Phys. 541 Advanced Statistical Mechanics

Prof. Barry M. McCoy

Mon. Wed. Fri. 11:45-12:40

Physics PL-117

Modern statistical mechanics has close connections with condensed matter physics, quantum field theory and advanced mathematics. This course will present these topics with a focus on phase transitions, critical phenomena, solvable models and the interpretation in terms of quantum field theory.

The course will cover the following topics:

1) Theorems on the existence and non existence of order;

2) The phenomenology of critical phenomena and it's relation to quantum field theory;

3) Low density virial expansions for fluid systems;

4) Melting (freezing) transition of hard spheres, powerlaw, and Lennard-Jones potentials;

5) N vector models (known in quantum field theory as the nonlinear sigma model) will be studied by high temperature series expansions. In this context we will introduce the field theory concepts of renormalization and asymptotic freedom.

6) Commuting transfer matrices and the Yang-Baxter equation for integrable models. Solutions for the Ising model, the 6 and 8 vertex model, the RSOS models and the chiral Potts model will be derived.

7) The Ising model will be studied in great detail. In particular we will compute the free energy, spontaneous magnetization, the correlation functions and form factor expansion and we will show how renormalization theory emerges from these calculations.

8) The Bethe's ansatz solution to the 6 vertex model and Baxter's solution of the free energy of the 8 vertex model by means of the TQ equation will be presented.

The text is "Advanced Statistical Mechanics" by B.M. McCoy. It is available in the book store. There will be no written exams. The grade will be determined by homework, a term paper and an oral examination.

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2011 Tentative Schedule

Aug. 29 Overview (Contents, preface chapter 1 passed out)
Aug. 31 Review of Thermo
Sept. 2 Review of Ensemble theory
Sept. 5 NO CLASS
Sept. 7 Reductionism and models
Sept. 9 Lattice gas/Ising correspondence, Chapter 3 intro and 3.1.1
Sept. 12 Sections 3.1.2-3.1.4 and 3.2
Sept. 14 Sections 3.3.2 (theorems 1 and 2 and 3.3.3 to property 4.
Sept. 16 Finish chapter 3.
Sept. 19 Begin Chapter 4; Survey of order, hard spheres
Sept. 21 Mermin and Wagner for quantum Heisenberg
Sept. 23 Lack of crystalline order in $D = 2$ and mechanism for the existence of ferromagnetism in $D = 3$
Sept. 26 Begin chapter 5; critical exponents and Ising scaling
Sept. 28 Heisenberg scaling and universality
Sept. 30 Finish scaling and begin Mayer expansion
Oct. 3 Second virial coefficient
Oct. 5 Mayer's first theorem and step 1 of second theorem
Oct. 7 Finish of Mayers' second theorem
Oct. 10 Groeneveld's theorems
Oct. 12 Convergence and region of no phase transitions
Oct. 14 Ree-Hoover and hard spheres
Oct. 17 High density expansions
Oct. 19 Classical high temperature expansions; stat. mech versus QFT
Oct. 21 Differential approximants and quantum high temperature expansions.
Oct. 24 Ising model summary
Oct. 26 Dimers as Pfaffians
Oct. 28 Pfaffian evaluation
Oct. 31 Ising partition function
Nov. 2 Ising correlation determinants
Nov. 4 Wiener-Hopf sum equations
Nov. 7 Szego's theorem
Nov. 9 Form factors $T < T_c$
Nov. 11 Form factors $T > T_c$
Nov. 14 $T = T_c$ correlation and scaling theory for Ising
Nov, 16 Ising Susceptibility

Nov. 18	Overview of star triangle and integrability
Nov. 21	Six vertex star triangle
Nov. 23	NO CLASS
Nov, 25	NO CLASS
Nov. 28	8 vertex star triangle and chiral Potts
Nov. 30	Hard hexagons and Hamiltonian limits (chapters 14)
Dec. 2	Bethe's ansatz and TQ equations for 8 vertex
Dec. 5	TQ equations, 8 vertex free energy
Dec. 7	Hard hexagons
Dec. 9	Chiral Potts
Dec. 12	Chiral Potts