
List of Figures

1.1	Superposition is like a coin toss	28
2.1	A superradiant laser	33
2.2	NMR of ethanol	37
2.3	Micrometer-sized, single-photon emitters.	44
2.4	Rydberg atoms used to detect radio frequency across the entire spectrum	49
2.5	NIST's ytterbium ion clock	50
2.6	US Navy Quartermaster Seaman Delaney Bodine uses a sextant.	56
2.7	Detecting the gravitational quadrupole of a simple submarine model.	62
2.8	Engine room in an Ohio class nuclear submarine.	62
2.9	A ghost image of a toy soldier.	69
2.10	Ghost images under turbulence and time separation	70
2.11	The Coherent Hard X-ray Scattering (CHX) beamline at the National Synchrotron Light Source II.	71
2.12	The Lockheed HAVE BLUE stealth proof of concept.	72
2.13	Quantum radar	73
3.1	Using a slide rule to compute that $2 \times 3 = 6$	84
3.2	A simple AND gate and its "truth-table."	91
3.3	A simple NOT gate and its truth table.	91
3.4	Full adder	92
3.5	Four-bit adder	92
3.6	An illustration of the complexity classes	114
4.1	Feynman diagram	125
4.2	Exercise in entropy	129
4.3	The value of each variable as the program <code>SORT_NUMBERS</code> runs	132

4.4	An electron bucket	133
4.5	Rules for John Conway’s “Life”	141
4.6	The Fredkin gate (CSWAP)	153
4.7	The Toffoli gate (CCNOT)	153
4.8	Ed Fredkin’s course on digital physics	154
4.9	Attendees at the Physics of Computation Conference .	160
5.1	The possible energy states of two electrons in a hypo- thetical quantum system.	176
5.2	Alice and the Cheshire Cat	186
5.3	A locked suggestion box	193
5.4	The perfluorobutadienyl iron complex IBM used to factor the number 15	204
5.5	A locked safe	214
6.1	2-bit quantum carry circuit.	234
6.2	2-bit quantum sum circuit.	234
6.3	Four-bit quantum adder	235
6.4	Four-bit quantum adder, optimized.	236
6.5	An ion trap built by the Air Force Research Lab . . .	241
6.6	The Jiuzhang Quantum Computer.	243
6.7	A closeup of the Jiuzhang Quantum Computer	250
7.1	Using a LED for QKD	277
7.2	The NSA’s DIANA one-time pad system.	279
7.3	The BB84 Key Exchange Process	282
7.4	Quantum submarine communication	287
7.5	Air Force Research Laboratory quantum key distribu- tion rig	290
7.6	Analysis of Russian intelligence on the US Manhattan Project	291
7.7	xkcd #465: Quantum Teleportation.	298
8.1	A military quantum technology fever dream	311
9.1	Major science, technology, and military projects	394
9.2	Graduate research output in QIS	402
9.3	Patents concerning qubits or quantum entanglement .	452
B.1	Swirls in a soap bubble	485
B.2	Demonstration of wavelength	485

B.3	The photoelectric effect	487
B.4	Newton's rings	490
B.5	Thomas Young's dual-slit experiment	491
B.6	Thomas Young's notebook showing light rays.	491
B.7	Michelson interferometer	496
B.8	Fifth Solvay Conference, Brussels, 1927	503
B.9	Light is a transverse wave	506
B.10	Enhancing a photograph with a circular polarizer. . .	509
B.11	Unpolarized, linearly polarized, and circularly polarized light	510
B.12	Two linear polarizing filters not-overlapping and overlapping	511
B.13	Two overlapping linear polarizing filters aligned 0° , 90° and 0° , 45°	512
B.14	Three overlapping linear polarizers aligned (0° , 90° , 45°) and (0° , 45° , 90°)	512
B.15	Diagram of white light from a candle blocked by colored filters	520
B.16	Diagram of white light from a candle partially blocked by polarizing filters	522
B.17	Diagram showing white light from a candle passing through three filters	522

