

# Contents

<i>Preface</i>	vii
1. The Basic Ideas	1
1.1 Quantum mechanics and summing up amplitudes . . . . .	1
1.2 Double slit experiment . . . . .	3
1.3 Infinite slits experiment and paths correspondence . . . . .	5
2. The Path Integral for Quantum Mechanics	7
2.1 Time slicing: From infinitesimal to finite time intervals . . . . .	7
2.2 Re-derivation of the Feynman path integrals via the Trotter formula . . . . .	8
2.3 Continuous paths but nowhere differentiable . . . . .	11
2.4 Commutation relations . . . . .	12
2.5 Free particle . . . . .	12
2.6 Quadratic potentials and harmonic oscillator . . . . .	14
2.7 Perturbation theory via path integrals . . . . .	20
3. Introduction to the Semiclassical Approximation	25
3.1 Ordinary WKB method . . . . .	26
3.1.1 Preliminary section . . . . .	26
3.1.2 Hamilton-Jacobi equation . . . . .	28
3.1.3 WKB solutions . . . . .	30
3.1.4 Connection formulas . . . . .	33
3.2 WKB in the path integral language . . . . .	34
3.2.1 Stationary phase method . . . . .	34
3.2.2 Jacobi equation and Van Vleck determinant . . . . .	36

3.3	The semiclassical propagator . . . . .	40
3.3.1	Steady phase approximation method for the path integral . . . . .	41
3.3.2	Approximated path integral evaluation . . . . .	42
3.3.3	Functional determinants . . . . .	45
3.3.4	Final expression . . . . .	46
4.	Wigner Functions and its associated Path Integral . . . . .	49
4.1	Marinov's path integral for Wigner functions . . . . .	53
4.2	Semiclassical expansion in the Marinov's path integral . . . . .	57
5.	Classical Mechanics and its associated Path Integral . . . . .	65
5.1	The work of Koopman-von Neumann (KvN) on the operatorial version of classical mechanics . . . . .	65
5.2	Path Integrals for classical mechanics (CPI) from the KvN formalism . . . . .	67
5.3	Cartan calculus via the CPI . . . . .	72
5.4	Geometric quantization . . . . .	76
5.4.1	Dequantization in the $q$ and $p$ -polarizations and supertime . . . . .	81
5.4.2	Generating functionals and Dyson-Schwinger equa- tions . . . . .	90
5.4.3	Warnings on the dequantization rules . . . . .	94
5.5	Superposition in classical mechanics . . . . .	99
Appendix A	Asynchronous variation of the action . . . . .	105
Appendix B	The equation for the function $f(t_2, t_1)$ intro- duced in Section 2.6 . . . . .	111
Appendix C	Variational calculus in the discrete formalism . . . . .	113
Appendix D	Brief review of Grassmann variables . . . . .	117
Appendix E	Dimensional analysis of $\theta$ and $\bar{\theta}$ . . . . .	121
Appendix F	Schrödinger and Heisenberg picture in $\theta$ and $\bar{\theta}$ . . . . .	125

Appendix G	Classical path integral in the momentum representation	129
Appendix H	Classical path integral via the Trotter formula	133
Appendix I	Ordering problems in the classical path integral	137
	<i>Bibliography</i>	141