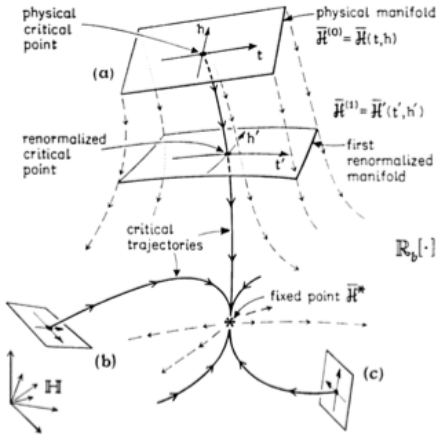
SCALING AND THE RENORMALIZATION GROUP: AN INTRODUCTION

by H. Saleur

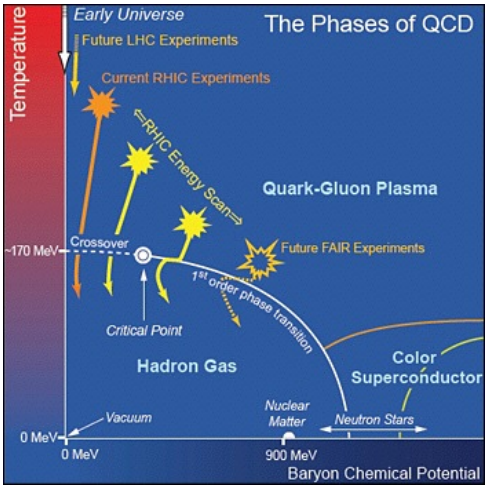
SYLLABUS:

PART I: THE STATISTICAL MECHANICS APPROACH

Chapter 1&2: CRITICALITY and MEAN FIELD THEORY
Phase diagrams, critical points, phenomenology of criticality
Main models: magnets, fluids. Other models: polymers, percolation
The mean field free energy (Laudan Ginzburg functional) and critical exponents.
Mean field for correlation functions.
Corrections to mean field. Upper critical dimension.
Chapter 3: THE MAIN IDEAS OF THE RENORMALIZATION GROUP (RG):
Real space renormalization, scaling, critical exponents.
General features of the RG: fixed points, eigenvalues, scaling, amplitudes
Chapter 4: THE PERTURBATIVE RENORMALIZATION GROUP NEAR D=4
The operator product expansion and the perturbative RG
Ising model near four dimensions, Gaussian fixed point
Wilson Fisher fixed point, the ϵ expansion
Other topics: logarithmic corrections in $D = 4$; redundant operators; symmetry breaking



A physical system seen through the RG



Critical points occur all over physics

Chapter 5: LOW DIMENSIONAL SYSTEMS
The XY model, the solid on solid (SOS) models
The $O(n)$ model in $2+\epsilon$ dimensions,
Other topics: sigma models, topological terms
Additional material: VARIOUS ASPECTS
Phase diagrams, crossovers (Reading)
Finite size effects
Localization

PART II: THE RG IN QUANTUM MECHANICS

Chapter 6: QUANTUM CRITICALITY
Examples of quantum critical systems.
Relationship between quantum mechanics and statistical mechanics. Path integrals
Path integrals for fermions. Grassmann variables, Fermion coherent states.
Chapter 7: RG FOR FERMIONS IN 1D
The Gaussian fixed point
Quadratic perturbations
Quartic perturbations at tree level
Quartic perturbations at one loop: Luttinger liquid
Chapter 8: THE RG FOR QUANTUM SPIN CHAINS
Coherent states for quantum spins
Spin chains and sigma models
RG and topological terms.

GRADES:

The final grade will be based on homeworks distributed every week and a final take home exam.

READING MATERIAL:

The course will be based on the book by J. Cardy - "Scaling and renormalization in statistical physics", Cambridge University Press - and on the review article by R. Shankar - "Renormalization group approach to interacting fermions", arXiv:cond-mat/9307009. Many other references will be provided during class, together with additional notes for selected material.