Physics 8806 (Fall 2018)

Introduction to Condensed Matter Physics

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The goal of this two-semester course is to provide a modern introduction to the diverse field of condensed matter physics, for both theorists and experimentalists.

The 1st semester (2018 Fall) covers three aspects:
(1) elementary excitations and how to measure them;
(2) optical properties;
(3) transport properties.

The 2nd semester (2019 Spring) will cover three topics:
(1) magnetism;
(2) superconductivity;
(3) mesoscopic physics.

Instructor: Assistant Professor **Yuan-Ming Lu**

Contact Information:

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Office Hours: Tuesday 8-9AM

Course Location: 2015 Physics Research Building

Course Time: Tuesday and Thursday 9:35AM - 10:55AM

Pre-requisites (recommended):

- Quantum Mechanics 2 (Physics 7502), "Modern Quantum Mechanics" by Sakurai or "Principles of Quantum Mechanics" by Shankar or similar textbooks
- Classical and Statistical Physics II (Physics 7602), Landau-Lifschitz or Pathria-Beale or "Statistical Physics of Particles" by Mehran Kardar or similar textbooks

Textbook:

We do not have a specific textbook for the 2nd semester, but lecture notes will be provided.

Main References:

- *Condensed Matter Physics* by Michael Marder (2nd edition, Wiley, 2015)
- *Solid-State Physics: Introduction to the Theory* by J. Patterson and B. C. Bailey (2nd edition, Springer, 2010)
- *Transport in Nanostructures* by David K. Ferry, Stephen M. Goodnick and Jonathan Bird (2nd edition, Cambridge University Press, 2009)
- *Quantum Theory of the Solid State: An Introduction* by Lev Kantorovich (Springer, 2004)
- *Superconductivity, Superfluids, and Condensates* by James F. Annett (Oxford University Press, 2004)
- *Magnetism in Condensed Matter* by Stephen Blundell (Oxford University Press, 2001)

Other References:

- *Solid State Physics* by Neil Ashcroft and David Mermin (1st edition, Cengage Learning, 1976)
- *Introduction to Superconductivity* by Michael Tinkham (2nd edition, McGraw-Hill, 1996)

- *Introduction to Mesoscopic Physics* by Joseph Imry (Oxford University Press, 1997)
- *Many-Particle Physics* by Gerald Mahan (3rd edition, Springer, 2000)
- A Quantum Approach to Condensed Matter Physics by Philip L. Taylor and Olle Heinonen (Cambridge University Press, 2002)
- *Introduction to Solid State Physics* by Charles Kittel (8th Edition, Wiley, 2004)
- *Introduction To Condensed Matter Physics* by Duan Feng and Guojun Jin (World Scientific, 2005)
- *Optical Properties of Solids* by Mark Fox (2nd Edition, Oxford University Press, 2010)
- *Fundamentals of Semiconductors: Physics and Materials Properties* by Peter Yu and Manuel Cardona (4th edition, Springer, 2010)
- *Advanced Solid State Physics* by Philip Phillips (2nd edition, Cambridge University Press, 2012)
- *The Oxford Solid State Basics* by Steven H. Simon (1st Edition, Oxford University Press, 2013)

Assignments:
Homework will be assigned roughly every week. Handout on Thuesday, due next Tuesday. Since there is no TA, students will be grading each other's homework.

Term paper:
A term paper in PRL format (not exceeding 4 pages) should be submitted. A number of topics will be suggested in Appendix **??**. Different students should choose different topics. Each student will give an oral presentation of about 12 mins (+3 mins questions).

Grading:
Homework $\longrightarrow$ 70%; Term paper $\longrightarrow$ 30%.

Contents (may evolve with time):

- Magnetic moments
- Crystal fields
- Magnetic resonances
- Magnetic interactions
- Magnetic orders and broken symmetry
- Magnetism in metals
- Magnetism in low dimensionality

- Bose-Einstein condensate and superfluid helium-4
- Phenomenology of superconductivity
- Ginzburg-Landau theory
- Microscopic BCS theory
- Type-II superconductors
- Josephson effects
- Helium-3 and unconventional superconductors
- Quantum confined systems
- Transmission in nanostructures
- Ballistic transport in quantum wires
- Quantum dots
- Weakly disordered systems