QUANTUM STATISTICAL MECHANICS AND CONDENSED MATTER

[Manu Valle, Michele Modugno]

Thermodynamics and Statistical Mechanics. The Microcanonical Distribution. The Canonical and Grand Canonical Distributions. Ideal gases. Bosons. Fermions.

Statistical to Quantum Mechanics. Real-time Quantum Mechanics. Imaginary-Time Quantum Mechanics. The Transfer Matrix.

Phase Transitions. Critical Behavior. The Landau-Ginzburg Hamiltonian. The scaling hypothesis.

The renormalization group. The Gaussian model. Renormalization group for the phi^4 model. The epsilon-expansion.

Superfluidity: classical and quantum fluids; the macroscopic wave-function; superfluid properties of Helium II: flow quantization and vortices; the momentum distribution; quasiparticle excitations.

Superconductivity: conduction in metals; superconducting materials; the Meissner-Ochsenfeld effect; perfect diamagnetism; type I and type II superconductivity.

The BCS theory of superconductivity: the electron-phonon interaction; Cooper pairs; density matrix and off-diagonal long range order; the BCS wave-function; the mean-field Hamiltonian; energy gap and quasiparticle states; prediction of the BCS theory.

Bose-Einstein condensates and ultracold atomic gases. Gross-Pitaevskii equation.

Textbooks

R. Shankar, *Quantum Field Theory and Condensed Matter*, Cambridge Univ. Press 2017.

Mehran Kardar, *Statistical Physics of Fields*, Cambridge University Press 2007.

Alexander Altland and Ben Simons, *Condensed Matter Field Theory*, Second Edition, Cambridge University Press 2010.

J. F. Annett, *Superconductivity, Superfluids and Condensates*, Oxford Univ. Press 2004.