References

Chapter 1

[1.1] A. Einstein, B. Podolsky, and N. Rosen, *Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?*, Phys. Rev. **47**, 777 (1935). 3

[1.2] J. S. Bell, *On the Einstein–Podolsky–Rosen Paradox*, Physics **1**, 195 (1964). 3, 34, 35

[1.3] J. F. Clauser, M. A. Horne, A. Shimony, and R. A. Holt, *Proposed Experiment to Test Local Hidden-Variable Theories*, Phys. Rev. Lett. **23**, 880 (1969). 3

[1.4] A. Aspect, P. Grangier, and G. Roger, *Experimental Tests of Realistic Local Theories via Bell's Theorem*, Phys. Rev. Lett. **47**, 460 (1981). 3, 4

[1.5] R. P. Feynman, *Simulating Physics with Computers*, International Journal of Theoretical Physics **21**, 467 (1982). 4, 18, 29, 31

[1.6] R. J. Glauber, *The Quantum Theory of Optical Coherence*, Phys. Rev. **130**, 2530 (1963). 4, 251

[1.7] R. P. Feynman, *Quantum Mechanical Computers*, Foundations of Physics **16**, 507 (1986). 6, 18

[1.8] P. W. Shor, in *Proceedings of the 35th Annual Symposium on the Foundations of Computer Science* (IEEE Computer Society Press, New York, 1994), p. 124. 6, 22, 27

[1.9] J. I. Cirac and P. Zoller, *Quantum Computations with Cold Trapped Ions*, Phys. Rev. Lett. **74**, 4091 (1995). 6, 14, 18, 358, 362

[1.10] F. Schmidt-Kaler, H. Häffner, S. Gulde, M. Riebe, G. P. T. Lancaster, T. Deuschle, C. Becher, W. Hänsel, J. Eschner, C. F. Roos, and R. Blatt, *How to Realize a Universal Quantum Gate with Trapped Ions*, Appl. Phys. B **77**, 789 (2003). 6, 362

[1.11] D. Leibfried, B. DeMarco, V. Meyer, D. Lucas, M. Barrett, J. Britton, W. M. Itano, B. Jelenkovic, C. Langer, T. Rosenband, and D. J. Wineland, *Experimental Demonstration of a Robust, High-Fidelity Geometric Two Ion-Qubit Phase Gate*, Nature **422**, 412 (2003). 6

[1.12] M. A. Nielsen and I. I. Chuang, *Quantum Computation and Quantum Information*, 1st ed. (Cambridge University Press, Cambridge, 2000, 2010). 6, 25, 34, 252

[1.13] M. J. Collett and C. W. Gardiner, *Squeezing of Intracavity and Travelling Wave Light Fields Produced in Parametric Amplification*, Phys. Rev. A **30**, 1386 (1984). 8, 121, 154

[1.14] C. W. Gardiner and M. J. Collett, *Input and Output in Damped Quantum Systems—Quantum Stochastic Differential Equations and the Master Equation*, Phys. Rev. A **31**, 3761 (1985). 8, 121, 154, 161

[1.15] T. Pellizzari, S. A. Gardiner, J. I. Cirac, and P. Zoller, *Decoherence, Continuous Observation, and Quantum Computing: A Cavity QED Model*, Phys. Rev. Lett. **75**, 3788 (1995). 15

[1.16] H. J. Kimble, *The Quantum Internet*, Nature **453**, 1023 (2008). 15, 32, 337

[1.17] D. Loss and D. P. DiVincenzo, *Quantum Computation with Quantum Dots*, Phys. Rev. A **57**, 120 (1998). 16

[1.18] R. Hanson, L. P. Kouwenhoven, J. R. Petta, S. Tarucha, and L. M. K. Vandersypen, *Spins in Few-Electron Quantum Dots*, Rev. Mod. Phys. **79**, 1217 (2007). 16

[1.19] K. M. Weiss, J. M. Elzerman, Y. L. Delley, J. Miguel-Sanchez, and A. Imamoğlu, *Coherent Two-Electron Spin Qubits in an Optically Active Pair of Coupled InGaAs Quantum Dots*, Phys. Rev. Lett. **109**, 107401 (2012). 16

[1.20] M. P. Hedges, J. J. Longdell, Y. Li, and M. J. Sellars, *Efficient Quantum Memory for Light*, Nature **465**, 1052 (2010). 17

[1.21] M. Zhong, M. P. Hedges, R. L. Ahlefeldt, J. G. Bartholomew, S. E. Beavan, S. M. Wittig, J. J. Longdell, and M. J. Sellars, *Optically Addressable Nuclear Spins in a Solid with a Six-Hour Coherence Time*, Nature **517**, 177 (2015). 17

[1.22] E. Knill, R. Laflamme, and G. J. Milburn, *A Scheme for Efficient Quantum Computation with Linear Optics*, Nature **409**, 46 (2001). 17

[1.23] T. B. Pittman, M. J. Fitch, B. C. Jacobs, and J. D. Franson, *Experimental Controlled-NOT Logic Gate for Single Photons in the Coincidence Basis*, Phys. Rev. A **68**, 032316 (2003). 17

[1.24] E. Martin-Lopez, A. Laing, T. Lawson, R. Alvarez, X.-Q. Zhou, and J. L. O'Brien, *Experimental Realization of Shor's Quantum Factoring Algorithm Using Qubit Recycling*, Nature Photonics **6**, 773 (2012). 17

[1.25] R. Hanson and D. D. Awschalom, *Coherent Manipulation of Single Spins in Semiconductors*, Nature **453**, 1043 (2008). 17

Chapter 2

[2.1] R. P. Feynman, *Simulating Physics with Computers*, International Journal of Theoretical Physics **21**, 467 (1982). 4, 18, 29, 31

[2.2] R. P. Feynman, *Quantum Mechanical Computers*, Foundations of Physics **16**, 507 (1986). 6, 18

[2.3] J. I. Cirac and P. Zoller, *Quantum Computations with Cold Trapped Ions*, Phys. Rev. Lett. **74**, 4091 (1995). 6, 14, 18, 358, 362

[2.4] P. W. Shor, in *Proceedings of the 35th Annual Symposium on the Foundations of Computer Science* (IEEE Computer Society Press, New York, 1994), p. 124. 6, 22, 27

[2.5] A. Ekert and R. Jozsa, *Quantum Computation and Shor's Factoring Algorithm*, Rev. Mod. Phys. **68**, 733 (1996). 22, 26, 27, 28, 29

[2.6] D. P. DiVincenzo, *The Physical Implementation of Quantum Computation*, Fortschritte der Physik **48**, 771 (2000). 22

[2.7] D. Deutsch, *Quantum Computational Networks*, Proc. Roy. Soc. London Ser. A **425**, 73 (1989). 23

[2.8] T. Sleator and H. Weinfurter, *Realizable Universal Quantum Logic Gates*, Phys. Rev. Lett. **74**, 4087 (1995). 23

[2.9] A. Peres, *Quantum Theory: Concepts and Methods* (Kluwer, Dordrecht, Boston, 1995). 25

[2.10] M. A. Nielsen and I. I. Chuang, *Quantum Computation and Quantum Information*, 1st ed. (Cambridge University Press, Cambridge, 2000, 2010). 6, 25, 34, 252

[2.11] V. Vedral, A. Barenco, and A. Ekert, *Quantum Networks for Elementary Arithmetic Operations*, Phys. Rev. A **54**, 147 (1996). 26

[2.12] S. Lloyd, *Universal Quantum Simulators*, Science **273**, 1073 (1996). 29

[2.13] H. F. Trotter, *On the Product of Semigroups of Operators*, Proceedings of the American Mathematical Society **10**, 545 (1959). 30

[2.14] T. Kato, in Trotter's Product Formula for an Arbitrary Pair of Self-Adjoint Contraction Semigroups, *Topics in Functional Analysis (Essays Dedicated to M. G. Krein on the Occasion of his 70th Birthday)* (Academic Press, Boston, 1978). 30

Chapter 3

[3.1] H. J. Kimble, *The Quantum Internet*, Nature **453**, 1023 (2008). 15, 32, 337

[3.2] M. A. Nielsen and I. I. Chuang, *Quantum Computation and Quantum Information*, 1st ed. (Cambridge University Press, Cambridge, 2000, 2010). 6, 25, 34, 252

[3.3] R. Horodecki, P. Horodecki, M. Horodecki, and K. Horodecki, *Quantum Entanglement*, Rev. Mod. Phys. **81**, 865 (2009). 34, 39

[3.4] J. S. Bell, *On the Einstein–Podolsky–Rosen Paradox*, Physics **1**, 195 (1964). 3, 34, 35

[3.5] C. H. Bennett, H. J. Bernstein, S. Popescu, and B. Schumacher, *Concentrating Partial Entanglement by Local Operations*, Phys. Rev. A **53**, 2046 (1996). 39

[3.6] S. Popescu and D. Rohrlich, *Thermodynamics and the Measure of Entanglement*, Phys. Rev. A **56**, 3319 (1997). 39

[3.7] L. Amico, R. Fazio, A. Osterloh, and V. Vedral, *Entanglement in Many-Body Systems*, Rev. Mod. Phys. **80**, 517 (2008). 39

[3.8] W. Dür, G. Vidal, and J. I. Cirac, *Three Qubits Can be Entangled in Two Inequivalent Ways*, Phys. Rev. A **62**, 062314 (2000). 40

[3.9] D. M. Greenberger, M. Horne, and A. Zeilinger, in *Bell's Theorem, Quantum Theory and Conceptions of the Universe*, edited by M. Kafatos (Kluwer Academic (Also available as arXiv:0712.0921), Dordrecht, the Netherlands, 1989), p. 69. 40

[3.10] A. Peres, *Separability Criterion for Density Matrices*, Phys. Rev. Lett **77**, 1413 (1996). 41

[3.11] R. Horodecki, P. Horodecki, and M. Horodecki, *Quantum α-Entropy Inequalities: Independent Condition for Local Realism?*, Phys. Lett A **210**, 377 (1996). 41

[3.12] B. P. Lanyon, C. Hempel, D. Nigg, M. Müller, R. Gerritsma, F. Zähringer, P. Schindler, J. T. Barreiro, M. Rambach, G. Kirchmair, M. Hennrich, P. Zoller, R. Blatt, and C. F. Roos, *Universal Digital Quantum Simulation with Trapped Ions*, Science **334**, 57 (2011). 42

[3.13] W. K. Wooters and W. H. Zurek, *A Single Quantum Cannot be Cloned*, Nature **299**, 802 (1982). 42

[3.14] H. Barnum, C. M. Caves, C. A. Fuchs, R. Jozsa, and B. Schumacher, *Noncommuting Mixed States Cannot Be Broadcast*, Phys. Rev. Lett. **76**, 2818 (1996). 42, 43

[3.15] C. H. Bennett, G. Brassard, C. Crepeau, R. Jozsa, A. Peres, and W. K. Wootters, *Teleporting an Unknown Quantum State via Dual Classical and Einstein–Podolsky–Rosen Channels*, Phys. Rev. Lett. **70**, 1895 (1993). 43

[3.16] D. Bouwmeester, J.-W. Pan, K. Mattle, M. Eibl, H. Weinfurter, and A. Zeilinger, *Experimental Quantum Teleportation*, Nature **390**, 575 (1997). 43

[3.17] D. Boschi, S. Branca, F. De Martini, L. Hardy, and S. Popescu, *Experimental Realization of Teleporting an Unknown Pure Quantum State via Dual Classical and Einstein-Podolsky-Rosen Channels*, Phys. Rev. Lett. **80**, 1121 (1998). 43

[3.18] A. Furusawa, J. L. Sørensen, S. L. Braunstein, C. A. Fuchs, H. J. Kimble, and E. S. Polzik, *Unconditional Quantum Teleportation*, Science **282**, 706 (1998). 43

Chapter 4

[4.1] L. Allen and J. H. Eberly, *Optical Resonance and Two-Level Atoms* (Dover, Mineola, N. Y., 1975). 47, 372

[4.2] B. R. Mollow, *Pure-State Analysis of Resonant Light Scattering: Radiative Damping, Saturation, and Multiphoton Effects*, Phys. Rev. A **12**, 1919 (1975). 47, 138, 140

[4.3] T. A. Savard, K. M. O'Hara, and J. E. Thomas, *Laser-Noise-Induced Heating in Far-Off Resonance Optical Traps*, Phys. Rev. A **56**, R1095 (1997). 50

[4.4] C. W. Gardiner, J. Ye, H. C. Nagerl, and H. J. Kimble, *Evaluation of Heating Effects on Atoms Trapped in an Optical Trap*, Phys. Rev. A **61**, 045801 (2000). 50

Chapter 5

[5.1] F. Bloch, *Nuclear Induction*, Phys. Rev. **70**, 460 (1946). 54, 59

[5.2] M. V. Berry, *Quantal Phase Factors Accompanying Adiabatic Changes*, Proceedings of the Royal Society of London. A. Mathematical and Physical Sciences **392**, 45 (1984). 68

Chapter 6

[6.1] S. Schiemann, A. Kuhn, S. Steuerwald, and K. Bergmann, *Efficient Coherent Population Transfer in NO Molecules Using Pulsed Lasers*, Phys. Rev. Lett. **71**, 3637 (1993). 77, 78, 180

[6.2] T. A. Laine and S. Stenholm, *Adiabatic Processes in Three-Level Systems*, Phys. Rev. A **53**, 2501 (1996). 77, 180

[6.3] K. Bergmann, H. Theuer, and B. W. Shore, *Coherent Population Transfer among Quantum States of Atoms and Molecules*, Rev. Mod. Phys. **70**, 1003 (1998). 77, 180

Chapter 7

[7.1] P. L. Kapitza and P. A. M. Dirac, *The Reflection of Electrons from Standing Light Waves*, Mathematical Proceedings of the Cambridge Philosophical Society **29**, 297 (1933). 80, 84

[7.2] P. E. Moskowitz, P. L. Gould, and D. E. Pritchard, *Deflection of Atoms by Standing-Wave Radiation*, J. Opt. Soc. Am. B **2**, 1784 (1985). 80, 84

[7.3] P. L. Gould, G. A. Ruff, and D. E. Pritchard, *Diffraction of Atoms by Light: The Near-Resonant Kapitza–Dirac Effect*, Phys. Rev. Lett. **56**, 827 (1986). 80, 84

[7.4] A. D. Cronin, J. Schmiedmayer, and D. E. Pritchard, *Optics and Interferometry with Atoms and Molecules*, Rev. Mod. Phys. **81**, 1051 (2009). 83, 87

[7.5] P. J. Martin, B. G. Oldaker, A. H. Miklich, and D. E. Pritchard, *Bragg Scattering of Atoms from a Standing Light Wave*, Phys. Rev. Lett. **60**, 515 (1988). 84

[7.6] M. Kozuma, L. Deng, E. W. Hagley, J. Wen, R. Lutwak, K. Helmerson, S. L. Rolston, and W. D. Phillips, *Coherent Splitting of Bose–Einstein Condensed Atoms with Optically Induced Bragg Diffraction*, Phys. Rev. Lett. **82**, 871 (1999). 84

[7.7] H. Müller, S.-W. Chiow, and S. Chu, *Atom-Wave Diffraction between the Raman–Nath and the Bragg Regime: Effective Rabi Frequency, Losses, and Phase Shifts*, Phys. Rev. A **77**, 023609 (2008). 87

[7.8] P. Marte, P. Zoller, and J. L. Hall, *Coherent Atomic Mirrors and Beam Splitters by Adiabatic Passage in Multilevel Systems*, Phys. Rev. A **44**, R4118 (1991). 87, 88

Chapter 8

[8.1] I. I. Sobelman, *Introduction to the Theory of Atomic Spectra* (Pergamon, Oxford, 1972). 90, 94, 95, 110

[8.2] I. I. Sobelman, *Atomic Spectra and Radiative Transitions* (Springer, Berlin, New York, 1979). 90, 94, 95

[8.3] M. J. Seaton, *Quantum Defect Theory*, Rep. Prog. Phys. **46**, 167 (1983). 93

[8.4] E. Arimondo, M. Inguscio, and P. Violino, *Experimental Determinations of the Hyperfine Structure in the Alkali Atoms*, Rev. Mod. Phys. **49**, 31 (1977). 100, 101

[8.5] D. M. Brink and G. R. Satchler, *Angular Momentum* (Oxford University Press, Oxford, 1975). 111, 112, 374

Chapter 9

[9.1] M. J. Collett and C. W. Gardiner, *Squeezing of Intracavity and Travelling Wave Light Fields Produced in Parametric Amplification*, Phys. Rev. A **30**, 1386 (1984). 8, 121, 154

[9.2] C. W. Gardiner and M. J. Collett, *Input and Output in Damped Quantum Systems—Quantum Stochastic Differential Equations and the Master Equation*, Phys. Rev. A **31**, 3761 (1985). 8, 121, 154, 161

[9.3] B. R. Mollow, *Pure-State Analysis of Resonant Light Scattering: Radiative Damping, Saturation, and Multiphoton Effects*, Phys. Rev. A **12**, 1919 (1975). 47, 138, 140

Chapter 10

[10.1] W. J. Munro and C. W. Gardiner, *Non-Rotating-Wave Master Equation*, Phys. Rev. A **53**, 2633 (1996). 149

Chapter 11

[11.1] M. J. Collett and C. W. Gardiner, *Squeezing of Intracavity and Travelling Wave Light Fields Produced in Parametric Amplification*, Phys. Rev. A **30**, 1386 (1984). 8, 121, 154

[11.2] C. W. Gardiner and M. J. Collett, *Input and Output in Damped Quantum Systems—Quantum Stochastic Differential Equations and the Master Equation*, Phys. Rev. A **31**, 3761 (1985). 8, 121, 154, 161

[11.3] B. Yurke and J. S. Denker, *Quantum Network Theory*, Phys. Rev. A **29**, 1419 (1984). 154, 383

[11.4] C. W. Gardiner, *Input and Output in Damped Quantum Systems III: Formulation of Damped Systems Driven by Fermion Fields*, Opt. Comm. **243**, 57 (2004). 168

Chapter 12

[12.1] K. S. Choi, H. Deng, J. Laurat, and H. J. Kimble, *Mapping Photonic Entanglement into and out of a Quantum Memory*, Nature **452**, 67 (2008). 169

[12.2] S. Ritter, C. Nolleke, C. Hahn, A. Reiserer, A. Neuzner, M. Uphoff, M. Mucke, E. Figueroa, J. Bochmann, and G. Rempe, *An Elementary Quantum Network of Single Atoms in Optical Cavities*, Nature **484**, 195 (2012). 169

[12.3] M. I. Kolobov and I. V. Sokolov, *Quantum Theory of Light Interaction with an Optical Amplifier*, Opt. Spektrosk. **62**, 112 (1987). 169

[12.4] H. J. Carmichael, *Quantum Trajectory Theory for Cascaded Open Systems*, Phys. Rev. Lett. **70**, 2273 (1993). 169

[12.5] C. W. Gardiner, *Driving a Quantum System with the Output Field from Another Driven Quantum System*, Phys. Rev. Lett. **70**, 2269 (1993). 169

[12.6] C. W. Gardiner and A. S. Parkins, *Driving Atoms with Light of Arbitrary Statistics*, Phys Rev A **50**, 1792 (1994). 169, 173, 174

[12.7] H. J. Carmichael, *Statistical Methods in Quantum Optics 2: Non-Classical Fields* (Springer, Berlin, Heidelberg, New York, 2008). 173, 337

[12.8] K. Stannigel, P. Rabl, and P. Zoller, *Driven-Dissipative Preparation of Entangled States in Cascaded Quantum-Optical Networks*, New Journal of Physics **14**, 063014 (2012). 174

[12.9] T. Ramos, H. Pichler, A. J. Daley, and P. Zoller, *Quantum Spin Dimers from Chiral Dissipation in Cold-Atom Chains*, Phys. Rev. Lett. **113**, 237203 (2014). 174

[12.10] H. Pichler, T. Ramos, A. J. Daley, and P. Zoller, Quantum Optics of Chiral Spin Networks, arXiv:1411.2963 [quant-ph], (2014). 174

Chapter 13

[13.1] S. Schiemann, A. Kuhn, S. Steuerwald, and K. Bergmann, *Efficient Coherent Population Transfer in NO Molecules Using Pulsed Lasers*, Phys. Rev. Lett. **71**, 3637 (1993). 77, 78, 180

[13.2] T. A. Laine and S. Stenholm, *Adiabatic Processes in Three-Level Systems*, Phys. Rev. A **53**, 2501 (1996). 77, 180

[13.3] K. Bergmann, H. Theuer, and B. W. Shore, *Coherent Population Transfer among Quantum States of Atoms and Molecules*, Rev. Mod. Phys. **70**, 1003 (1998). 77, 180

Chapter 14

[14.1] R. H. Lehmberg, *Radiation from an N-Atom System. I. General Formalism*, Phys. Rev. A **2**, 883 (1970). 185

[14.2] R. H. Lehmberg, *Radiation from an N-Atom System. II. Spontaneous Emission from a Pair of Atoms*, Phys. Rev. A **2**, 889 (1970). 185

[14.3] M. Abramowitz and I. A. Stegun, *Handbook of Mathematical Functions* (Dover, New York, 1965). 188, 189, 198, 350, 352

[14.4] R. H. Dicke, *Coherence in Spontaneous Radiation Processes*, Phys. Rev. **93**, 99 (1954). 194, 437

[14.5] M. Gross and S. Haroche, *Superradiance: An Essay on the Theory of Collective Spontaneous Emission*, Physics Reports **93**, 301 (1982). 194

Chapter 15

[15.1] P. Marte, R. Dum, R. Taieb, and P. Zoller, *Resonance Fluorescence From Quantized One-Dimensional Molasses*, Phys. Rev. A **47**, 1378 (1993). 201

Chapter 16

[16.1] S. Stenholm, *The Semiclassical Theory of Laser Cooling*, Rev. Mod. Phys. **58**, 699 (1986). 212, 228

[16.2] J. Dalibard and C. Cohen-Tannoudji, *Laser Cooling below the Doppler Limit by Polarization Gradients: Simple Theoretical Models*, J. Opt. Soc. Am. B **6**, 2023 (1989). 212

[16.3] C. N. Cohen-Tannoudji and W. D. Phillips, *New Mechanisms for Laser Cooling*, Physics Today **44 (10)**, 33 (1990). 212

[16.4] J. Dalibard and C. Cohen-Tannoudji, *Atomic Motion in Laser Light: Connection Between Semiclassical and Quantum Descriptions*, Journal of Physics B: Atomic and Molecular Physics **18**, 1661 (1985). 212

[16.5] H. J. Metcalf and P. van der Straten, *Laser Cooling and Trapping* (Springer, New York, Berlin, Heidelberg, 1999). 212

[16.6] P. D. Lett, W. D. Phillips, S. L. Rolston, C. E. Tanner, R. N. Watts, and C. I. Westbrook, *Optical Molasses*, J. Opt. Soc. Am. B Soc. **6**, 2084 (1989). 227

Chapter 17

[17.1] M. Lindberg and S. Stenholm, *The Master Equation for Laser Cooling of Trapped Particles*, Journal of Physics B: Atomic and Molecular Physics **17**, 3375 (1984). 228

[17.2] S. Stenholm, *The Semiclassical Theory of Laser Cooling*, Rev. Mod. Phys. **58**, 699 (1986). 212, 228

[17.3] J. I. Cirac, R. Blatt, P. Zoller, and W. D. Phillips, *Laser Cooling of Trapped Ions in a Standing Wave*, Phys. Rev. A **46**, 2668 (1992). 228

Chapter 18

[18.1] L. Mandel, *Fluctuations of Photon Beams and their Correlations*, Proceedings of the Physical Society **72**, 1037 (1958). 243

[18.2] P. L. Kelley and W. H. Kleiner, *Theory of Electromagnetic Field Measurement and Photoelectron Counting*, Phys. Rev. **136**, A316 (1964). 243

[18.3] R. J. Glauber, *The Quantum Theory of Optical Coherence*, Phys. Rev. **130**, 2530 (1963). 4, 251

[18.4] R. J. Glauber, *Coherent and Incoherent States of the Radiation Field*, Phys. Rev. **131**, 2766 (1963). 251

[18.5] M. Corti and V. Degiorgio, *Third-Order Intensity Correlations in Laser Light*, Optics Communications **11**, 1 (1974). 251

[18.6] M. A. Nielsen and I. I. Chuang, *Quantum Computation and Quantum Information*, 1st ed. (Cambridge University Press, Cambridge, 2000, 2010). 6, 25, 34, 252

[18.7] D. F. Walls and G. J. Milburn, *Quantum Optics*, 2nd ed. (Springer, Berlin, Heidelberg, 2008). 255, 337

Chapter 19

[19.1] P. Alsing and H. J. Carmichael, *Spontaneous Dressed-State Polarization of a Coupled Atom and Cavity Mode*, Quantum Optics: Journal of the European Optical Society Part B **3**, 13 (1991). 267

[19.2] N. G. van Kampen, *Stochastic Processes in Physics and Chemistry* (North Holland, Amsterdam, New York, Oxford, 1981, 1992). 274

Chapter 20

[20.1] H. P. Yuen and J. Shapiro, *Optical Communication with Two-Photon Coherent States—Part I: Quantum-State Propagation and Quantum Noise*, IEEE Transactions on Information Theory **24**, 657 (1978). 285

[20.2] J. Shapiro, H. P. Yuen, and A. Mata, *Optical Communication with Two-Photon Coherent States—Part II: Photoemissive Detection and Structured Receiver Performance*, IEEE Transactions on Information Theory **25**, 179 (1979). 285

[20.3] H. P. Yuen and J. Shapiro, *Optical Communication with Two-Photon Coherent States—Part III: Quantum Measurements Realizable with Photoemissive Detectors*, IEEE Transactions on Information Theory **26**, 78 (1980). 285

Chapter 21

[21.1] J. N. Hollenhorst, *Quantum Limits on Resonant-Mass Gravitational-Radiation Detectors*, Phys. Rev. D **19**, 1669 (1979). 301

[21.2] C. M. Caves, *Quantum-Mechanical Noise in an Interferometer*, Phys. Rev. D **23**, 1693 (1981). 302

[21.3] R. E. Slusher, L. W. Hollberg, B. Yurke, J. C. Mertz, and J. F. Valley, *Observation of Squeezed States Generated by Four-Wave Mixing in an Optical Cavity*, Physical Review Letters **55**, 2409 (1985). 308

[21.4] L.-A. Wu, H. J. Kimble, J. L. Hall, and H. Wu, *Generation of Squeezed States by Parametric Down Conversion*, Phys. Rev. Lett. **57**, 2520 (1986). 308, 311

[21.5] R. Movshovich, B. Yurke, P. G. Kaminsky, A. D. Smith, A. H. Silver, R. W. Simon, and M. V. Schneider, *Observation of Zero-Point Noise Squeezing via a Josephson-Parametric Amplifier*, Phys. Rev. Lett. **65**, 1419 (1990). 308, 417

[21.6] N. Bloembergen, *Nonlinear Optics: a Lecture Note and Reprint Volume* (Benjamin, New York, 1965). 309

[21.7] C. M. Caves, *Quantum Limits on Noise in Linear Amplifiers*, Phys. Rev. D **26**, 1817 (1982). 321

Chapter 22

[22.1] R. Miller, T. E. Northup, K. M. Birnbaum, A. Boca, A. D. Boozer, and H. J. Kimble, *Trapped Atoms in Cavity QED: Coupling Quantized Light and Matter*, Journal of Physics B: Atomic, Molecular and Optical Physics **38**, S551 (2005). 327, 328, 337

[22.2] E. Jaynes and F. Cummings, *Comparison of Quantum and Semiclassical Radiation Theories with Application to the Beam Maser*, Proc IEEE **51**, 89 (1963). 327

[22.3] G. Rempe, H. Walther, and N. Klein, *Observation of Quantum Collapse and Revival in a One-Atom Maser*, Phys. Rev. Lett. **58**, 353 (1987). 328, 336

[22.4] J. M. Raimond, M. Brune, and S. Haroche, *Manipulating Quantum Entanglement with Atoms and Photons in a Cavity*, Rev. Mod. Phys. **73**, 565 (2001). 328

[22.5] A. Blais, R.-S. Huang, A. Wallraff, S. M. Girvin, and R. J. Schoelkopf, *Cavity Quantum Electrodynamics for Superconducting Electrical circuits: An Architecture for Quantum Computation*, Phys. Rev. A **69**, 062320 (2004). 334, 383, 402

[22.6] S. Haroche and J.-M. Raimond, *Exploring the Quantum* (Oxford, New York, 2006). 334

[22.7] H. J. Kimble, *The Quantum Internet*, Nature **453**, 1023 (2008). 15, 32, 337

[22.8] D. F. Walls and G. J. Milburn, *Quantum Optics*, 2nd ed. (Springer, Berlin, Heidelberg, 2008). 255, 337

[22.9] H. J. Carmichael, *Statistical Methods in Quantum Optics 2: Non-Classical Fields* (Springer, Berlin, Heidelberg, New York, 2008). 173, 337

Chapter 23

[23.1] C. A. Blockley, D. F. Walls, and H. Risken, *Quantum Collapses and Revivals in a Quantized Trap*, EPL (Europhysics Letters) **17**, 509 (1992). 343

[23.2] C. A. Blockley and D. F. Walls, *Cooling of a Trapped Ion in the Strong-Sideband Regime*, Phys. Rev. A **47**, 2115 (1993). 343

[23.3] S. A. Gardiner, J. I. Cirac, and P. Zoller, *Nonclassical States and Measurement of General Motional Observables of a Trapped Ion*, Phys. Rev. A **55**, 1683 (1997). 347

[23.4] D. Leibfried, R. Blatt, C. Monroe, and D. Wineland, *Quantum Dynamics of Single Trapped Ions*, Rev. Mod. Phys. **75**, 281 (2003). 350

[23.5] M. Abramowitz and I. A. Stegun, *Handbook of Mathematical Functions* (Dover, New York, 1965). 188, 189, 198, 350, 352

[23.6] M. Combescure, *Trapping of Quantum Particles for a Class of Time-Periodic Potentials: A Semi-Classical Approach*, Annals of Physics **173**, 210 (1987). 354, 356

Chapter 24

[24.1] J. I. Cirac and P. Zoller, *Quantum Computations with Cold Trapped Ions*, Phys. Rev. Lett. **74**, 4091 (1995). 6, 14, 18, 358, 362

[24.2] D. James, *Quantum Dynamics of Cold Trapped Ions with Application to Quantum Computation*, Applied Physics B: Lasers and Optics **66**, 181 (1998). 361

[24.3] C. Monroe, D. M. Meekhof, B. E. King, W. M. Itano, and D. J. Wineland, *Demonstration of a Fundamental Quantum Logic Gate*, Phys. Rev. Lett. **75**, 4714 (1995). 362

[24.4] F. Schmidt-Kaler, H. Haffner, M. Riebe, S. Gulde, G. P. T. Lancaster, T. Deuschle, C. Becher, C. F. Roos, J. Eschner, and R. Blatt, *Realization of the Cirac–Zoller Controlled-NOT Quantum Gate*, Nature **422**, 408 (2003). 362

[24.5] F. Schmidt-Kaler, H. Häffner, S. Gulde, M. Riebe, G. P. T. Lancaster, T. Deuschle, C. Becher, W. Hänsel, J. Eschner, C. F. Roos, and R. Blatt, *How to Realize a Universal Quantum Gate with Trapped Ions*, Appl. Phys. B **77**, 789 (2003). 6, 362

[24.6] A. Sørensen and K. Mølmer, *Quantum Computation with Ions in Thermal Motion*, Phys. Rev. Lett. **82**, 1971 (1999). 368

[24.7] K. Mølmer and A. Sørensen, *Multiparticle Entanglement of Hot Trapped Ions*, Phys. Rev. Lett. **82**, 1835 (1999). 368, 372

[24.8] D. M. Greenberger, M. A. Horne, A. Shimony, and A. Zeilinger, *Bell's Theorem without Inequalities*, American Journal of Physics **58**, 1131 (1990). 368

[24.9] L. Allen and J. H. Eberly, *Optical Resonance and Two-Level Atoms* (Dover, Mineola, N. Y., 1975). 47, 372

[24.10] D. M. Brink and G. R. Satchler, *Angular Momentum* (Oxford University Press, Oxford, 1975). 111, 112, 374

[24.11] J. J. García-Ripoll, P. Zoller, and J. I. Cirac, *Coherent Control of Trapped Ions Using Off-Resonant Lasers*, Phys. Rev. A **71**, 062309 (2005). 375, 378, 379

[24.12] Y. Aharonov and J. Anandan, *Phase Change During a Cyclic Quantum Evolution*, Phys. Rev. Lett. **58**, 1593 (1987). 379

[24.13] J. Anandan, J. Christian, and K. Wanelik, *Resource Letter GPP-1: Geometric Phases in Physics*, American Journal of Physics **65**, 180 (1997). 379

[24.14] A. Sørensen and K. Mølmer, *Entanglement and Quantum Computation with Ions in Thermal Motion*, Phys. Rev. A **62**, 022311 (2000). 379

[24.15] P. Schindler, D. Nigg, T. Monz, J. T. Barreiro, E. Martinez, S. X. Wang, S. Quint, M. F. Brandl, V. Nebendahl, C. F. Roos, M. Chwalla, M. Hennrich, and R. Blatt, *A Quantum Information Processor with Trapped Ions*, New Journal of Physics **15**, 123012 (2013). 379

[24.16] D. Kielpinski, C. Monroe, and D. J. Wineland, *Architecture for a Large-Scale Ion-Trap Quantum Computer*, Nature **417**, 709 (2002). 380

[24.17] R. Blatt and D. Wineland, *Entangled States of Trapped Atomic Ions*, Nature **453**, 1008 (2008). 380

[24.18] C. Monroe, R. Raussendorf, A. Ruthven, K. R. Brown, P. Maunz, L.-M. Duan, and J. Kim, *Large-Scale Modular Quantum Computer Architecture with Atomic Memory and Photonic Interconnects*, Phys. Rev. A **89**, 022317 (2014). 380

Chapter 25

[25.1] W. H. Louisell, *Radiation and Noise in Quantum Electronics* (McGraw–Hill, New York, 1964). 383

[25.2] B. Yurke and J. S. Denker, *Quantum Network Theory*, Phys. Rev. A **29**, 1419 (1984). 154, 383

[25.3] M. H. Devoret, in *Quantum Fluctuations (Les Houches, Session LXIII 1995)*, edited by S. Reynaud, E. Giacobino, and J. Zinn-Justin (Elsevier, Amsterdam, 1997), Vol. LXIII, p. 351. 383

[25.4] A. Blais, R.-S. Huang, A. Wallraff, S. M. Girvin, and R. J. Schoelkopf, *Cavity Quantum Electrodynamics for Superconducting Electrical circuits: An Architecture for Quantum Computation*, Phys. Rev. A **69**, 062320 (2004). 334, 383, 402

[25.5] R. M. Foster, *A Reactance Theorem*, Bell Systems Technical Journal **3**, 259 (1924). 387

Chapter 26

[26.1] J. Clarke and F. K. Wilhelm, *Superconducting Quantum Bits*, Nature **453**, 1031 (2008). 402, 417

[26.2] A. Blais, R.-S. Huang, A. Wallraff, S. M. Girvin, and R. J. Schoelkopf, *Cavity Quantum Electrodynamics for Superconducting Electrical circuits: An Architecture for Quantum Computation*, Phys. Rev. A **69**, 062320 (2004). 334, 383, 402

[26.3] A. Cottet, *Implementation of a Quantum Bit in a Superconducting Circuit*, Ph. D. thesis, Université Paris VI (2002). 411

[26.4] J. Koch, T. M. Yu, J. Gambetta, A. A. Houck, D. I. Schuster, J. Majer, A. Blais, M. H. Devoret, S. M. Girvin, and R. J. Schoelkopf, *Charge-Insensitive Qubit Design Derived from the Cooper Pair Box*, Phys. Rev. A **76**, 042319 (2007). 411, 412

[26.5] J. A. Schreier, A. A. Houck, J. Koch, D. I. Schuster, B. R. Johnson, J. M. Chow, J. M. Gambetta, J. Majer, L. Frunzio, M. H. Devoret, S. M. Girvin, and R. J. Schoelkopf, *Suppressing Charge Noise Decoherence in Superconducting Charge Qubits*, Phys. Rev. B **77**, 180502 (2008). 411

[26.6] M. H. Devoret and R. J. Schoelkopf, *Superconducting Circuits for Quantum Information: An Outlook*, Science **339**, 1169 (2013). 412

[26.7] G. Kirchmair, B. Vlastakis, Z. Leghtas, S. E. Nigg, H. Paik, E. Ginossar, M. Mirrahimi, L. Frunzio, S. Girvin, and R. Schoelkopf, *Observation of Quantum State Collapse and Revival Due to the Single-Photon Kerr Effect*, Nature **495**, 205 (2013). 412, 413

[26.8] H. Paik, D. I. Schuster, L. S. Bishop, G. Kirchmair, G. Catelani, A. P. Sears, B. R. Johnson, M. J. Reagor, L. Frunzio, L. I. Glazman, S. M. Girvin, M. H. Devoret, and R. J. Schoelkopf, *Observation of High Coherence in Josephson Junction Qubits Measured in a Three-Dimensional Circuit QED Architecture*, Phys. Rev. Lett. **107**, 240501 (2011). 413

[26.9] M. D. Reed, L. DiCarlo, B. R. Johnson, L. Sun, D. I. Schuster, L. Frunzio, and R. J. Schoelkopf, *High-Fidelity Readout in Circuit Quantum Electrodynamics Using the Jaynes-Cummings Nonlinearity*, Phys. Rev. Lett. **105**, 173601 (2010). 416

[26.10] L. DiCarlo, M. D. Reed, L. Sun, B. R. Johnson, J. M. Chow, J. M. Gambetta, L. Frunzio, S. M. Girvin, M. H. Devoret, and R. J. Schoelkopf, *Preparation and Measurement of Three-Qubit Entanglement in a Superconducting Circuit*, Nature **467**, 574 (2010). 416

[26.11] M. Hatridge, S. Shankar, M. Mirrahimi, F. Schackert, K. Geerlings, T. Brecht, K. M. Sliwa, B. Abdo, L. Frunzio, S. M. Girvin, R. J. Schoelkopf, and M. H. Devoret, *Quantum Back-Action of an Individual Variable-Strength Measurement*, Science **339**, 178 (2013). 416

[26.12] J. Martinis, *Superconducting Phase Qubits*, Quantum Information Processing **8**, 81 (2009). 417

[26.13] B. Yurke, P. Kaminsky, R. Miller, E. Whittaker, A. Smith, A. Silver, and R. Simon, *Observation of 4.2 K Equilibrium-Noise Squeezing via a Josephson-Parametric Amplifier*, Physical Review Letters **60**, 764 (1988). 417

[26.14] R. Movshovich, B. Yurke, P. G. Kaminsky, A. D. Smith, A. H. Silver, R. W. Simon, and M. V. Schneider, *Observation of Zero-Point Noise Squeezing via a Josephson-Parametric Amplifier*, Phys. Rev. Lett. **65**, 1419 (1990). 308, 417

[26.15] N. Bergeal, R. Vijay, V. E. Manucharyan, I. Siddiqi, R. J. Schoelkopf, S. M. Girvin, and M. H. Devoret, *Analog Information Processing at the Quantum Limit with a Josephson Ring Modulator*, Nat Phys **6**, 296 (2010). 418, 419, 420

[26.16] N. Bergeal, F. Schackert, M. Metcalfe, R. Vijay, V. E. Manucharyan, L. Frunzio, D. E. Prober, R. J. Schoelkopf, S. M. Girvin, and M. H. Devoret, *Phase-Preserving Amplification Near the Quantum Limit with a Josephson Ring Modulator*, Nature **465**, 64 (2010). 418

Chapter 27

[27.1] J. I. Cirac, P. Zoller, H. J. Kimble, and H. Mabuchi, *Quantum State Transfer and Entanglement Distribution among Distant Nodes in a Quantum Network*, Phys. Rev. Lett. **78**, 3221 (1997). 432, 433

Chapter 28

[28.1] M. Fleischhauer and M. D. Lukin, *Quantum Memory for Photons: Dark-State Polaritons*, Phys. Rev. A **65**, 022314 (2002). 434

[28.2] M. Fleischhauer, A. Imamoğlu, and J. P. Marangos, *Electromagnetically Induced Transparency: Optics in Coherent Media*, Rev. Mod. Phys. **77**, 633 (2005). 434

[28.3] R. H. Dicke, *Coherence in Spontaneous Radiation Processes*, Phys. Rev. **93**, 99 (1954). 194, 437

[28.4] L. M. Duan, M. D. Lukin, J. I. Cirac, and P. Zoller, *Long-Distance Quantum Communication with Atomic Ensembles and Linear Optics*, Nature **414**, 413 (2001). 452

Chapter 29

[29.1] S. H. Autler and C. H. Townes, *Stark Effect in Rapidly Varying Fields*, Phys. Rev. **100**, 703 (1955). 456

[29.2] K.-J. Boller, A. Imamoğlu, and S. E. Harris, *Observation of Electromagnetically Induced Transparency*, Phys. Rev. Lett. **66**, 2593 (1991). 457

[29.3] L. V. Hau, S. E. Harris, Z. Dutton, and C. H. Behroozi, *Light Speed Reduction to 17 Metres per Second in an Ultracold Atomic Gas*, Nature **397**, 594 (1999). 460