Physics 7500 **Statistical Mechanics** **Fall 2012**

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Office hours: Mo: 2:00 - 3:00, We: 1:15-2:00, and by appointment.
Text: R.K. Pathria, *Statistical mechanics*, second or third [Pathria and Beale] edition.
Additional textbooks: Landau and Lifshitz, *Statistical physics*;
Kittel, *Thermal physics*, *Elementary statistical physics*.
Grading: 20% for each of two one-hour exams, 30% for the final, 30% for the homework.
Homework: assigned weekly and collected on a week later. Late homework will not be accepted.
Final exam: December 13, 1:20 – 3:00 pm.

Course outline

1. **Statistical mechanics as basis for thermodynamics.** The postulate of equal probabilities. Two systems in thermal equilibrium. Entropy, temperature, pressure, and chemical potential. Fluctuations in energy. Number of states for the classical ideal gas. The role of indistinguishabilty. System in a thermal bath. Microcanonical and canonical distributions.

2. **General principles.** Ensemble theory. Phase space and Liouville's theorem. Microcanonical ensemble. Examples: two level system, ideal gas, system of quantum oscillators. Negative temperatures. Canonical ensemble. Partition function. Free energy. Thermodynamic potentials. Equipartition of energy. Energy fluctuations. Diatomic gas. Diamagnetism. Grand canonical distribution. Multiplicity fluctuations. Quantum statistics.

3. **Bose systems.** Bose-Einstein distribution. Ideal Bose gas. Hanbury-Brown and Twiss intensity interferometry. Black body radiation. Bose-Einstein condensation. Phonons. Debye model. Superfluidity.

4. **Fermi systems.** Fermi-Dirac distribution. Ideal Fermi gas. Landau diamagnetism. Pauli paramagnetism. Electrons in metals. Thermionic emission and photoeffect. White dwarf and neutron stars.

5. **Dense gases and fluids.** Cluster expansion. Virial coefficients. van der Waals gas.

6. **Phase transitions.** van der Waals model. Ising model, binary alloys, and lattice gas. Mean field theory. Izing model: zeroth and first order approximations. Order parameter and correlation function. Critical exponents. The Landau theory of phase transitions. Scaling. Critical points. Tricritical points. Fluctuations. Ising model: complete solution. Phase transitions in small systems.

7. **Fluctuations.** Brownian motion. Langevin equation. Non equilibrium systems. Fokker-Plank equation. Transport coefficients. Fluctuation-dissipation theorem. The Onsager relation.

8. **The renormalization group.** Scaling. The Kadanoff transformation. Relevant and irrelevant variables. Position space RG. Momentum space RG. The epsilon expansion.

Homework:

- Write clearly.
- Explain notations, especially if different from those used in lectures.
- Do not refer to equations in the textbook (you may refer to lectures or to the equation sheet).
- Do not write anything irrelevant.
- If a computer program has been used, attach a print-out.