Dipartimento di Scienze Fisiche e Chimiche

MASTER DEGREE IN PHYSICS

"STATISTICAL MECHANICS"

Teacher: Prof. Sergio Ciuchi ***CFU***: 6

Aim of the course

The goal of this course is to provide elements of basic statistical mechanics i.e. the mechanical description of the thermal equilibrium and how such state is attained.

On successful completion of this course the student should understand the fundamental concepts of both quantum and classical statistical mechanics and their applications to the study of phase transitions and critical phenomena.

URL: http://www.aquila.infn.it/ciuchi/

Programme

1. **Elements of thermodynamics and thermodynamic fluctuations**
   Thermodynamic potentials, equilibrium in isolated, closed and open systems.
   Gibbs-Duhem relation, Legendre transformation between thermodynamic potentials.
   Conditions of stability and fluctuations of a thermodynamic system in an external bath.

2. **Statistical approach to many body systems**
   Hamiltonian motion and its features. Liouville theorem. Ergodicity and mixing.
   The Bogoliubov-Born-Green-Yvon Kirckwood hierarchy. Boltzmann equation and H-theorem.

3. **Systems in external bath**
   Motion of a particle in an external bath. Langevin equation. Fokker-Planck equation.
   Reduced density matrix for a quantum system.

4. **Complements of quantum mechanics**
   Second quantization of bosons and fermions in non-relativistic theory.

Interaction representation, time Euclidean S-matrix and thermal perturbation theory in quantum statistical mechanics.

5. **Classical and quantum statistical mechanics**

   Theory of ensembles: microcanonical, canonical, grand canonical. Relations between the partition functions and equivalence between the ensembles. Applications: quantum gases, equipartition generalized virial theorem, the virial expansion. Linear response theory.

6. **Mean field theory and phase transitions**

   Variational principle in classical and quantum statistical mechanics. Mean field theory from the variational principle. Ising model within mean field theory.

   Landau theory of second order phase transitions. Spontaneous symmetry breaking. Breaking of a continuous symmetry. Mermin and Wagner theorem.

   Superconducting phase transition in mean field theory in the Bardeen-Cooper-Schrieffer model..

Reference text books:

J.J. Sakurai "Modern quantum mechanics", Addison Wesley
K. Huang "Statistical Mechanics", Wiley
M. Falcioni A. Vulpiani “Meccanica Statistica Elementare”, Springer
C. Di Castro R. Raimondi “Statistical Mechanics and Applications in Condensed Matter”, Cambridge
A. Reichl "A modern course in statistical physics", Edward Arnold
D. Chandler "introduction to modern statistical mechanics", Oxford University Press
D. Wu and D. Chandler "introduction to modern statistical mechanics" solution manuals, ", Oxford University Press
D.A.R. Dalvit et al. "Problems on statistical mechanics", Institute of Physics Pub. Ltd.
P.W. Anderson "Basic Notions of Condensed Matter Physics", Benjamin

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Assessment methods and criteria: Weekly exercises and oral exam at the end of the course.

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