Contents

Preface ix

Preface to the English Edition xi

§1. The algebra of observables in classical mechanics 1

§2. States 6

§3. Liouville’s theorem, and two pictures of motion in classical mechanics 13

§4. Physical bases of quantum mechanics 15

§5. A finite-dimensional model of quantum mechanics 27

§6. States in quantum mechanics 32

§7. Heisenberg uncertainty relations 36

§8. Physical meaning of the eigenvalues and eigenvectors of observables 39

§9. Two pictures of motion in quantum mechanics. The Schrödinger equation. Stationary states 44

§10. Quantum mechanics of real systems. The Heisenberg commutation relations 49

§11. Coordinate and momentum representations 54

§12. “Eigenfunctions” of the operators $Q$ and $P$ 60

§13. The energy, the angular momentum, and other examples of observables 63
§ 14. The interconnection between quantum and classical mechanics. Passage to the limit from quantum mechanics to classical mechanics 69

§ 15. One-dimensional problems of quantum mechanics. A free one-dimensional particle 77

§ 16. The harmonic oscillator 83

§ 17. The problem of the oscillator in the coordinate representation 87

§ 18. Representation of the states of a one-dimensional particle in the sequence space $l_2$ 90

§ 19. Representation of the states for a one-dimensional particle in the space $\mathcal{D}$ of entire analytic functions 94

§ 20. The general case of one-dimensional motion 95

§ 21. Three-dimensional problems in quantum mechanics. A three-dimensional free particle 103

§ 22. A three-dimensional particle in a potential field 104

§ 23. Angular momentum 106

§ 24. The rotation group 108

§ 25. Representations of the rotation group 111

§ 26. Spherically symmetric operators 114

§ 27. Representation of rotations by $2 \times 2$ unitary matrices 117

§ 28. Representation of the rotation group on a space of entire analytic functions of two complex variables 120

§ 29. Uniqueness of the representations $D_j$ 123

§ 30. Representations of the rotation group on the space $L^2(S^2)$. Spherical functions 127

§ 31. The radial Schrödinger equation 130

§ 32. The hydrogen atom. The alkali metal atoms 136

§ 33. Perturbation theory 147

§ 34. The variational principle 154

§ 35. Scattering theory. Physical formulation of the problem 157

§ 36. Scattering of a one-dimensional particle by a potential barrier 159
§37. Physical meaning of the solutions $\psi_1$ and $\psi_2$ 164
§38. Scattering by a rectangular barrier 167
§39. Scattering by a potential center 169
§40. Motion of wave packets in a central force field 175
§41. The integral equation of scattering theory 181
§42. Derivation of a formula for the cross-section 183
§43. Abstract scattering theory 188
§44. Properties of commuting operators 197
§45. Representation of the state space with respect to a complete set of observables 201
§46. Spin 203
§47. Spin of a system of two electrons 208
§48. Systems of many particles. The identity principle 212
§49. Symmetry of the coordinate wave functions of a system of two electrons. The helium atom 215
§50. Multi-electron atoms. One-electron approximation 217
§51. The self-consistent field equations 223
§52. Mendeleev’s periodic system of the elements 226

Appendix: Lagrangian Formulation of Classical Mechanics 231