

# Contents

<b>1</b>	<b>Unveiling the quantum</b>	1
1.1	One century of quantum physics	4
1.2	Emergence of the microscopic world	10
1.3	Thought experiments coming of age	14
1.4	Aims and outline of this book	20
<b>2</b>	<b>Strangeness and power of the quantum</b>	25
2.1	The superposition principle and the wave function	26
2.2	Quantum interference and complementarity	34
2.3	Identical particles	42
2.4	Entanglement and non-locality	52
2.5	The quantum–classical boundary	68
2.6	Taming the quantum to process information	83
<b>3</b>	<b>Of spins and springs</b>	101
3.1	The field oscillator	106
3.2	Coupled field modes	126
3.3	The spin system	143
3.4	Coupling a spin and a spring: the Jaynes–Cummings model	151
<b>4</b>	<b>The environment is watching</b>	163
4.1	Quantum description of open systems	165
4.2	Quantum maps: the Kraus sum representation	173
4.3	The Lindblad master equation	178
4.4	Quantum Monte Carlo trajectories	189
4.5	Damped spin–spring system: from Rabi to Purcell	203
4.6	Kicking a spring with spins: the micromaser	208
4.7	Collective coupling of $\mathcal{N}$ spins to a spring: superradiance	220
<b>5</b>	<b>Photons in a box</b>	231
5.1	A short history of cavity QED	232
5.2	Giant atom in a cavity: an ideal cavity QED situation	251
5.3	Two experiments unveiling the quantum in a cavity	272
5.4	An atom–photon entangling machine	278
<b>6</b>	<b>Seeing light in subtle ways</b>	297
6.1	Complementarity at quantum–classical boundary	299

6.2	Non-destructive photon number measurement	313
6.3	A quantum gate for multi-particle entanglement engineering	326
6.4	The quantum analogue/digital converter	334
6.5	Photon number parity and Wigner function measurements	348
<b>7</b>	<b>Taming Schrödinger's cat</b>	<b>355</b>
7.1	Representations of photonic cats	358
7.2	A thought experiment to generate optical cats	364
7.3	Dispersive cats in cavity QED	369
7.4	Resonant cats in cavity QED	385
7.5	Decoherence of cavity cats	405
7.6	Non-local cats	430
<b>8</b>	<b>Atoms in a box</b>	<b>443</b>
8.1	Ion trap physics	446
8.2	Engineering ionic states of motion	471
8.3	Ion relaxation and engineered environments	478
8.4	Quantum logic with trapped ions: individual qubit addressing	489
8.5	Quantum logic with trapped ions: collective qubit addressing	501
8.6	Perspectives of ion traps for quantum information	513
<b>9</b>	<b>Entangling matter waves</b>	<b>517</b>
9.1	Second quantization of matter waves	520
9.2	Main features of Bose–Einstein condensation	523
9.3	The phase in Bose–Einstein condensate interference	526
9.4	Coherent collisions and cat-state generation	534
9.5	Matter waves in periodical lattices	546
9.6	Entangling collisions in a Bose–Einstein condensate	556
<b>10</b>	<b>Conclusion</b>	<b>565</b>
	<b>Appendix</b>	<b>569</b>
A.1	Characteristic functions	570
A.2	The Wigner distribution	572
A.3	The Husimi- $Q$ distribution	579
A.4	Phase-space representations of relaxation	582
	<b>Bibliography</b>	<b>587</b>
	<b>Index</b>	<b>603</b>