

Quantum Paradoxes and Physical Reality

by

Franco Selleri

*Dipartimento di Fisica,
Università di Bari, Italy*

edited by

Alwyn van der Merwe

*Department of Physics,
University of Denver, U.S.A.*

o



KLUWER ACADEMIC PUBLISHERS
DORDRECHT / BOSTON / LONDON

Table of Contents

Preface	vii
Chapter 1 / Quantum Theorists and the Physical World	1
1.1. Three Central Questions about Physics	1
1.2. The Older Generation	4
1.3. The Middle Generation	8
1.4. The Younger Generation	17
1.5. Conclusions	24
Chapter 2 / Is Quantum Mechanics a Complete Theory?	33
2.1. The Problem of Completeness and of Hidden Variables	33
2.2. De Broglie's Paradox	36
2.3. The Spin-1/2 System in Quantum Mechanics	40
2.4. A Simple Proof of von Neumann's Theorem	44
2.5. The Theorem is not General Enough	48
2.6. Von Neumann's Theorem: Assumptions, Definitions, and Results	51
2.7. General Proof of von Neumann's Theorem	54
2.8. Jauch and Piron's Theorem	61
2.9. The Debate on Impossibility Proofs	69
Chapter 3 / The Wave—Particle Duality	73
3.1. Duality for Photons	73
3.2. Duality for Neutrons	77
3.3. Einstein's Discovery of Duality	81
3.4. De Broglie's Duality	86
3.5. Schrödinger's Waves	92
3.6. Bohr's Complementarity	97
3.7. Fock's Relativity with Respect to the Means of Observation	103
3.8. Heisenberg Beyond Complementarity	107
3.9. The Consciousness Interpretation	111
3.10. Delayed Choices	114
3.11. How to do what Complementarity Forbids	118

Chapter 4 / Properties of Quantum Waves	123
4.1. Quantum Waves and Quantum Potential	123
4.2. Experiments on the Nature of Duality	130
4.3. Stimulated Emission	137
4.4. Quantitative Empty Wave Amplification	144
4.5. Two Further Experimental Proposals	156
4.6. Triple-Slit Experiments	160
4.7. The Bohm—Aharonov Effect	167
4.8. Further Ideas about Wave—Particle Duality	171
Chapter 5 / The Einstein—Podolsky—Rosen Paradox	181
5.1. The Original Formulation	181
5.2. Bohr’s Answer	187
5.3. Two Types of State Vectors	191
5.4. Spin States for Two Particles	197
5.5. Reality and Separability	200
5.6. The EPR Paradox: Quantum Mechanics Complete	204
5.7. The EPR Paradox: Quantum Mechanics not Complete	210
5.8. From Theory to Practice	216
5.9. The Experimental Information	226
5.10. Solution 1: Modifying the Past	235
5.11. Solution 2: Superluminal Connections	240
5.12. Solution 3: New Definitions of Probability	247
5.13. Solution 4: Modifications of Quantum Theory	254
Chapter 6 / The EPR Paradox in the Real World	264
6.1. Criticisms of Einstein Locality	264
6.2. Probabilistic Einstein Locality	269
6.3. New Proof of Bell’s Inequality	276
6.4. Probabilities for Pairs of Correlated Systems	279
6.5. A New Factorizability Condition	285
6.6. All the Inequalities of Einstein Locality	290
6.7. Tests of the EPR Paradox in Particle Physics	302
6.8. On the Possibility of New Experiments	307
6.9. Variable Probabilities	310
Chapter 7 / Perspectives of Physical Realism	321
7.1. Objectivity of Scientific Knowledge	321
7.2. Mathematics and Reality	325
7.3. The Role of History of Physics	334
7.4. Fragmentation of Modern Physics	338
7.5. Niels Bohr and Philosophy	345
7.6. Quantum Physics and Biological Sciences	352
7.7. Forms of Physical Realism	356
Index	367