Field Theory of Condensed Matter and Ultracold Gases

Nicolas Dupuis

To be published by World Scientific

This book provides a pedagogical introduction to the concepts and methods of quantum field theory necessary for the study of condensed matter and ultracold atomic gases. After a thorough discussion of the basic methods of field theory and many-body physics (functional integrals, perturbation theory, Feynman diagrams, correlation functions and linear response theory, symmetries and their consequences, etc.), the book covers a wide range of topics, from the electron gas and Fermi-liquid theory to superfluidity and superconductivity, the magnetic instabilities in electron systems, and the dynamical mean-field theory of the Mott transition. The focus is on the study of model Hamiltonians, where the microscopic physics and characteristic energy scales are encoded into a few effective parameters, rather than first-principle methods which start from a realistic Hamiltonian at the microscopic level and make material-specific predictions. The reader is expected to be familiar with elementary quantum mechanics and statistical physics and some acquaintance with condensed-matter physics and ultracold gases may also be useful. No prior knowledge of field theory or the many-body problem is required.

Vol. I

(to appear in 2023)

Table of contents (short/long)

Functional integrals, symmetries, and correlation functions

Quantum many-body systems (I)

Vol. II

(Preliminary versions of some chapters are available at https://www.lptmc.jussieu.fr/users/dupuis)

The renormalization group

Quantum many-body systems (II)