

# Contents

<b>1. Review of Quantum Mechanics and Basic Principles of Field Theory</b> .....	1
1.1 Single-Particle Quantum Mechanics .....	1
1.2 Many-Particle Quantum Mechanics: Second Quantization....	12
1.3 The Variation Principle and the Noether Theorem .....	18
1.4 Quantization of the Electromagnetic Field .....	23
<b>2. Quantization with Path Integral Methods</b> .....	27
2.1 Single-Particle Quantum Mechanics and Path Integrals .....	27
2.2 The Path Integral for Bosons .....	37
2.3 The Path Integral for Fermions.....	42
2.4 The Path Integral for the Gauge Field .....	45
2.5 The Path Integral for the Spin System .....	47
<b>3. Symmetry Breaking and Phase Transition</b> .....	51
3.1 Spontaneous Symmetry Breaking .....	51
3.2 The Goldstone Mode.....	60
3.3 Kosterlitz–Thouless Transition .....	68
3.4 Lattice Gauge Theory and the Confinement Problem.....	78
<b>4. Simple Examples for the Application of Field Theory</b> .....	91
4.1 The RPA Theory of a Coulomb Gas .....	91
4.2 The Bogoliubov Theory of Superfluidity .....	102
<b>5. Problems Related to Superconductivity</b> .....	113
5.1 Superconductivity and Path Integrals .....	113
5.2 Macroscopic Quantum Effects and Dissipation: The Josephson Junction .....	133
5.3 The Superconductor–Insulator Phase Transition in Two Dimensions and the Quantum Vortices .....	146

<b>6. Quantum Hall Liquid and the Chern–Simons Gauge Field . . . . .</b>	161
6.1 Two-Dimensional Electron System . . . . .	161
6.2 Effective Theory of a Quantum Hall Liquid . . . . .	167
6.3 The Derivation of the Laughlin Wave Function . . . . .	186
<b>Appendix . . . . .</b>	193
A. Fourier Transformation . . . . .	193
B. Functionals and the Variation Principle . . . . .	195
C. Quantum Statistical Mechanics . . . . .	199
<b>References . . . . .</b>	201
<b>Index . . . . .</b>	205