

Contents

1	Introduction	1
1.1	What Are Wiring Diagrams?	1
1.2	Purposes of this Monograph	3
1.3	Audience and Features	5
1.4	Chapter Summaries	5
1.5	References for the Main Results and Examples	8
 Part I Wiring Diagrams		
2	Wiring Diagrams	13
2.1	Colored Operads.....	13
2.2	Defining Wiring Diagrams.....	23
2.3	Operad Structure	30
2.4	Summary of this Chapter	37
3	Generators and Relations	39
3.1	Generating Wiring Diagrams	40
3.2	Internal Wasted Wires	44
3.3	Elementary Relations	46
3.4	Summary of this Chapter	61
4	Decomposition of Wiring Diagrams	63
4.1	Factoring Wiring Diagrams	64
4.2	Unary Wiring Diagrams.....	69
4.3	Unary Wiring Diagrams with No Loop Elements	74
4.4	Summary of this Chapter	87
5	Finite Presentation	89
5.1	Stratified Presentation	90
5.2	Finite Presentation for Wiring Diagrams.....	94
5.3	Finite Presentation for Normal Wiring Diagrams.....	101
5.4	Finite Presentation for Strict Wiring Diagrams	102
5.5	Summary of this Chapter	105

6	Finite Presentation for Algebras over Wiring Diagrams	107
6.1	Operad Algebras.....	108
6.2	Algebras over the Operad of Wiring Diagrams	112
6.3	Finite Presentation for the Propagator Algebra	121
6.4	Algebras over the Operad of Normal Wiring Diagrams	140
6.5	Finite Presentation for the Algebra of Discrete Systems	141
6.6	Algebras over the Operad of Strict Wiring Diagrams	149
6.7	Finite Presentation for the Algebra of Open Dynamical Systems	149
6.8	Summary of this Chapter	155
 Part II Undirected Wiring Diagrams		
7	Undirected Wiring Diagrams	159
7.1	Defining Undirected Wiring Diagrams	159
7.2	Pushouts	164
7.3	Operad Structure	165
7.4	Summary of this Chapter	174
8	Generators and Relations	175
8.1	Generating Undirected Wiring Diagrams	175
8.2	Elementary Relations	178
8.3	Wasted Cables	186
8.4	Summary of this Chapter	189
9	Decomposition of Undirected Wiring Diagrams	191
9.1	A Motivating Example	191
9.2	Factoring Undirected Wiring Diagrams	195
9.3	The Inner Undirected Wiring Diagram	197
9.4	The Outer Undirected Wiring Diagram	200
9.5	Iterated Splits	204
9.6	Iterated Loops	207
9.7	Summary of this Chapter	209
10	Finite Presentation for Undirected Wiring Diagrams	211
10.1	Stratified Presentation	211
10.2	Elementary Equivalences	214
10.3	Summary of this Chapter	219
11	Algebras of Undirected Wiring Diagrams	221
11.1	Finite Presentation for Algebras	222
11.2	Finite Presentation for the Relational Algebra	229
11.3	Spivak's Conjecture: Rigidity of the Relational Algebra	232
11.4	Finite Presentation for the Typed Relational Algebra	236
11.5	Summary of this Chapter	239

Part III Maps Between Operads of Wiring Diagrams

12 A Map from Normal to Undirected Wiring Diagrams 243

 12.1 Operad Maps 244

 12.2 Normal to Undirected Wiring Diagrams 247

 12.3 Examples of the Operad Map 253

 12.4 Image of the Operad Map 257

 12.5 Map from Strict to Undirected Wiring Diagrams 263

 12.6 Summary of this Chapter 267

13 A Map from Wiring Diagrams to Undirected Wiring Diagrams 269

 13.1 Wiring Diagrams to Undirected Wiring Diagrams 270

 13.2 Examples of the Operad Map 276

 13.3 Surjectivity of the Operad Map 278

 13.4 Summary of this Chapter 285

14 Problems 287

A Further Reading 291

B List of Notation 295

References 299

Index 303