

Physics 7450: Syllabus

Course information:

- **Instructor:** [Professor Leo Radzihovsky](#)
 - **Office:** Duane Physics F623 (Gamow Tower)
 - **Phone:** 303-492-5436
 - **Email:** radzihov@colorado.edu (best way to reach me)
 - **Office Hours:** Friday 3-4pm (or by appointment)
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- **Class meets:** Tuesday, Thursday 2 - 3:15 pm, in Duane Physics, G2B41
 - **Home page:** <http://www.colorado.edu/physics/phys7450/>
 - **Graders:** Yi-Ping Huang, yiping.huang@colorado.edu, office F229
 - **Main Texts:** by Jeno Solyom, Springer
 - ["Fundamentals of the Physics of Solids I"](#), Electronic Properties
 - ["Fundamentals of the Physics of Solids II"](#), Electronic Properties
 - ["Fundamentals of the Physics of Solids III"](#), Normal, Broken-Symmetry, and Correlated Systems
 - **Other suggested reading:**
 - *Quantum Field Theory of Many-body Systems*, by Xiao-Gang Wen
 - *Principles of Condensed Matter Physics*, by P. M. Chaikin and T. C. Lubensky
 - *Many-Particle Physics*, by G. Mahan
 - *Quantum Theory of Many-Particle Systems*, by A. Fetter and J. Walecka
 - *Field Theories of Condensed Matter Systems*, by E. Fradkin
 - **Course description:** Advanced condensed matter physics with focus on microscopics and phenomenology of crystalline solids
 - **Prerequisites:** Graduate Quantum Mechanics 1 and 2, E&M, Statistical Mechanics, Solids 1, and interest and desire to learn
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- **First day of class:** Tuesday, January 12, 2015
 - **Homework (70%):** roughly every one or two weeks
 - **Research paper (30%):** due on the last day of class, Thursday, April 30, 2015
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Course description:

This is an advanced graduate course on macroscopic properties of solids with focus on phenomena where interactions and fluctuations play an important role. Utilizing methods of many-body physics and path-integrals, we will cover a range of advanced topics that will include elasticity and phonons, superfluidity, magnetism, Fermi liquids, superconductivity and quantum Hall effect.

Course outline:

- **Review and Introduction**
 - scope and states of condensed matter physics: "More is Different"
 - band structure: insulators and conductors
 - thermodynamics
 - transport

- **Elasticity, fluctuations and thermodynamics of crystals**
 - elasticity of Goldstone modes
 - quantum field theory of lattice vibrations: phonons
 - thermodynamics of phonons
 - thermal expansion and melting
 - correlation functions and x-ray scattering
 - Hohenberg-Mermin-Wagner theorem
 - **Bosonic matter**
 - Bose gases thermodynamics and BEC
 - Bogoliubov theory of a superfluid
 - Lee-Huang-Yang thermodynamics
 - Ginzburg-Landau theory and Landau's quantum hydrodynamics
 - XY model, 2d order, vortices and the Kosterlitz-Thouless transition
 - **Magnetism in charge insulators**
 - Paramagnetism
 - Spin exchange vs dipolar interaction
 - Heisenberg model and crystalline anisotropies
 - Hohenberg-Primakoff and Schwinger bosons
 - Jordan-Wigner transformation and XXZ chain
 - Coherent-spin states and Berry phases
 - Mean-field and Landau theory of FM and AFM states
 - **Electron liquid**
 - Fermi gas thermodynamics
 - Hartree-Fock theory of interactions
 - Response functions
 - Landau Fermi liquid theory
 - Pauli magnetism
 - Landau diamagnetism
 - **Superconductivity**
 - Cooper instability
 - BCS and Bogoliubov theory
 - BCS-BEC crossover
 - Ginzburg-Landau theory
 - Vortex physics
 - **Quantum Hall and related effects**
 - Hall effect
 - Landau levels and Integer QHE
 - de Haas-van Alphen oscillations
 - Fractional QHE
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Official course details:

Homework details

- Weekly homework assignments will be posted on D2L
- Homeworks are due in class on the due-date of the assignment
- You are encouraged to work together on the homework problems, but you must write up the answers in your own words.
- Homework is a large part of your grade, so failing to turn in more than one assignment, and thereby getting a 0 will have a big impact on your grade. Talk to me, *now*, if you will have a scheduling problem during the term so that you will be unable to complete any of the

assignments. Permission for exceptions from the normal class work schedule must be requested in advance.

- It is best if you print out the assignment early, so you see the problems before class.

Research paper

- On any topic of your choice related to the subject of condensed matter physics
- Typeset in a professional publishable format, 15 - 20 pages, that includes:
 - pedagogical introduction and motivation
 - summary, conclusion and future directions
 - simple derivations and physical interpretation of the results
 - graphs and figures should have clear and detailed captions
- Due on the last day of class

Classroom conduct

To ensure a distraction free environment for all students, all laptop computers, MP3 players, cell phones, and similar devices are **not** to be used during lecture.

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See policies at <http://www.colorado.edu/policies/classbehavior.html> and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

Honor code

All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-735-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at <http://www.colorado.edu/policies/honor.html> and <http://www.colorado.edu/academics/honorcode/>

Bringing someone else's clicker to class to give them credit is a direct violation of the CU honor code - please do not do it, nor tolerate other people doing it. Please feel free to talk to me if anything is going on you are not comfortable with.

Disabilities

If you qualify for accommodations because of a disability, please submit to me ([Professor Radzihovsky](#)) a letter from Disability Services in a timely manner so that your needs be addressed. Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322, and <http://www.Colorado.EDU/disabilityservices>

If you have a temporary medical condition or injury, see guidelines at <http://www.colorado.edu/disabilityservices/go.cgi?select=temporary.html>

Discrimination and Harassment

The University of Colorado at Boulder policy on Discrimination and Harassment, the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships apply to all students, staff and faculty. Any student, staff or faculty member who believes s/he has been the subject of sexual harassment or discrimination or harassment based upon race, color, national origin, sex, age, disability, creed, religion, sexual orientation, or veteran status should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Judicial Affairs at 303-492-5550. Information about the ODH, the above referenced policies and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at <http://www.colorado.edu/odh>

Religious observances

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, please speak to me ([Professor Radzihovsky](#)) regarding any accomodation you might need regarding religious observances.