
Contents

1	Introduction	1
1.1	Problem of High-Temperature Superconductivity	1
1.2	Discovery of High-Temperature Superconductors	4
1.3	Generic Properties of Cuprate Superconductors	6
2	Crystal Structure	13
2.1	The Structure of $\text{Ba}_{1-x}\text{K}_x\text{BiO}_3$	15
2.2	The Structure of $\text{La}_{2-x}\text{M}_x\text{CuO}_{4-y}$	17
2.2.1	Structural Phase Transitions in $\text{La}_{2-x}\text{M}_x\text{CuO}_4$	19
2.2.2	Theory of Structural Phase Transitions	25
2.2.3	Copper-Oxide Ladder Compounds	28
2.3	$\text{Nd}_{2-x}\text{Ce}_x\text{CuO}_4$ Compounds	32
2.4	YBaCuO-Based Compounds	33
2.4.1	Structure of $\text{YBa}_2\text{Cu}_3\text{O}_{7-y}$	34
2.4.2	Modifications of the YBCO Structure	38
2.4.3	Rutheno-Cuprates Magneto-Superconductors	39
2.5	Bi-, Tl- and Hg-Compounds	40
2.6	High-Pressure Effects	45
2.7	Conclusion	49
3	Antiferromagnetism in Cuprate Superconductors	51
3.1	Magnetic Neutron Scattering	52
3.2	Antiferromagnetism in $\text{La}_{2-x}\text{M}_x\text{CuO}_4$ Compound	55
3.2.1	Magnetic Phase Diagram	55
3.2.2	Microscopic Models	59
3.2.3	Theory of Magnetic Phase Transitions	63
3.2.4	Spin Dynamics	68
3.3	Antiferromagnetism in $\text{YBa}_2\text{Cu}_3\text{O}_{6+x}$ Compounds	80
3.3.1	Magnetic Phase Diagram	80
3.3.2	Spin Dynamics	84
3.3.3	Resonance Mode	92
3.3.4	Antiferromagnetism in $\text{REBa}_2\text{Cu}_3\text{O}_{6+x}$	98

3.4	Nuclear Magnetic Resonance Studies	100
3.4.1	The Knight Shift	103
3.4.2	Spin–Lattice Relaxation	108
3.4.3	Spin Pseudogap	113
3.5	Conclusion	118
4	Thermodynamic Properties of Cuprate Superconductors	121
4.1	Anisotropic Ginzburg–Landau Model	121
4.2	Specific Heat	126
4.2.1	Low-Temperature Electronic Specific Heat	126
4.2.2	Pseudogap in Electronic Specific Heat	130
4.2.3	Fluctuation Effects	136
4.3	Magnetic Properties	142
4.3.1	Vortex Matter	143
4.3.2	Critical Magnetic Fields	156
4.3.3	Magnetic Penetration Depth	167
4.4	Conclusion	175
5	Electronic Properties of Cuprate Superconductors	177
5.1	Electronic Structure: Overview	178
5.1.1	Crystal Chemistry and Bands	178
5.1.2	Effects of Impurity Substitution	183
5.2	Photoemission Spectroscopy	199
5.2.1	High-Energy Spectroscopy	202
5.2.2	Angle-Resolved Photoemission Spectroscopy	214
5.3	Optical Electron Spectroscopy	251
5.3.1	Dynamical Conductivity	252
5.3.2	Normal-State Optical Spectra	256
5.3.3	Superconducting State	272
5.3.4	Electronic Raman Scattering	290
5.4	Transport Properties	301
5.4.1	Resistivity	304
5.4.2	Hall Effect	310
5.4.3	Heat Transport	317
5.4.4	Theoretical Models	323
5.5	Superconducting Gap and Pseudogap	327
5.5.1	Gap Symmetry	327
5.5.2	Tunneling Experiments	329
5.5.3	Phase-Sensitive Experiments	342
6	Lattice Dynamics and Electron–Phonon Interaction	349
6.1	Neutron Scattering Studies	350
6.1.1	Doping Dependence of Phonon Spectra	351
6.1.2	Phonon Renormalization in Superconducting State	356

6.2	Optical Investigations	358
6.3	Isotope Effect	365
6.4	Theoretical Models	371
6.5	Conclusion	375
7	Theoretical Models of High-T_c Superconductivity	377
7.1	Electronic Structure of Cuprates	378
7.1.1	Band-Structure Calculations	378
7.1.2	Model Hamiltonians for CuO_2 Plane	382
7.2	Electron Excitations in the Normal State	393
7.2.1	Single-Particle Electron Spectrum	393
7.2.2	Spin Dynamics	419
7.3	Magnetic Mechanism of Superconductivity	428
7.3.1	Unconventional Ground State	428
7.3.2	Spin-Fluctuation Pairing	434
7.3.3	Models with Strong Correlations	439
7.4	Electron-Phonon Superconducting Pairing	455
7.4.1	Anisotropic Electron-Phonon Interaction	456
7.4.2	Van Hove Singularity Scenario	459
7.4.3	Polaron and Bipolaron Superconductivity	460
7.5	Charge Fluctuation Models	465
7.5.1	Plasmon Model	466
7.5.2	Exciton Models	469
7.5.3	Coulomb Repulsion Pairing	472
7.6	Conclusion	477
8	Applications	479
8.1	Electric Power Applications	480
8.1.1	Superconducting Tapes and Cables	480
8.1.2	Fault Current Limiters	483
8.1.3	Superconducting Rotating Machines	483
8.2	Electronic Applications	485
8.2.1	Josephson Junctions	485
8.2.2	Passive Microwave Devices	488
8.2.3	Active Microwave Devices	489
8.2.4	Superconducting Quantum Interference Devices	491
8.3	Conclusion	494
A	Thermodynamic Green Functions in Superconductivity Theory	495
A.1	Thermodynamic Green Functions	496
A.1.1	Green Function Definition	496
A.1.2	Spectral Representation	497
A.1.3	Sum Rules and Symmetry Relations	498

A.2	Eliashberg Equations for Fermion–Boson Models	499
A.2.1	Dyson Equation	499
A.2.2	Noncrossing Approximation	501
A.3	Superconductivity in the Hubbard Model	503
A.3.1	Dyson Equation	504
A.3.2	Mean-Field Approximation	505
A.3.3	Self-Energy Operator	508
A.4	Superconductivity in the t - J Model	510
	References	513
	Index	565



<http://www.springer.com/978-3-642-12632-1>

High-Temperature Cuprate Superconductors

Experiment, Theory, and Applications

Plakida, N.

2010, X, 570 p. 160 illus., 26 illus. in color., Hardcover

ISBN: 978-3-642-12632-1