

# Contents

<b>1</b>	<b>Introduction</b>	1
1.1	Mesoscopic Physics	1
1.1.1	Two-Dimensional Electron Gas	3
1.2	Quantum Hall Effect Basics	5
1.2.1	Classical Hall Effect	5
1.2.2	Experimental Results	6
1.2.3	Landau Quantization	8
1.3	Theoretical Approaches to Quantum Hall Effect	12
1.3.1	Single Particle Picture	12
1.3.2	Effective Theory	17
1.3.3	Microscopic Approach	24
1.4	Quantum Hall Effect at Mesoscopic Scales	31
1.4.1	Mesoscopic Systems Utilizing Edge States	31
1.4.2	Formulation of Problems and Outline	34
	References	36

## Part I Integer Quantum Hall Effect

<b>2</b>	<b>Equilibrium and Non-Equilibrium Bosonization</b>	41
2.1	Bosonization of One-Dimensional Fermions	41
2.1.1	One-Dimensional Interacting Systems	41
2.1.2	Bosonic Fields and Hamiltonian	43
2.1.3	Quantization of Boson Fields and Zero Modes	46
2.2	Correlation Function at Finite Temperature	47
2.3	Non-Equilibrium Bosonization	49
2.3.1	Non-Equilibrium Boundary Conditions and Full Counting Statistics	50
2.3.2	Equilibrium Boundary Conditions: A Simple Test	51

2.4	Conclusions . . . . .	53
	References . . . . .	53
<b>3</b>	<b>Interaction Induced Dephasing of Edge States. . . . .</b>	<b>55</b>
3.1	Experimental Results . . . . .	55
3.1.1	Only Interfering Edge Channel is Biased . . . . .	55
3.1.2	All Edge Channels are Biased . . . . .	57
3.2	Model of Mach-Zehnder Interferometer . . . . .	58
3.2.1	Fields and Hamiltonian . . . . .	59
3.2.2	Bosonization. . . . .	60
3.2.3	Strong Interaction Limit and the Universality. . . . .	61
3.3	Visibility and Phase Shift . . . . .	63
3.4	Discussion of Experiments . . . . .	66
3.4.1	Only Interfering Edge Channel is Biased . . . . .	69
3.4.2	All Edge Channels are Biased . . . . .	71
3.4.3	Effects of Finite Temperature. . . . .	73
3.5	Conclusion . . . . .	74
	References . . . . .	76
<b>4</b>	<b>Noise Induced Dephasing of Edge States. . . . .</b>	<b>77</b>
4.1	Experimental Setup and the Model . . . . .	78
4.2	Correlation Functions. . . . .	80
4.3	Situation with Non-Equilibrium Gaussian Noise . . . . .	82
4.4	Noise Induced Phase Transition. . . . .	85
4.4.1	Non-Gaussian Noise in Markovian Limit. . . . .	85
4.4.2	Quantum Correction at Critical Point . . . . .	87
4.5	Conclusions . . . . .	88
	References . . . . .	89
<b>5</b>	<b>Energy Relaxation at the Quantum Hall Edge . . . . .</b>	<b>91</b>
5.1	Experimental Results . . . . .	92
5.2	Theoretical Model . . . . .	94
5.2.1	Correlation Function . . . . .	95
5.3	Electron Distribution Function . . . . .	98
5.3.1	Short Distances. . . . .	98
5.3.2	Intermediate Distances. . . . .	100
5.3.3	Long Distances. . . . .	102
5.4	Measured and Total Heat Fluxes . . . . .	102
5.5	Conclusions . . . . .	105
	References . . . . .	107

## Part II Fractional Quantum Hall Effect

<b>6</b>	<b>Classification of Effective Edge Models . . . . .</b>	<b>111</b>
6.1	Effective Theory of Quantum Hall Edges . . . . .	112
6.1.1	Chern–Simons Theory and Gauge Anomaly . . . . .	112
6.1.2	Hydrodynamics of Incompressible Edge Deformations . . . . .	114
6.1.3	Quantization of Edge Excitations . . . . .	116
6.1.4	Gauge-Invariant Formulation . . . . .	117
6.2	Multi-Channel Edge Models . . . . .	119
6.2.1	Kinematics of Edge Models . . . . .	119
6.2.2	Local Excitations . . . . .	122
6.2.3	Scaling Dimensions of Local Excitations . . . . .	123
6.3	Conclusions . . . . .	124
	References . . . . .	125
<b>7</b>	<b>Spectroscopy of Quantum Hall Edge States at Complex Filling Factors . . . . .</b>	<b>127</b>
7.1	Minimal Models for Filling Factor $\nu = 2/m$ . . . . .	129
7.2	The Role of Coulomb Interactions . . . . .	132
7.3	Experimental Determination of Scaling Dimensions of Quasi-Particles . . . . .	133
7.3.1	Charge Current Through Interferometer . . . . .	133
7.3.2	Low-Temperature and High-Temperature Behavior of Current . . . . .	137
7.4	Conclusion . . . . .	138
	References . . . . .	140
<b>8</b>	<b>Microscopic Theory of Fractional Quantum Hall Interferometers . . . . .</b>	<b>143</b>
8.1	Byers–Yang Paradox . . . . .	145
8.2	Outline of Microscopic Theory . . . . .	147
8.3	Microscopic Description of a Quantum Hall Interferometer . . . .	149
8.3.1	Plasma Analogy and Incompressible States . . . . .	151
8.3.2	Low-Energy Subspace . . . . .	155
8.4	Projection onto the Low-Energy Subspace . . . . .	157
8.4.1	Edge Hamiltonian . . . . .	158
8.4.2	Tunneling Hamiltonian . . . . .	160
8.4.3	Deformations of the Ground State . . . . .	163
8.5	Quantum Hall Interferometer Away From Equilibrium . . . . .	165
8.5.1	Ohmic Contacts . . . . .	166
8.5.2	Current Through the Interferometer . . . . .	169
8.6	Conclusion . . . . .	173
	References . . . . .	174

**9 Summary of Results. . . . . 177**

    9.1 Integer Quantum Hall Effect. . . . . 177

    9.2 Fractional Quantum Hall Effect. . . . . 178

**Appendices . . . . . 181**

Mesoscopic Quantum Hall Effect

Levkivskyi, I.

2012, XIV, 198 p., Hardcover

ISBN: 978-3-642-30498-9