

Course Syllabus for PY 896, Advanced Topic in Condensed Matter Physics: Many-Body Physics in Cold Atoms Systems

Instructor: Anatoli Polkovnikov

Overview: The course focuses on many-body phenomena in systems of cold atoms, both fermionic and bosonic. The emphasis is given to similarities and differences with conventional condensed matter systems as well as to recent experimental and theoretical advances in this field. The course starts from the overview of basic things like atomic interactions and resonant scattering, laser and evaporative cooling technique, Bose-Einstein condensation in weakly interacting systems. Then we move to more advanced topics like 1D Bose and Fermi systems, BEC-BCS crossover, rotating condensates, and quantum phase transitions in optical lattices. If there is interest and time permitted we can cover additional topics like entanglement and quantum information in these systems, fractionalization, dynamics far from equilibrium, etc. This course is not very technical rather the emphasis is given on the ideas and principles behind various phenomena. Since this is a seminar course, presentations and discussions by students are very encouraged.

Prerequisites: Graduate level quantum mechanics including second quantization, statistical physics. Solid-State Physics I (PY 741) would be helpful but not required.

Requirements: There will be no exam in this course. Instead there will be student presentations on advanced topics not covered in the class. There will be also homework assignments.

Recommended literature:

- C.J. Pethick and H. Smith, Bose-Einstein Condensation in Dilute Gases, Cambridge (2002).
- L. Pitaevskii and S. Stringari, Bose-Einstein Condensation, Oxford (2003).
- A. J. Leggett, Bose-Einstein condensation in the alkali gases: Some fundamental concepts, Rev. Mod. Phys. **73**, 207 (2001) (Erratum *ibid* **75**, 1083 (2003)).
- A. L. Fetter and J. D. Walecka, Quantum Theory of Many-Particle Systems, Dover (2003).
- J. W. Negele and H. Orland, Quantum Many-Particle Systems, Perseus Books Group (1998).
- S. Sachdev, Quantum Phase Transitions, Cambridge (1999).
- T. Giamarchi, Quantum Physics in One Dimension, Oxford (2004).
- P. M. Chaikin and T. C. Lubensky, Principles of Condensed Matter Physics, Cambridge (1995).