

Contents

1 Introduction	1
2 Vortex Dynamics at Low Dissipation Levels	5
2.1 Basic Concepts of Superconductivity	5
2.1.1 Type II Superconductors and Vortices	7
2.1.2 Vortex Solids, Flux-Line Melting, and Vortex Fluids	9
2.1.3 High-Temperature Superconductors	10
2.2 Pinning and Activation Energy	11
2.3 Dimensionality in HTSC's	14
2.3.1 Structural Anisotropy	14
2.3.2 Influence of Magnetic Field and Temperature	15
2.4 Disorder and Vortex Glass	16
2.4.1 Larkin and Ovchinnikov Model of Collective Pinning	17
2.4.2 Vortex Glass Theory of Fisher, Fisher, and Huse	19
2.5 <i>B-T</i> Phase Diagram of Layered HTSC's	23
3 Oxygen Stoichiometry and Vortex Dynamics in $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$	25
3.1 Sample Preparation and Characterization	26
3.1.1 Preparation and Annealing	26
3.1.2 X-Ray Analysis	29
3.1.3 Experimental Setup	29
3.1.4 Hall Effect	30

CONTENTS

3.1.5	Aslamasov-Larkin Analysis	31
3.2	Activation Energy	34
3.3	Critical Currents	41
3.4	Vortex Glass Phase	43
3.5	Conclusions from Transport Measurements on BSCCO	48
4	The Vortex Glass Phase of $\text{YBa}_2\text{Cu}_3\text{O}_7$	51
4.1	Sample Preparation	52
4.2	Sample Characterization	54
4.3	Current-Voltage Characteristics	55
4.3.1	I - V Glass Line	56
4.3.2	Crossover Current Density	58
4.3.3	Vortex Glass Scaling	62
4.3.4	Influence of the Measurement Window	63
4.4	Resistive Transitions	65
4.5	Alternative Models	66
4.6	Conclusions on the Vortex Glass Phase in YBCO	68
5	The Vortex Instability at High Dissipation Levels	71
5.1	Flux-Flow Dissipation	72
5.2	Larkin-Ovchinnikov Instability	74
5.3	Bezuglyj-Shklovskij Extension for Quasi-Particle Heating	76
6	The Flux-Flow Instability in $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$	79
6.1	Sample Information and Experimental Details	79
6.2	The Voltage Instability in CVC's	80
6.2.1	Heating Effects	81
6.2.2	Larkin-Ovchinnikov Flux-Flow Instability	83
6.2.3	Experimental Observation of Quasi-Particle Heating	84
6.2.4	Quasi-Particle Scattering Rates and Diffusion Lengths	86

6.3 Angular Dependence of the Instability	88
6.4 Conclusions on the Vortex Instability in BSCCO	92
7 Correlation of Instability and Vortex Glass in $\text{YBa}_2\text{Cu}_3\text{O}_7$	93
7.1 Influence of Substrate Material	93
7.2 LO and BS Quasi-Particle Scattering Rates	95
7.3 Vortex Glass Phase Correlation	100
7.4 Conclusions on the Vortex Instability in YBCO	103
8 Time-Resolved Measurements of the Vortex Instability	107
8.1 Experimental Setup	108
8.2 Heating Effects for Rapid Current Pulses	109
8.3 Time Dependence of the Voltage Instability	111
8.4 Conclusions from Time-Resolved Measurements	117
9 Concluding Remarks	121
Bibliography	125