Physics 518, Critical Phenomena and Field Theory
Syllabus Fall 2005

Instructor:
Prof. Jinwu Ye,
Office 315 Davey Lab
Phone: 863-5345
E-mail: jye@phys.psu.edu

Time and Location:
9:45 am-11:00 am, Tuesday and Thursday
207 Osmond.

Office hours:
Anytime

Pre-requisite:
Physics 517, 563

Reference Book:
P. M. Chaikin and T. C. Lubensky, Principles of Condensed Matter Physics

Grading information:
There will be 5 homework sets and a final take home exam.
A letter grade will be given as your final grade

Tentative Schedule:
Part I: Ginsburg-Landau theory, mean field theory and fluctuations

1. Order parameter, Symmetry breaking, critical exponents
2. Mean Field Theory, Fluctuations, Two-point correlation functions, Fluctuation-Dissipation theorem
3. Broken symmetry, Goldstone Modes, Mermin-Wegner theorem
5. First order Transitions, hysteresis, meta-stable states, supercooling and superheating
6. Multi-critical points: Bi-, Tri-, Tetra-Critical points, Lifshitz points

**Part II: Scaling and Renormalization group in momentum space**

1. Critical exponents, Kadanoff’s scaling, Scale invariance, Symmetry and Universality class

2. Wilson Renormalization Group in momentum space, Fixed points, $4 - \epsilon$ expansions

3. Large $N$ expansion

**Part III: Renormalization group in real space and duality transformation**

1. Transfer Matrix Method in one dimension

2. Real Space Renormalization group in one and higher dimensions.

3. High temperature and low temperature series expansions, Duality transformation

4. Ising Model, Ising Lattice gauge theory, duality

**Part IV: Topological phase transitions**

1. Non-linear sigma model, $2 + \epsilon$ expansion.

2. Topological defects, Kosterlitz-Thouless Transition

3. 2-dimensional melting transitions, elasticity, translational and orientational order parameters, dislocations and disclinations, hexatic phase

**Part V: Introduction to Quantum Phase Transitions**

1. Bose-Einstein condensations, weakly interacting Bose gas, dilute Bose gas

2. Superfluid He4, Supersolid

3. Superfluid He3, p-wave pairing, B phase (BW state); A phase (ABM state); A1 and A2 phases.

4. Quantum anti-ferromagnet to paramagnet transition

5. Superconductor to insulator transition

6. ........