Scuola Superiore di Catania

Corso specialistico
a.a. 2019-2020

Teoria statistica dei campi

Statistical field theory

Module 1. Statistical field theory

Collective behaviour of many-body systems: from particles to fields. Thermody-namic and hydrodynamic limits. Phase transitions as `emergent' physical phenomena.
Critical phenomena. Liquid-gas transition. Magnetic critical point: the Ising model. Superuid transition in 4He. Self-avoiding random walk. Critical exponents. Singular behaviour and subdominant singularities: confluent singularities. Main critical exponents. Spatial correlations and anomalous exponent. Static susceptibility and two-point correlation function. Correlation length. Quantum critical points: dynamical exponent.

Landau theory. Transition order. Coarse graining. Functional methods. Partition function. Fluctuations and breakdown of mean-field approximation. Ginzburg-Levanyuk criterion for the Landaumodel. Upper critical dimension. Gaussian approximation. Landau functional in Fourier space. Fluctuation corrections to the specific heat and critical exponents.

Fluctuation phenomena in superconductors. Fluctuation diamagnetism. Ginzburg-Landau equations in a magnetic field. Zero-dimensional diamagnetic susceptibility: fluctuation correction. Dimensional analysis of Landau theory. Breakdown of perturbation theory. Asymptotic expansion.

Scaling. Renormalization group (RG) theory. Fixed points. Critical manifold. Hints at universality. Local behaviour of RG ow near a fixed point. Relevant, irrelevant, marginal variables. Examples. Josephson scaling law. Dangerous irrelevant variables.

Scaling and RG theory for superconductors.

Spontaneous breaking of a continuous symmetry (SSB): O(n) invariance. Longitudinal and transverse susceptibilities. Goldstone's modes. SSB of gauge invariance: the Anderson-Higgs mechanism. Superconductivity: Meissner's effect.

Path integrals for quantum mechanics. Semiclassical methods. Linear response and correlation functions. Dissipation and fluctuation.

Topological order and quantum phase transitions.

Module 2. Conformal field theory

Introduction to conformal transformation within field theory.
Two-dimensional case.
Virasoro algebra and representations thereof.
An exact description of the Ising model at the critical point through conformal theory methods.