Advanced Statistical Mechanics - Web course

COURSE OUTLINE

The course on Advanced Statistical Mechanics: Phase transitions and critical phenomena is about different phases of matter and its study using statistical mechanics.

In this course phenomenology of phase transitions of different order will be elaborated, statistical thermodynamics of these systems will be established, different models will be constructed to study the phenomena, analytical and numerical techniques will be discussed for solving these models. Renormalization group technique will be introduced.

Contents:

Phenomenology: Phase transitions in different systems, origin of phase transition, classification of order transitions: first and second, phenomenological description of liquid-gas and paramagnet-ferromagnetic transition.

Statistical mechanics of phase transition: Basic concepts, ensembles, partition function, statistical thermodynamics, stability, response functions, convexity of free energy, fluctuation and correlation, statistical thermodynamic description of phase transition, Critical point exponents, exponent inequalities etc.

Lattice Models: Lattice models to describe phase transitions such as Ising Models, Pott's model, X-Y and Heisenberg models, their ground states, etc.

Analytical techniques: Mean Field Theory: Mean Field Theory for Ising model, Landau theory, Correlation functions, Classical mean field theories.

Transfer matrix: Setting up the transfer matrix, Calculation of free energy and correlation functions, Results of Ising model in one and two dimensions.

Numerical Techniques: Series Expansion: High and low temperature series, application in 1-d Ising model, Analysis of series.
Monte Carlo: Importance sampling, Metropolis algorithm, Data analysis, statistical error, finite-size effect. Application in percolation, ferromagnetic transition, etc.

Renormalization Group: Scale invariance and scaling hypothesis. Definition of renormalization group transformation, parameter space, universality, scaling and critical exponents. Application in one-dimensional Ising model. Introduction to Monte Carlo renormalization group.

COURSE DETAIL

Module	Topics and Contents	No. of Lectures
1	**Critical Phenomena:** Phase transitions in different systems, Origin of phase transitions, First and second order transitions, phenomenological description of liquid-gas and paramagnetic-ferromagnetic transition.	6
2	**Statistical mechanics of phase transition:** Basic concepts, ensembles, partition function, statistical	6

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Physics

Pre-requisites:

Statistical Mechanics.

Coordinators:

Dr. S.B. Santra
Department of PhysicsIIT Guwahati

	thermodynamics, stability, response functions, convexity of free energy, fluctuation and correlation, statistical thermodynamic description of phase transition, Critical point exponents, exponent inequalities etc.	
3	**Lattice Models:** Lattice models to describe phase transitions such as Ising Models, Pott's model, X-Y and Heisenberg models, their ground states, etc.	4
4	**Analytical techniques:** • Mean Field Theory: Mean Field Theory for Ising model, Landau theory, Correlation functions, Classical mean field theories. • Transfer matrix: Setting up the transfer matrix, Calculation of free energy and correlation functions, Results of Ising model. Results in one and two dimensions.	8
5	**Numerical Techniques:** • Series Expansion: High and low temperature series, application in 1-d Ising model, Analysis of series. • Monte Carlo: Importance sampling, Metropolis algorithm, Data analysis, statistical error, finite-size effect. Applications in percolation, ferromagnetic transition.	8
6.	**Renormalization Group:** Scale invariance and scaling hypothesis. Definition of renormalization group transformation, parameter space, universality, scaling and critical exponents. Application in one-dimensional Ising model. Introduction to Monte Carlo renormalization group.	8

References:

1. J. M. Yeomans, Statistical Mechanics of Phase transitions, (Clarendon Press, Oxford, 1992).
2. H. E. Stanley, Introduction to Phase transitions and Critical Phenomena, (Oxford University Press, New York, 1987).
3. J. J. Binney, N. J. Dowrick, A. J. Fisher and M. E. J. Newman, The theory of Critical Phenomena, (Oxford University Press, Oxford, 1992).
4. S. K. Ma, Modern theory of Critical Phenomena, (Levant Books, Kolkata, 2007).
5. M. E. Fisher, Rev. Mod. Phys. 46, 597 (1974).