

Contents

1	Introduction	1
1.1	Layered Materials and Their Electronic Structure	3
1.1.1	$\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$	4
1.1.2	$\text{YBa}_2\text{Cu}_3\text{O}_{6+x}$	5
1.1.3	$\text{Nd}_{2-x}\text{Ce}_x\text{CuO}_4$	6
1.2	General Phase Diagram of Cuprates and Main Questions	7
1.2.1	Normal-State Properties	8
1.2.2	Superconducting State: Symmetry of the Order Parameter	12
1.3	Triplet Pairing in Strontium Ruthenate (Sr_2RuO_4): Main Facts and Main Questions	15
1.4	From the Crystal Structure to Electronic Properties	19
1.4.1	Comparison of Cuprates and Sr_2RuO_4 : Three-Band Approach	19
1.4.2	Effective Theory for Cuprates: One-Band Approach ..	22
1.4.3	Spin Fluctuation Mechanism for Superconductivity ...	23
	References	28
2	Theory of Cooper Pairing Due to Exchange of Spin Fluctuations	33
2.1	Generalized Eliashberg Equations for Cuprates and Strontium Ruthenate	33
2.2	Theory for Underdoped Cuprates	46
2.2.1	Extensions for the Inclusion of a d -Wave Pseudogap ..	48
2.2.2	Fluctuation Effects	52
2.3	Derivation of Important Formulae and Quantities	60
2.3.1	Elementary Excitations	60
2.3.2	Superfluid Density and Transition Temperature for Underdoped Cuprates	62
2.3.3	Raman Scattering Intensity Including Vertex Corrections	65
2.3.4	Optical Conductivity	71
2.4	Comparison with Similar Approaches for Cuprates	73
2.4.1	The Spin Bag Mechanism	74

2.4.2	The Theory of a Nearly Antiferromagnetic Fermi Liquid (NAFL)	76
2.4.3	The Spin–Fermion Model	77
2.4.4	BCS–Like Model Calculations	80
2.5	Other Scenarios for Cuprates: Doping a Mott Insulator	84
2.5.1	Local vs. Nonlocal Correlations	84
2.5.2	The Large- U Limit	86
2.5.3	Projected Trial Wave Functions and the RVB Picture	88
2.5.4	Current Research and Discussion	90
	References	92
3	Results for High-T_c Cuprates Obtained from a Generalized Eliashberg Theory: Doping Dependence	99
3.1	The Phase Diagram for High- T_c Superconductors	99
3.1.1	Hole–Doped Cuprates	99
3.1.2	Electron–Doped Cuprates	109
3.2	Elementary Excitations in the Normal and Superconducting State: Magnetic Coherence, Resonance Peak, and the Kink Feature	115
3.2.1	Interplay Between Spins and Charges: a Consistent Picture of Inelastic Neutron Scattering Together with Tunneling and Optical–Conductivity Data	115
3.2.2	The Spectral Density Observed by ARPES: Explanation of the Kink Feature	125
3.3	Electronic Raman Scattering in Hole–Doped Cuprates	137
3.3.1	Raman Response and its Relation to the Anisotropy and Temperature Dependence of the Scattering Rate	138
3.4	Collective Modes in Hole–Doped Cuprates	144
3.4.1	A Reinvestigation of Inelastic Neutron Scattering	145
3.4.2	Explanation of the “Dip–Hump” Feature in ARPES	148
3.4.3	Collective Modes in Electronic Raman Scattering?	149
3.5	Consequences of a $d_{x^2-y^2}$ –Wave Pseudogap in Hole–Doped Cuprates	151
3.5.1	Elementary Excitations and the Phase Diagram	152
3.5.2	Optical Conductivity and Electronic Raman Response	158
3.5.3	Brief Summary of the Consequences of the Pseudogap	167
	References	169
4	Results for Sr_2RuO_4	177
4.1	Elementary Spin Excitations in the Normal State of Sr_2RuO_4	179
4.1.1	Importance of Spin–Orbit Coupling	179
4.1.2	The Role of Hybridization	182
4.1.3	Comparison with Experiment	185
4.2	Symmetry Analysis of the Superconducting Order Parameter	187

4.2.1	Triplet Pairing Arising from Spin Excitations	188
4.3	Summary, Comparison with Cuprates, and Outlook	192
	References	197
5	Summary, Conclusions, and Critical remarks	201
	References	208
A	Solution Method for the Generalized Eliashberg	
	Equations for Cuprates	211
	References	214
B	Derivation of the Self-Energy (Weak-Coupling Case)	215
C	$d_{x^2-y^2}$-Wave Superconductivity Due to Phonons?	225
	Index	227