Contents

Preface v
Author's Note x

1 Mathematical Background 1

1.1 Bounded operators 1
1.2 Convexity and order 2
1.3 Trace class operators 2
1.4 States 4
1.5 Duality 4
1.6 Convergence 5
1.7 Operator algebras* 6
1.8 Unbounded operators 7
1.9 One parameter semigroups 8
1.10 Tensor products 10
1.11 Measure theory 11
Notes 14

2 Operational Ideas 15

2.1 The repeated Stern–Gerlach experiment 15
2.2 Operations and effects 17
2.3 Pure operations 21
2.4 Irreversible dynamics 26
2.5 A more general formulation* 30
Notes 34

3 Continuous Measurements 35

3.1 Observables 35
3.2 Simultaneous measurement 38
3.3 Approximate position measurements 39
3.4 Observables on phase space 41
3.5 The Wigner distribution 44
Notes 46

4 Operation-Valued Measures 49

4.1 Operations and measures 49
4.2 Composition of instruments 51
4.3 Strongly repeatable instruments 54
4.4 Conditional expectations* 59
4.5 Covariant instruments 60
4.6 Position measurements 66
Notes 68

5 Statistical Properties of Quantum Fields 69

5.1 Measurements in quantum optics 69
5.2 Definition of quantum stochastic processes 70
5.3 Classification of quantum stochastic processes 73
5.4 Measurements on quantum fields 79
5.5 Generators of dynamical semigroups 82
Notes 84

6 The Generalised Wigner–Weisskopf Atom 85

6.1 Beam-foil spectroscopy 85
6.2 Irreducible and simple processes 86
6.3 Recurrence and transience 90
6.4 Transition processes 98
Notes 101

7 Contraction Semigroups on Hilbert Space 103

7.1 Introduction 103
7.2 Dilations of contraction semigroups 105
7.3 Spectrum of the Hamiltonian 108
7.4 Absorption of a particle within a region 112
Notes 116

8 Quantum and Classical Fields 117

8.1 Fock space 117
8.2 Classical states 120
8.3 Evolution of quantum fields with fluctuations 124
8.4 The Weyl algebra* 127
8.5 Generalised coherent states 129
Notes 134

9 Hamiltonian Formalism 135

9.1 Fundamental considerations 135
9.2 Complete positivity* 136
9.3 Projection-valued measures 141
9.4 Finite-dimensional dynamical semigroups 143
Notes 147

10 General Theory of Open Systems 149

10.1 Systems interacting with reservoirs 149
10.2 A second example 150
10.3 Stochastic evolution equations 151
10.4 Derivation of the master equation 153
10.5 Solutions of the master equation 154
Notes 156

Appendix 158

References 161

Index 169