01.07.2019

Bar-Ilan University

Advanced Condensed Matter
86-823-01

Transport Phenomena and Phase Transitions in Interacting Quantum liquids

Lecturer: Prof. Efrat Shimshoni

Course type: Lecture

Date: 2019-2020 **semester:** B **weekly hours:** 4L

Details of subjects to be covered:

1) Linear Response Theory
   - 1.1 Review: classical theory for electric and thermal conduction in metals; screening and the Thomas-Fermi approximation
   - 1.2 Response to electromagnetic fields: a microscopic approach to quantum many-body systems
   - 1.3 The fluctuation-dissipation theorem and the Kubo formula; interpretation of experimental probes: dielectric function, conductivity, dynamical structure factor and noise
   - 1.4 Causality and conservation laws as encoded in response functions
2) Interacting Particles and Collective Phenomena
   - 2.1 Interacting electrons in metals; the plasmon mode; strangeness of 1d: Tomonaga-Luttinger liquid, spin-charge separation and Wigner crystallization
   - 2.2 Interacting Boson systems: symmetry breaking and superfluidity/superconductivity; the Meisner effect and the Anderson-Higgs mechanism
   - 2.3 Superfluidity in 2d: topological order and the Kosterlitz-Thouless transition
   - 2.4 Charge-flux duality and the superconductor-insulator transition
   - 2.5 Phase-slips in superconducting wires
3) Quantum Hall Liquids
   - 3.1 The integer quantum Hall effect: 2d electron gas in a strong magnetic field
   - 3.2 The fractional quantum Hall liquid: flux attachment and statistics transmutations
   - 3.3 Quantum Hall edge states
   - 3.4 Quantum Hall effect in graphene and topological insulators

Pre-requisite:

Advanced Quantum Mechanics, Advanced Statistical Mechanics

Course mandatories and Grading:

Homework assignments 100%

Recommended Bibliography:

Linear Response Theory:

1) P. Nozieres and D. Pines, *Theory of Quantum Liquids, Vol. 1&2* (Advanced Book Classics, Addison-Wesley, 1966).

Interacting Particles and Collective Phenomena:

1) A. Altland and B. Simons, *Condensed Matter Field Theory* (Cambridge University Press, 2006).
2) N. Nagaosa, *Quantum Field Theory in Condensed Matter Physics* (Springer-Verlag, 1999).
3) T. Giamarchi, *Quantum Physics in One-Dimension* (Oxford University Press, 2004).

Quantum Hall Liquids:

1) R. E. Prange, S. M. Girvin and K. von Klitzing, *The Quantum Hall Effect*, (Springer-Verlag).
2) S. Das Sarma and A. Pinczuk, *Perspectives in Quantum Hall Effects* (John Wiley & Sons, 1997).