- 1) This course is intended for discussions on modern issues of emergent symmetries and its applications in various condensed matter/man-body systems. Although there are no official pre-requisites, Phys 526 (QFT I) is highly recommended. However, the level of the course can be further fine tuned for the attending audience.
- 2) Topics here are tentative and can be subject to further revisions. Part I.5)*, Part II.3)** are currently listed here but are optional depending on the level of the audience. In our first meeting of the class, we will have more discussions on the topics and perhaps finalize then. You are also welcome to email me about what your suggestions.
- 3) Apart from the two general references listed above, other more specialized references (review articles and research papers) will be provided as the course progresses.
- 4) Some of the lectures will be devoted to open discussions on selected topics including informal student seminars. Student Assessment and evaluation will be discussed and finalized after hearing your feedbacks during the first meeting of the class.
- 5) We will meet every Tuesday/Thursday 1230pm-2pm.

(This page may be further updated/revised)