



# Contents



# Table of Contents

Dedication	v
Preface	xiii
Questions to Consider xxii; Plausible, If Radical, Answers to Quantum Questions xxiv	
1. Introduction	3
Is Reality Continuous or Discrete? 4; Absolute Principles of Physics 6; Probability, Entropy, and Information 7	
2. Chance	11
The History of Chance 13	
3. Matter	19
Boltzmann's Philosophy 22	
4. Light	25
Planck's Discovery of the Blackbody Radiation Law 28; The Significance of Planck's Quantum of Action 32; Comparison of Matter and Light Distribution Laws 33; The Ultraviolet Catastrophe 34; No Progress on Microscopic Irreversibility 37	
5. Statistical Mechanics	39
What Did Statistics Mean for Einstein? 40; What Are the Fluctuations? 41; Had Gibbs Done Everything Before Einstein? 42	
6. Light Quantum Hypothesis and Nonlocality	47
Photoelectric Effect 49; Entropies of Radiation and Matter 51; Nonlocality 52	
7. Brownian Motion and Relativity	55
8. Specific Heat	59
9. Wave-Particle Duality	65
From Matter to Light to Matter 67	
10. Bohr-Einstein Atom	71
Chance in Atomic Processes 77; An Independent Criticism of Bohr on Einstein 78	



11. Transition Probabilities	81
12. Microscopic Irreversibility	87
The Origin of Microscopic Irreversibility 89;	
Detailed Balancing 92	
13. A Nobel Prize and Experimental Confirmations	95
14. De Broglie Pilot Waves	99
15. Bose-Einstein Statistics	103
16. Bohr-Kramers-Slater	107
17. Matrix Mechanics	111
Heisenberg on Einstein's Light Quanta 114	
18. Wave Mechanics	119
19. Dirac's Principles of Quantum Mechanics	123
Dirac's Three Polarizers 140; The Mystery of the Oblique	
Polarizer 140; Objective Reality and Dirac's "Manner of	
Speaking" 143; The Schrödinger Equation 144;	
Dirac's Principle of Superposition 144; Dirac's Axiom of	
Measurement 146; Dirac's Projection Postulate 147;	
Pauli's Two Kinds of Measurement 149	
20. Statistical Interpretation	153
21. Heisenberg's Uncertainty Principle	159
Heisenberg's Microscope 160	
22. Bohr Complementarity	165
Heisenberg's Microscope Revisited 167; Bohr's Uncertainty	
Derivation 168; Free Choice in Quantum Mechanics 169	
23. Nonlocality at the 1927 Solvay Conference	171
"Collapse" of the Wave Function 179; The Two-Slit Experiment	
180; Nature's Choice and the Experimenter's Choice 181	
24. Copenhagen Interpretation	183
What Exactly Is in the Copenhagen Interpretation? 186;	
Opposition to the Copenhagen Interpretation 191	



<b>25. Von Neumann Measurement</b>	<b>195</b>
The Measurement Problem 197; The Measurement Apparatus 198; The <i>Schnitt</i> and Conscious Observer 200	
<b>26. Einstein-Podolsky-Rosen</b>	<b>205</b>
Two Places or Paths at the Same Time? 207; Is Quantum Mechanics Complete or Incomplete? 210; EPR in the 21st Century 213	
<b>27. Nonseparability</b>	<b>215</b>
Separability According to Quantum Theory 216	
<b>28. Schrödinger and His Cat</b>	<b>219</b>
Superposition 221; Schrödinger's Cat 222; How Does "Objective Reality" Resolve The Cat Paradox? 226	
<b>29. Entanglement and Symmetry</b>	<b>229</b>
Einstein's Introduction of a False Asymmetry? 230; What Did Einstein See? The Special Frame? 232; No Hidden Variables, but Hidden Constants! 233; Alice's "Free Choice" of Spin Direction 234; Can Conservation Laws Do It All? 238; Pauli's Kinds of Measurement Again 239; How Symmetry and Conservation Explain Entanglement 242	
<b>30. David Bohm's Hidden Variables</b>	<b>247</b>
No "Hidden Variables," but Hidden Constants? 248; Problem of Irreversibility 251	
<b>31. Hugh Everett III's Many Worlds</b>	<b>253</b>
Information and Entropy 255; The <i>Appearance</i> of Irreversibility in a Measurement 256; On the "Conscious Observer" 258; Bryce De Witt 260; Summary of Everett's Ideas 260	
<b>32. John Bell's Inequality</b>	<b>263</b>
Bell's Theorem 265; Experimental Tests of Bell's Inequality 266; Bell's "Shifty Split" 274; Are There Quantum Jumps? 275; John Bell Today 277	
<b>33. Feynman Two-Slit Experiment</b>	<b>279</b>
Feynman's Path-Integral Formulation of Quantum Mechanics 287	



<b>34. Decoherence</b>	<b>289</b>
Decoherence and the Measurement Problem 296; What Decoherence Gets Right 294	
<b>35. Einstein's Principles</b>	<b>301</b>
What Were They 303; Absolute Principles 305	
<b>36. Einstein's Statistics</b>	<b>307</b>
Boltzmann's Principle 307; Quantum Mechanics a Statistical Theory 309; Quantum Statistics 309	
<b>37. Einstein's Continuum</b>	<b>311</b>
God Created the Integers 312	
<b>38. Einstein's Field Theory</b>	<b>315</b>
Castle In The Air 316	
<b>39. Einstein's Objective Reality</b>	<b>321</b>
Irreversibility and Objective Reality 323	
<b>40. Einstein's Quantum Theory</b>	<b>327</b>
<b>41. Einstein's Cosmology</b>	<b>343</b>
The Cosmological Constant 343; The Flatness Problem 343; The Problem of Missing Mass (Dark Matter) 345; Dark Energy (Is the Expansion Accelerating?) 346; The Information Paradox 347	
<b>42. Einstein's Mistakes</b>	<b>349</b>
Fields and Particles 349; Quantum Physics 350; Cosmology 352	
<b>43. Albert Einstein &amp; Information Philosophy</b>	<b>355</b>
On Information Philosophy 355; Where's the Information in Entangled Particles? 359; Where's the Information in the Two-Slit Experiment? 359; Where's the Information in Microscopic Irreversibility? 360; Where's the Information in the Measurement Problem? 361; Where's the Information in a Deterministic World? 361; How Did All the Information in the Universe Get Created? 362	



44. Quantum Information	365
Entangled Qubits	367
45. Problems Solved?	369
Microscopic Irreversibility	369;
Nonlocality	370;
Wave-Particle Duality	371;
Ontological Chance	371;
Nonlocality and Action-at-a-Distance	372;
Two-Slit Experiment	373;
Measurement Problem	373;
Conscious Observer	374;
Entanglement and “Spooky”	
Action-at-a-Distance	374;
Schrödinger’s Cat	375;
No “Hidden Variables,” but Hidden Constants	376;
Is the Universe Deterministic or Indeterministic?	377;
What Is Quantized?	377;
The Bottom Line	378;
How to Restore Credit to Einstein	379;
Poincaré and Einstein	381
46. The Idea of Physical Reality	383
"Maxwell's Influence on the Evolution of the	
Idea of Physical Reality"	385
47. On the Method of Theoretical Physics	389
The Herbert Spencer Lecture	389;
Analysis	395
48. Physics and Reality	397
49. Quantum Mechanics and Reality	409
Bibliography	415
Index	425
Books, Credits, Colophon	435
About I-Phi Books	436

