Statistical Field Theory

Collective behaviour of many-body systems: from particles to fields. Thermodynamic and hydrodynamic limits. Phase transitions as 'emergent' physical phenomena.

Critical phenomena. Liquid-gas transition. Magnetic critical point: the Ising model. Superfluid transition in ^{4}He. 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 Landau model. Upper critical dimension. Gaussian approximation. Landau functional in Fourier space. Fluctuation corrections to the specific heat and critical exponents.

Fluctuation phenomena in superconductors: $d = 0$, arbitrary d and $T \geq T_c$. 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 flow near a fixed point. Relevant, irrelevant, marginal variables. Examples. Josephson scaling law. Dangerous irrelevant variables.

Scaling and RG theory for superconductors. ϵ-expansion for T_c, ν, α.

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.