Harvard University Physics 268r Spring 2012

Special Topics in Condensed Matter Physics. Quantum Many- Body Systems

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Course Meetings TTh, 11:30 - 1:00 in Lyman 250

Course Grade Grading will be based on class participation (10%), homeworks (50%), and final projects (40%).

Office hours to be arranged

This course will review field theory methods and Greens function approach to quantum many-body systems. Subjects discussed will include interacting electron and phonon systems, magnetism and superconductivity, systems with disorder, low dimensional systems, systems of ultracold atoms, nonequilibrium phenomena. Prerequisite: Applied Physics 295a or equivalent.

Tentative Outline of Lectures

1. Introduction to Green's functions. Schroedinger equation approach. Lippman-Schwinger equation.
2. Path integral approach to quantum mechanics.
3. Path integral approach to statistical physics. Variational method. Phase transitions in arrays of shunted Josephson junctions. Polarons.
4. The partition function for Many-particle system. Functional integrals for Bose particles.
5. Functional integral for Fermi particles. Random phase approximation for electron systems.
6. Analytic properties of Green's functions. Linear response theory. Relation to experiments: STM, ARPES, RSXS.
7. Electron-phonon interactions. Superconductivity.
8. Non-equilibrium systems. Keldysh formalism for bosons.
9. Non-equilibrium systems. Keldysh formalism for fermions.
10. Fermi edge singulatiry problem.
11. Disordered fermionic systems.

Useful books

- *Quantum mechanics and path integrals*, R.P. Feynman and A.R. Hibbs, emended by D.F. Styer, Dover publications (2005)
- *Condensed matter field theory*, A. Altland and B. Simons, Cambridge University Press (2010)
- *Quantum many-particle systems*, J.W. Negele and H. Orland, Addison-Wesley publishing company (1988)
- *Theory of superconductivity*, J. R. Schrieffer, Addison-Wesley publishing company (1988)
- *Quantum theory of many-body systems. Techniques and applications*, A.M. Zagoskin, Springer (1998)
- *Green's functions for solid state physicists*, S. Doniach, E.H. Sondheimer, Imerial college press (1999)
- *Many-particle physics*, G.D. Mahan, Plenum press, (1990)
- *Many-body quantum theory in condensed matter physics*, H. Bruus and K. Flensberg, Oxford University press (2010)
- *Quantum field theory in condensed matter physics*, A. Tsvelik, Cambridge University Press (1996)
- *Field theory of non-equilibrium systems*, A. Kamenev, Cambridge University Press, (2011)
- *Functional integrals and collective excitations*, V.N. Popov, Cambridge University Press (1990)
- *Functional integrals in quantum field theory and statistical physics*, V.N. Popov, D. Reidel publishing company (1983)
- *Inhomogeneous superconductors. Granular and quantum efects.*, E. Simanek, Oxfod University press (1994)

- *Quantum physics in one dimension*, T. Giamarchi, Oxford science publishing, Clarendon press, Oxford (2004)
- *Methods of quantum field theory in statistical physics*, A.A. Abrikosov, L. P. Gorkov, I.E. Dzyaloshinski, Dover publications (1963)
- *Quantum transport theory*, J. Rammer, Perseus books (1998)