

Contents

<i>Preface</i>	<i>page ix</i>
1 Introduction	1
1.1 Phase transitions and order parameters	1
1.2 Models: Ising, XY, Heisenberg	3
1.3 Universality and critical exponents	10
1.4 Scaling of free energy	12
1.5 Correlations and hyperscaling	19
2 Ginzburg–Landau–Wilson theory	23
2.1 Partition function for interacting bosons	23
2.2 Bose–Einstein condensation	27
2.3 Hartree approximation	30
2.4 Landau’s mean-field theory	34
2.5 Upper critical dimension	40
3 Renormalization group	43
3.1 Idea	43
3.2 Momentum-shell transformation	46
3.3 ϵ -expansion	53
3.4 Dangerously irrelevant coupling	58
3.5 Corrections to scaling	59
3.6 Field-theoretic perspective	61
3.7 Computation of anomalous dimension	65
3.8 Summary	69

viii	<i>Contents</i>	
4	Superconducting transition	77
4.1	Meissner effect	77
4.2	Fluctuation-induced first-order transition	81
4.3	Type-II superconductors near four dimensions	85
4.4	Anomalous dimension for the gauge field	92
4.5	Width of the critical region	93
5	Near lower critical dimension	97
5.1	Goldstone modes	97
5.2	Mermin–Wagner–Hohenberg theorem	99
5.3	Non-linear σ -model	102
5.4	Low-temperature expansion	104
5.5	Discussion	106
6	Kosterlitz–Thouless transition	115
6.1	Vortices and spin waves	115
6.2	Mean-field theory	118
6.3	Duality and the sine-Gordon theory	123
6.4	Renormalization of the sine-Gordon model	131
6.5	Universal jump of superfluid density	138
6.6	Heisenberg model	140
7	Duality in higher dimensions	147
7.1	Frozen lattice superconductor	147
7.2	Confinement of magnetic monopoles	152
7.3	Magnetic field correlations	154
7.4	Compact electrodynamics	156
8	Quantum phase transitions	165
8.1	Dynamical critical exponent	165
8.2	Quantum critical point in Φ^4 -theory	168
8.3	Bose–Hubbard model	174
8.4	Quantum fluctuations and the superfluid density	181
8.5	Universal conductivity in two dimensions	185
	<i>Appendix A</i> Hubbard–Stratonovich transformation	195
	<i>Appendix B</i> Linked-cluster theorem	197
	<i>Appendix C</i> Gauge fixing for long-range order	199
	<i>Select bibliography</i>	203
	<i>Index</i>	209