PHYS 8302: Statistical Physics II

Instructor: Dr. M. Bachmann
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Course website: www.smsyslab.org/teaching.html

Topics: The second part of this course starts off with the grand canonical theory and second quantization of fermionic and bosonic many-body quantum systems. Thermodynamic properties of the ideal Fermi and Bose gases, including phenomena such as Bose-Einstein condensation, black-body radiation (photons) and lattice vibrations in solids (phonons), magnetism, and conductivity, are discussed in detail. Advanced topics in the context of phase transitions contain elements of microscopic and phenomenological quantum-statistical field theories, renormalization-group theory, time-dependent non-equilibrium response theory and computational statistical physics (as time permits).

References: The following references can be used as guides, but the course does not follow a single text book.
Basic theory of quantum gases: *Theoretical Physics 8: Statistical Physics* by W. Nolting; *Statistical Mechanics* by F. Schwabl; *A Modern Course in Statistical Physics* by L. E. Reichl; *Fundamentals of Statistical and Thermal Physics* by Frederick Reif,
Advanced Topics: *Quantum Theory of Many-Particle Systems* by A. L. Fetter and J. D. Walecka; *Methods of Quantum Field Theory in Statistical Physics* by A. A. Abrikosov, L. P. Gorkov, and I. E. Dzyaloshinski; *Quantum and Statistical Field Theory* by M. Le Bellac.

Class: Tuesday and Thursday, 2:20pm–3:35pm, room 327 Physics Bldg.

Office Hours: You can contact me at any time.

Exams: Midterm and Final (take-home). The midterm exam will be in early March; the final exam in May. In both exams, only own hand-written lecture notes and homework solutions are admitted, but no text books or printed scripts. Excused midterm exam absence causes the grade of the final exam to be substituted for the midterm exam; unexcused absence entails grade F. Missing the final exam without documented reason results in failing the course. If the instructor decides that final exam absence was excusable, an oral make-up exam will be set up.

Homework: There will be graded assignments on a regular basis (typically bi-weekly) with deadlines. No late homework is accepted. No submission via email.

Grade: Total Grade = (Homework + Midterm + Final)/3

Grading: [100,85]: A; (85,82.5]: A^-; (82.5,80]: B^+; (80,70]: B; (70,67.5]: B^-; (67.5,65]: C^+; (65,55]: C; (55,52.5]: C^-; (52.5,40]: D; (40,0]: F

Academic Honesty: All members of the academic community are committed to honesty. The academic honesty policy statement of UGA can be viewed online at www.uga.edu/honesty.

Outline (changes possible)

- Quantum Gases (quantum grand canonical ensemble, identical particles, Fock states, second quantization, (anti-)commutation relations, operators in second quantization, second quantization in momentum space, ideal quantum gases)
- Ideal Fermi Gas (fermionic equation of state, classical limit, density of states and Fermi function, Fermi gas at low temperatures, application: Pauli spin paramagnetism)
- Ideal Bose Gases and Bose-Einstein Condensation (thermal and caloric equations of state, classical limit, Bose-Einstein condensation, Bose-Einstein phase transition, thermodynamic properties of the condensate)
- Photons and Phonons (photon gas, radiation fields, Planck's Law, quantization of lattice vibrations, phonons, Debye model of solids and thermal properties)
- Advanced topics (extensions to statistical field theory, renormalization-group theory, computational statistical physics) as time permits