PHYS 8302: Statistical Physics II

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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 may include elements of microscopic and phenomenological quantum-statistical field theories, quantum-statistical path integrals, 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. An exam that was missed without documented reason is assigned the grade F. If the instructor decides that missing an exam was excusable, an oral make-up exam will be set up online. If you should be unable to take an exam for medical reasons, you must inform me before the exam starts and send me a copy of the original medical visit verification provided by your doctor by end of the exam day.

Homework: There will be graded assignments on a regular basis (typically bi-weekly) with strict deadlines. Late homework will not be accepted. Do not submit homework via email (unless directed otherwise).

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

COVID-19: Please adhere to the precaution guidelines issued by CDC and UGA strictly. Do not attend classes if you have COVID-19 symptoms or have tested positive. Wearing a mask or an appropriate face covering in class is recommended.

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, applications: conductivity in metals, 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, path integrals, computational statistical physics) as time permits