

Contents

| | | |
|----------|---|-----|
| 1 | Physicists in Wonderland | 1 |
| 1.1 | What This Book Is About | 1 |
| 1.2 | Back to Copenhagen | 4 |
| 1.3 | What Do Physicists Say Now? | 8 |
| 1.4 | But There has Never Been a Consensus | 11 |
| 1.5 | Why Bother? | 14 |
| 1.6 | Outline of the Book | 17 |
| 2 | The First Mystery: Interference and Superpositions | 21 |
| 2.1 | The Spin | 21 |
| 2.2 | The Mach–Zehnder Interferometer | 24 |
| 2.3 | The Quantum Formalism | 28 |
| 2.4 | How Does It Work? | 32 |
| 2.5 | What Is the Meaning of the Quantum State? | 33 |
| 2.5.1 | The Measurement Process Within the Quantum Formalism | 36 |
| 2.5.2 | The “Naive” Statistical Interpretation | 41 |
| 2.6 | Conclusions | 44 |
| | Appendices | 45 |
| 3 | “Philosophical” Intermezzo | 73 |
| 3.1 | Realism and Idealism | 73 |
| 3.2 | Scientific Realism | 80 |
| 3.2.1 | Underdetermination | 81 |
| 3.2.2 | Incommensurability of “Paradigms” | 83 |
| 3.2.3 | The Status of “Unobservable Entities” | 86 |
| 3.3 | Realism and Quantum Mechanics | 91 |
| 3.4 | Determinism | 94 |
| 3.4.1 | Definitions | 94 |
| 3.4.2 | Determinism and “Chaos Theory” | 98 |
| 3.4.3 | Probabilities in Classical Physics | 101 |

| | | |
|----------|---|------------|
| 3.4.4 | The Law of Large Numbers and Scientific Explanations | 104 |
| 3.4.5 | “Randomness” and Deterministic Dynamical Systems | 105 |
| 3.4.6 | Quantum Mechanics and Determinism | 106 |
| | Appendix | 107 |
| 4 | The Second Mystery: Nonlocality | 111 |
| 4.1 | Introduction | 111 |
| 4.2 | Einstein’s Boxes | 113 |
| 4.3 | What Is Nonlocality? | 115 |
| 4.4 | A Simple Proof of Nonlocality | 118 |
| 4.4.1 | An Anthropomorphic Thought Experiment | 118 |
| 4.4.2 | A Real Quantum Situation | 121 |
| 4.4.3 | Conclusions | 123 |
| | Appendix | 127 |
| 5 | The de Broglie–Bohm Theory | 129 |
| 5.1 | The Theory | 130 |
| 5.1.1 | The Equations of the Theory | 130 |
| 5.1.2 | How Does the de Broglie–Bohm Dynamic Work? | 134 |
| 5.1.3 | What About the Statistical Predictions of Quantum Mechanics? | 137 |
| 5.1.4 | Measurements of “Observables” in the de Broglie–Bohm Theory | 140 |
| 5.1.5 | “Contextuality” and Naive Realism About Operators | 151 |
| 5.1.6 | What About the Collapse of the Quantum State? | 152 |
| 5.1.7 | What Are the Meaning and the Origin of the Statistical Assumptions on the Initial Conditions in the de Broglie–Bohm Theory? | 155 |
| 5.1.8 | Heisenberg’s Relations and Absolute Uncertainty | 159 |
| 5.1.9 | What Is the Relationship Between the de Broglie–Bohm Theory and Ordinary Quantum Mechanics? | 161 |
| 5.2 | Some Natural Questions About the de Broglie–Bohm Theory | 162 |
| 5.2.1 | How Does the de Broglie–Bohm Theory Account for Nonlocality? | 162 |
| 5.2.2 | What About Relativity? | 169 |
| 5.2.3 | What About the Classical Limit? | 173 |
| 5.3 | Other Objections | 174 |
| 5.3.1 | Isn’t This a Return to Classical Mechanics? | 175 |
| 5.3.2 | Isn’t the Theory Too Complicated? | 176 |

| | | |
|----------|---|------------|
| 5.3.3 | What About the Symmetry Between Position and Momentum? | 177 |
| 5.3.4 | What About the No Hidden Variables Theorems? | 178 |
| 5.3.5 | If the Predictions of the de Broglie–Bohm Theory Are the Same as Those of Quantum Mechanics, What Is the Point of the de Broglie–Bohm Theory? | 179 |
| 5.3.6 | Why Isn’t there an Action–Reaction Principle in the de Broglie–Bohm Theory? | 179 |
| 5.4 | Conclusions | 180 |
| 5.4.1 | Trouble in Paradise? | 180 |
| 5.4.2 | The Merits of the de Broglie–Bohm Theory | 183 |
| | Appendices. | 185 |
| 6 | Are There Any Alternative Theories? | 199 |
| 6.1 | The Many-Worlds Interpretation | 200 |
| 6.1.1 | The Naive Many-Worlds Interpretation | 200 |
| 6.1.2 | A Precise Many-Worlds Interpretation | 207 |
| 6.1.3 | The Pure Wave Function Ontology | 209 |
| 6.2 | The Spontaneous Collapse Theories | 213 |
| 6.3 | The Decoherent Histories Approach | 216 |
| 6.4 | QBism | 222 |
| 6.5 | Conclusions | 227 |
| | Appendices. | 228 |
| 7 | Revisiting the History of Quantum Mechanics. | 233 |
| 7.1 | The Bohr–Einstein Debate. | 234 |
| 7.1.1 | What Was the Debate Really About? | 234 |
| 7.1.2 | The 1927 Solvay Conference. | 236 |
| 7.1.3 | The Photon and the Box Experiment | 238 |
| 7.1.4 | The Einstein–Podolsky–Rosen Argument | 241 |
| 7.1.5 | Who Won the Bohr–Einstein Debate? | 244 |
| 7.2 | Born and Einstein | 247 |
| 7.3 | What Did Schrödinger Really Worry About? | 249 |
| 7.4 | The von Neumann No Hidden Variables Theorem | 253 |
| 7.5 | Misunderstandings of Bell. | 258 |
| 7.6 | The Non-reception of de Broglie’s and Bohm’s Ideas. | 264 |
| 7.6.1 | Reactions to de Broglie. | 264 |
| 7.6.2 | Reactions to Bohm. | 269 |
| 7.7 | Quantum Mechanics, “Philosophy”, and Politics | 275 |
| 7.8 | Conclusions | 283 |
| 8 | Quantum Mechanics and Our “Culture”. | 285 |
| 8.1 | The Trouble with Quantum Mechanics | 286 |
| 8.2 | A Plea for “Copenhagen” | 288 |

| | | |
|-----|--|------------|
| 8.3 | But What About Now? | 289 |
| 8.4 | Understanding Quantum Mechanics: An Unfinished Story | 292 |
| | Glossary | 295 |
| | References | 303 |
| | Author Index | 323 |
| | Subject Index | 327 |



<http://www.springer.com/978-3-319-25887-4>

Making Sense of Quantum Mechanics

Bricmont, J.

2016, X, 331 p. 26 illus., 25 illus. in color., Hardcover

ISBN: 978-3-319-25887-4