

Bibliography

- [ÅBERG99] Sven Åberg, “Chaos Assisted Tunneling from Superdeformed States,” *Phys. Rev. Lett.* **82**, 299 (1999).
- [ADACHI88] S. Adachi, M. Toda, and K. Ikeda, “Potential for Mixing in Quantum Chaos,” *Phys. Rev. Lett.* **61**, 655 (1988).
- [ADACHI89] S. Adachi, M. Toda, and K. Ikeda, “Recovery of Liouville dynamics in quantum mechanically suppressed chaotic behavior,” *J. Phys. A* **22**, 3291 (1989).
- [ADAMS97] C. S. Adams and E. Riis, “Laser Cooling and Trapping of Neutral Atoms,” *Prog. Quant. Electr.* **21**, 1 (1997).
- [ALEXANDROV93] E. B. Alexandrov, M. P. Chaika, and G. I. Khvostenko, *Interference of Atomic States* (Springer-Verlag, Berlin, 1993).
- [ALLEN87] L. C. Allen and J. H. Eberly, *Optical Resonance and Two-Level Atoms* (Dover, New York, 1987).
- [AMMANN98] H. Ammann, R. Gray, I. Shvarchuck, and N. Christensen, “Quantum Delta-Kicked Rotor: Experimental Observation of Decoherence,” *Phys. Rev. Lett.* **80**, 4111 (1998).
- [ANDERSON58] P. W. Anderson, “Absence of Diffusion in Certain Random Lattices,” *Phys. Rev.* **109**, 1492 (1958).
- [ANDERSON95] M. H. Anderson, J. R. Ensher, M. R. Matthews, C. E. Wieman, and E. A. Cornell, “Observation of Bose-Einstein condensation in a dilute atomic vapor,” *Science* **269**, 198 (1995).
- [ARIMONDO77] E. Arimondo, M. Inguscio, and P. Violino, “Experimental determinations of the hyperfine structure in the alkali atoms,” *Rev. Mod. Phys.* **49**, 31 (1977).
- [ARMSTRONG71] Lloyd Armstrong, Jr., *Theory of the Hyperfine Structure of Free Atoms* (Wiley-Interscience, New York, 1971).

- [ARNDT91] M. Arndt, A. Buchleitner, R. N. Mantegna, and H. Walther, "Experimental Study of Quantum and Classical Limits in Microwave Ionization of Rubidium Rydberg Atoms," *Phys. Rev. Lett.* **67**, 2435 (1991).
- [ARNDT97] M. Arndt, M. Ben Dahan, D. Guéry-Odelin, M. W. Reynolds, and J. Dalibard, "Observation of a Zero-Energy Resonance in Cs-Cs Collisions," *Phys. Rev. Lett.* **79**, 625 (1997).
- [AVERBUKH95] V. Averbukh, N. Moiseyev, B. Mirbach, and H. J. Korsch, "Dynamical tunneling through a chaotic region," *Z. Phys. D* **35**, 247 (1995).
- [BALYKIN95] V. I. Balykin and V. S. Letokhov, *Atom Optics with Laser Light* (Harwood, Switzerland, 1995).
- [BAYFIELD74] J. E. Bayfield and P. M. Koch, "Multiphoton Ionization of Highly Excited Hydrogen Atoms," *Phys. Rev. Lett.* **33**, 258 (1974).
- [BAYFIELD89] J. E. Bayfield, G. Casati, I. Guarneri, and D. W. Sokol, "Localization of Classically Chaotic Diffusion for Hydrogen Atoms in Microwave Fields," *Phys. Rev. Lett.* **63**, 364 (1989).
- [BAYFIELD91] James E. Bayfield, "Near-classical noise enhancement of microwave ionization of Rydberg atoms," *Chaos* **1**, 110 (1991).
- [BAYFIELD96] J. E. Bayfield, S. Y. Luie, L. C. Perotti, and M. P. Skrzypkowski, "Ionization steps and phase-space metamorphoses in the pulsed microwave ionization of highly excited hydrogen atoms," *Phys. Rev. A* **53**, R12 (1996).
- [BELOBROV77] P. I. Belobrov, G. M. Zaslavskii, and G. Kh. Tartakovskii, "Stochastic breaking of bound states in a system of atoms interacting with a radiation field," *Sov. Phys. JETP* **44**, 945 (1977). Translation of *Zh. Eksp. Teor. Fiz.* **71**, 1799 (1976).
- [BENKADDA97] S. Benkadda, S. Kassibrakis, R. B. White, and G. M. Zaslavsky, "Self-similarity and transport in the standard map," *Phys. Rev. E* **55**, 4909 (1997).
- [BENSON95] Oliver Benson, Andreas Buchleitner, Georg Raithel, Markus Arndt, Rosario N. Mantegna, and Herbert Walther, "From coherent to noise-induced microwave ionization of Rydberg atoms," *Phys. Rev. A* **51**, 4862 (1995).
- [BERESTETSKII71] V. B. Berestetskii, E. M. Lifshitz, and L. P. Pitaevskii, *Relativistic Quantum Theory* (Pergamon Press, Oxford, 1971).
- [BERMAN78] G. P. Berman and G. M. Zaslavsky, "Condition of Stochasticity in Quantum Non-linear Systems," *Physica A* **91**, 450 (1978).

- [BERRY87] M. V. Berry, "Quantum chaology," *Proc. R. Soc. Lond. A* **413**, 183 (1987).
- [BERRY91] Michael Berry, "Some Quantum-to-Classical Asymptotics," in *Chaos and Quantum Physics: Proceedings of the Les Houches Summer School, Session LII, 1–31 August 1989*, M.-J. Giannoni, A. Voros, and J. Zinn-Justin, Eds. (North-Holland, Amsterdam, 1991).
- [BERRY99] M. V. Berry and E. Bodenschatz, "Caustics, multiply reconstructed by Talbot interference," *J. Mod. Opt.* **46**, 349 (1999).
- [BETHE57] Hans A. Bethe and Edwin E. Salpeter, *Quantum Mechanics of One- and Two-Electron Atoms* (Springer-Verlag, Berlin, 1957).
- [BHARUCHA97A] C. F. Bharucha, K. W. Madison, P. R. Morrow, S. R. Wilkinson, Bala Sundaram, and M. G. Raizen, "Observation of atomic tunneling from an accelerating optical potential," *Phys. Rev. A* **55**, R857 (1997).
- [BHARUCHA97B] Cyrus Farrokh Bharucha, *Experiments in Dynamical Localization of Ultra-Cold Sodium Atoms Using Time-Dependent Optical Potentials*, Ph.D. dissertation, The University of Texas at Austin (1997).
- [BHARUCHA99] C. F. Bharucha, J. C. Robinson, F. L. Moore, Qian Niu, Bala Sundaram, and M. G. Raizen, "Dynamical localization of ultracold sodium atoms," *Phys. Rev. E* **60**, 3881 (1999).
- [BHATTACHARYA00] Tanmoy Bhattacharya, Salman Habib, and Kurt Jacobs, "Continuous Quantum Measurement and the Emergence of Classical Chaos," *Phys. Rev. Lett.* **85**, 4852 (2000).
- [BHATTACHARYA01] Tanmoy Bhattacharya, Salman Habib, Kurt Jacobs, and Kosuke Shizume, "Strange happenings at the quantum-classical boundary: The delta-kicked rotor," arXiv.org preprint quant-ph/0105086 (2001).
- [BIJLSMA94] M. Bijlsma, B. J. Verhaar, and D. J. Heinzen, "Role of collisions in the search for an electron electric-dipole moment," *Phys. Rev. A* **49**, R4285 (1994).
- [BJORKLUND83] G. C. Bjorklund, M. D. Levenson, W. Lenth, and C. Ortiz, "Frequency Modulation (FM) Spectroscopy," *Appl. Phys. B* **32**, 145 (1983).
- [BLÜMEL89] R. Blümel, R. Graham, L. Sirko, U. Smilansky, H. Walther, and K. Yamada, "Microwave Excitation of Rydberg Atoms in the Presence of Noise," *Phys. Rev. Lett.* **62**, 341 (1989).

- [BLÜMEL91] R. Blümel, A. Buchleitner, R. Graham, L. Sirko, U. Smilansky, and H. Walther, “Dynamical localization in the microwave interaction of Rydberg atoms: The influence of noise,” *Phys. Rev. A* **44**, 4521 (1991).
- [BLÜMEL92] R. Blümel, I. H. Davidson, W. P. Reinhardt, H. Lin, and M. Sharnoff, “Quasilinear ridge structures in water surface waves,” *Phys. Rev. A* **45**, 2641 (1992).
- [BLÜMEL94] R. Blümel, “Exponential Sensitivity and Chaos in Quantum Systems,” *Phys. Rev. Lett.* **73**, 428 (1994).
- [BLÜMEL97] R. Blümel and W. P. Reinhardt, *Chaos in Atomic Physics* (Cambridge University Press, Cambridge, 1997).
- [BOHIGAS84] O. Bohigas, M. J. Giannoni, and C. Schmit, “Characterization of Chaotic Quantum Spectra and Universality of Level Fluctuation Laws,” *Phys. Rev. Lett.* **52**, 1 (1984).
- [BOHIGAS93] O. Bohigas, S. Tomsovic, and D. Ullmo, “Manifestations of Classical Phase Space Structures in Quantum Mechanics,” *Phys. Rep.* **223**, 43 (1993).
- [BOHM93] D. Bohm and B. J. Hiley, *The Undivided Universe* (Routledge, London, 1993).
- [BONCI98] Luca Bonci, Andrea Farusi, Paolo Grigolini, and Roberto Roncaglia, “Tunneling rate fluctuations induced by nonlinear resonances: A quantitative treatment based on semiclassical arguments,” *Phys. Rev. E* **58**, 5689 (1998).
- [BRACK97] Matthias Brack and Rajat K. Bhaduri, *Semiclassical Physics* (Addison-Wesley, Reading, 1997).
- [BRADLEY95] C. C. Bradley, C. A. Sackett, J. J. Tollett, and R. G. Hulet, “Evidence of Bose-Einstein Condensation in an Atomic Gas with Attractive Interactions,” *Phys. Rev. Lett.* **75**, 1687 (1995).
- [BRADLEY99] Michael P. Bradley, James V. Porto, Simon Rainville, James K. Thompson, and David E. Pritchard, “Penning Trap Measurements of the Masses of ^{133}Cs , $^{87,85}\text{Rb}$, and ^{23}Na with Uncertainties ≤ 0.2 ppb,” *Phys. Rev. Lett.* **83**, 4510 (1999).
- [BREIT31] G. Breit and I. I. Rabi, “Measurement of Nuclear Spin,” *Phys. Rev.* **38**, 2082 (1931).
- [BRINK62] D. M. Brink and G. R. Satchler, *Angular Momentum* (Oxford, 1962).
- [BRODIER01] Olivier Brodier, Peter Schlagheck, and Denis Ullmo, “Resonance-Assisted Tunneling in Near-Integrable Systems,” *Phys. Rev. Lett.* **87**, 064101 (2001).
- [BRUN96] Todd A. Brun, Ian C. Percival, and Rüdiger Schack, “Quantum chaos in open systems: a quantum state diffusion analysis,” *J. Phys. A* **29**, 2077 (1996).

- [BRUNE96] M. Brune, E. Hagley, J. Dreyer, X. Maître, A. Maali, C. Wunderlich, J. M. Raimond, and S. Haroche, “Observing the Progressive Decoherence of the ‘Meter’ in a Quantum Measurement,” *Phys. Rev. Lett.* **77**, 4887 (1996).
- [CASATI79] G. Casati, B. V. Chirikov, F. M. Izraelev, and Joseph Ford, “Stochastic Behavior of a Quantum Pendulum under a Periodic Perturbation,” in *Stochastic Behavior in Classical and Quantum Hamiltonian Systems: Proceedings of the Volta Memorial Conference, Como, 1977 (Lecture Notes in Physics Vol. 93)*, G. Casati and J. Ford, Eds. (Springer-Verlag, Berlin, 1979).
- [CASATI94] Giulio Casati, Robert Graham, Italo Guarneri, and Felix M. Izrailev, “Tunneling between localized states in classically chaotic systems,” *Phys. Lett. A* **190**, 159 (1994).
- [CASATI95] Giulio Casati and B. V. Chirikov, “Comment on ‘Decoherence, Chaos, and the Second Law,’” *Phys. Rev. Lett.* **75**, 350 (1995). A comment on [Zurek94].
- [CASTIN98] Y. Castin, J. I. Cirac, and M. Lewenstein, “Reabsorption of Light by Trapped Atoms,” *Phys. Rev. Lett.* **80**, 5305 (1998).
- [CHAPMAN95] Michael S. Chapman, Troy D. Hammond, Alan Lenef, Jörg Schmiedmayer, Richard A. Rubenstein, Edward Smith, and David E. Pritchard, “Photon Scattering from Atoms in an Atom Interferometer: Coherence Lost and Regained,” *Phys. Rev. Lett.* **75**, 3783 (1995).
- [CHINNERY96] P. A. Chinnery and V. F. Humphrey, “Experimental visualization of acoustic resonances within a stadium-shaped cavity,” *Phys. Rev. E* **53**, 272 (1996).
- [CHIRIKOV79] Boris V. Chirikov, “A Universal Instability of Many-Dimensional Oscillator Systems,” *Phys. Rep.* **52**, 263 (1979).
- [CHIRIKOV84] B. V. Chirikov and D. L. Shepelyansky, “Correlation Properties of Dynamical Chaos in Hamiltonian Systems,” *Physica D* **13**, 395 (1984).
- [CHIRIKOV87] B. V. Chirikov, F. M. Izrailev, and D. L. Shepelyansky, “Dynamical Stochasticity in Classical and Quantum Mechanics,” *Sov. Sci. Rev. C* **2**, 209 (1987).
- [CHIRIKOV88] B. V. Chirikov, F. M. Izrailev, and D. L. Shepelyansky, “Quantum Chaos: Localization vs. Ergodicity,” *Physica D* **33**, 77 (1988).
- [CHIRIKOV91] Boris V. Chirikov, “Time-Dependent Quantum Systems,” in *Chaos and Quantum Physics: Proceedings of the Les Houches Summer School, Session LII, 1–31 August 1989*, M.-J. Giannoni, A. Voros, and J. Zinn-Justin, Eds. (North-Holland, Amsterdam, 1991).

- [CHIRIKOV92] Boris V. Chirikov, "The Problem of Quantum Chaos," in *Quantum Chaos: Proceedings of the Eighth Chris Engelbrecht Summer School on Theoretical Physics, Blydepoort, Eastern Transvaal, South Africa, 13–24 January 1992*, W. Dieter Heiss, Ed. (Springer-Verlag, Berlin, 1992).
- [CHIRIKOV95] B. V. Chirikov and D. L. Shepelyansky, "Shnirelman Peak in Level Spacing Statistics," *Phys. Rev. Lett.* **74**, 518 (1995).
- [CHU85] Steven Chu, L. Hollberg, J. E. Bjorkholm, Alex Cable, and A. Ashkin, "Three-Dimensional Viscous Confinement and Cooling of Atoms by Resonance Radiation Pressure," *Phys. Rev. Lett.* **55**, 48 (1985).
- [CHU86] Steven Chu, J. E. Bjorkholm, A. Ashkin, and A. Cable, "Experimental Observation of Optically Trapped Atoms," *Phys. Rev. Lett.* **57**, 314 (1986).
- [CHU98] Steven Chu, "The manipulation of neutral particles," *Rev. Mod. Phys.* **70**, 685 (1998).
- [CLARKE95] R. M. Clarke, I. H. Chan, C. M. Marcus, C. I. Duruöz, J. S. Harris, Jr., K. Campman, and A. C. Gossard, "Temperature dependence of phase breaking in ballistic quantum dots," *Phys. Rev. B* **52**, 2656 (1995).
- [COHEN-TANNOUDJI77] Claude Cohen-Tannoudji, "Atoms in strong resonant fields," in *Les Houches, Session XXVII, 1975 — Frontiers in Laser Spectroscopy*, R. Balian, S. Haroche, and S. Liberman, Eds. (North-Holland, Amsterdam, 1977).
- [COHEN-TANNOUDJI92] Claude Cohen-Tannoudji, Jacques Dupont-Roc, and Gilbert Grynberg, *Atom-Photon Interactions* (Wiley, New York, 1992).
- [COHEN-TANNOUDJI98] Claude N. Cohen-Tannoudji, "Manipulating atoms with photons," *Rev. Mod. Phys.* **70**, 707 (1998).
- [COHEN91] Doron Cohen, "Quantum chaos, dynamical correlations, and the effect of noise on localization," *Phys. Rev. A* **44**, 2292 (1991).
- [COHEN99] Doron Cohen, "Non Perturbative Destruction of Localization in the Quantum Kicked Particle Problem," arXiv.org preprint [chao-dyn/9909016](https://arxiv.org/abs/9909016) (1999).
- [COOPER94] Fred Cooper, John F. Dawson, Dawn Meredith, and Harvey Shepard, "Semiquantum Chaos," *Phys. Rev. Lett.* **72**, 1337 (1994).
- [CORNEY77] Alan Corney, *Atomic and Laser Spectroscopy* (Oxford, 1977).
- [CREAGH98] S. C. Creagh, "Tunnelling in Two Dimensions," in *Tunneling in Complex Systems*, Steven Tomsovic, Ed. (World Scientific, Singapore, 1998).

- [CROMMIE95] M. F. Crommie, C. P. Lutz, D. M. Eigler, and E. J. Heller, “Quantum Corrals,” *Physica D* **83**, 98 (1995).
- [DAHAN96] Maxime Ben Dahan, Ekkehard Peik, Jakob Reichel, Yvan Castin, and Christophe Salomon, “Bloch Oscillations of Atoms in an Optical Potential,” *Phys. Rev. Lett.* **76**, 4508 (1996).
- [DALIBARD85] J. Dalibard and C. Cohen-Tannoudji, “Dressed-atom approach to atomic motion in laser light: the dipole force revisited,” *J. Opt. Soc. Am. B* **2**, 1707 (1985).
- [DALIBARD89] 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).
- [DAVIDSON94] Nir Davidson, Heun Jin Lee, Mark Kasevich, and Steven Chu, “Raman Cooling of Atoms in Two and Three Dimensions,” *Phys. Rev. Lett.* **72**, 3158 (1994).
- [DAVIS81] M. J. Davis and E. J. Heller, “Quantum Dynamical Tunneling in Bound States,” *J. Chem. Phys.* **75**, 246 (1981).
- [DAVIS95] K. B. Davis, M.-O. Mewes, M. R. Andrews, N. J. van Druten, D. S. Durfee, D. M. Kurn, and W. Ketterle, “Bose-Einstein Condensation in a Gas of Sodium Atoms,” *Phys. Rev. Lett.* **75**, 3969 (1995).
- [DE ALCANTARA BONFIM98] O. F. de Alcantara Bonfim, J. Florencio, and F. C. Sá Barreto, “Chaotic dynamics in billiards using Bohm’s quantum mechanics,” *Phys. Rev. E* **58**, R2693 (1998).
- [DELANDE91] Dominique Delande, “Chaos in Atomic and Molecular Physics,” in *Chaos and Quantum Physics: Proceedings of the Les Houches Summer School, Session LII, 1–31 August 1989*, M.-J. Giannoni, A. Voros, and J. Zinn-Justin, Eds. (North-Holland, Amsterdam, 1991).
- [DELANDE01] D. Delande, “Quantum Chaos in Atomic Physics,” in *Coherent Atomic Matter Waves: Proceedings of the Les Houches Summer School, Session LXXII, 27 July – 27 August 1999*, R. Kaiser, C. Westbrook, and F. David, Eds. (Springer-Verlag, Berlin, 2001).
- [DEMBOWSKI00] C. Dembowski, H.-D. Gräf, A. Heine, R. Hofferbert, H. Rehfeld, and A. Richter, “First Experimental Evidence for Chaos-Assisted Tunneling in a Microwave Annular Billiard,” *Phys. Rev. Lett.* **84**, 867 (2000).
- [DEMBOWSKI01] C. Dembowski, H.-D. Gräf, A. Heine, T. Hesse, H. Rehfeld, and A. Richter, “First Experimental Evidence of a Trace Formula for Billiard Systems Showing Mixed Dynamics,” *Phys. Rev. Lett.* **86**, 3284 (2001).

- [DEPUE99] Marshall T. DePue, Colin McCormick, S. Lukman Winoto, Steven Oliver, and David S. Weiss, "Unity Occupation of Sites in a 3D Optical Lattice," *Phys. Rev. Lett.* **82**, 2262 (1999).
- [DEVANEY89] Robert L. Devaney, *An Introduction to Chaotic Dynamical Systems*, second ed. (Addison-Wesley, Reading, 1989).
- [DOHERTY00] A. C. Doherty, K. M. D. Vant, G. H. Ball, N. Christensen, and R. Leonhardt, "Momentum distributions for the quantum δ -kicked rotor with decoherence," *J. Opt. B: Quant. Semiclass. Opt.* **2**, 605 (2000).
- [DORON95] E. Doron and S. D. Frischat, "Semiclassical Description of Tunneling in Mixed Systems: Case of the Annular Billiard," *Phys. Rev. Lett.* **75**, 3661 (1995).
- [DUM92] R. Dum, P. Zoller, and H. Ritsch, "Monte Carlo simulation of the atomic master equation for spontaneous emission," *Phys. Rev. A* **45**, 4879 (1992).
- [DUNN77] M. H. Dunn and A. I. Ferguson, "Coma Compensation in Off-Axis Laser Resonators," *Opt. Comm.* **20**, 214 (1977).
- [DYRTING93] S. Dyrting, G. J. Milburn, and C. A. Holmes, "Nonlinear quantum dynamics at a classical second-order resonance," *Phys. Rev. E* **48**, 969 (1993).
- [DYRTING96] S. Dyrting and G. J. Milburn, "Quantum chaos in atom optics: using phase noise to model continuous momentum and position measurement," *Quant. Semiclass. Opt.* **8**, 541 (1996).
- [ECKHARDT88] Bruno Eckhardt, "Quantum Mechanics of Classically Non-Integrable Systems," *Phys. Rep.* **163**, 205 (1988).
- [EDLÉN66] Bengt Edlén, "The Refractive Index of Air," *Metrologia* **2**, 12 (1966).
- [EICHMANN88] U. Eichmann, K. Richter, D. Wintgen, and W. Sandner, "Scaled-Energy Spectroscopy and Its Relation with Periodic Orbits," *Phys. Rev. Lett.* **61**, 2438 (1988).
- [EINSTEIN17] A. Einstein, "Zum Quantensatz von Sommerfeld und Epstein," *Verh. Deutsch. Phys. Ges.* **19**, 82 (1917).
- [ELLEGAARD95] C. Ellegaard, T. Guhr, K. Lindemann, H. Q. Lorensen, J. Nygård, and M. Oxborrow, "Spectral Statistics of Acoustic Resonances in Aluminum Blocks," *Phys. Rev. Lett.* **75**, 1546 (1995).
- [ELLINGER94] K. Ellinger, J. Cooper, and P. Zoller, "Light-pressure force in N -atom systems," *Phys. Rev. A* **49**, 3909 (1994).

- [FEYNMAN65] R. P. Feynman and A. R. Hibbs, *Quantum Mechanics and Path Integrals* (McGraw-Hill, New York, 1965).
- [FISCHER93] Martin Christian Fischer, *Design and Performance of a Ring Dye Laser*, Master's thesis, The University of Texas at Austin (1993).
- [FISCHER98] M. C. Fischer, K. W. Madison, Qian Niu, and M. G. Raizen, "Observation of Rabi oscillations between Bloch bands in an optical potential," *Phys. Rev. A* **58**, R2648 (1998).
- [FISCHER00] Baruch Fischer, Amir Rosen, Alexander Bekker, and Shmuel Fishman, "Experimental observation of localization in the spatial frequency domain of a kicked optical system," *Phys. Rev. E* **61**, R4694 (2000).
- [FISCHER01A] M. C. Fischer, B. Gutiérrez-Medina, and M. G. Raizen, "Observation of the Quantum Zeno and Anti-Zeno Effects in an Unstable System," *Phys. Rev. Lett.* **87**, 040402 (2001).
- [FISCHER01B] Martin Christian Fischer, *Atomic Motion in Optical Potentials*, Ph.D. dissertation, The University of Texas at Austin (2001).
- [FISHMAN82] Shmuel Fishman, D. R. Grempel, and R. E. Prange, "Chaos, Quantum Recurrences, and Anderson Localization," *Phys. Rev. Lett.* **49**, 509 (1982).
- [FISHMAN96] Shmuel Fishman, "Quantum Localisation," in *Quantum Dynamics of Simple Systems: Proceedings of the Forty Fourth Scottish Universities Summer School in Physics, Stirling, August 1994*, G. L. Oppo, S. M. Barnett, E. Riis, and M. Wilkinson, Eds. (Scottish Universities Summer School in Physics and Institute of Physics Publishing, Bristol, 1996).
- [FOX90] Ronald F. Fox, "Quantum Chaos in Two-Level Quantum Systems," in *The Ubiquity of Chaos*, Saul Krasner, Ed. (Am. Assoc. Adv. Sci., Washington, D.C., 1990).
- [FOX94] Ronald F. Fox and T. C. Elston, "Chaos and the quantum-classical correspondence in the kicked pendulum," *Phys. Rev. E* **49**, 3683 (1994).
- [FREDERICK88] John H. Frederick and Eric J. Heller, "Ring torsional dynamics and spectroscopy of benzophenone: a new twist," *J. Chem. Phys.* **88**, 2169 (1988).
- [FRISCH33] R. Frisch, "Experimenteller Nachweis des Einsteinischen Strahlungsrückstosses," *Z. Phys.* **86**, 42 (1933).
- [FRISCHAT98] S. D. Frischat and E. Doron, "Dynamical Tunneling in Mixed Systems," *Phys. Rev. E* **57**, 1421 (1998).

- [FROMHOLD94] T. M. Fromhold, L. Eaves, F. W. Sheard, M. L. Leadbeater, T. J. Foster, and P. C. Main, “Magnetotunneling Spectroscopy of a Quantum Well in the Regime of Classical Chaos,” *Phys. Rev. Lett.* **72**, 2608 (1994).
- [GALVEZ88] E. J. Galvez, B. E. Sauer, L. Moorman, P. M. Koch, and D. Richards, “Microwave Ionization of H Atoms: Breakdown of Classical Dynamics for High Frequencies,” *Phys. Rev. Lett.* **61**, 2011 (1988).
- [GAO93] Bo Gao, “Effects of Zeeman degeneracy on the steady-state properties of an atom interacting with a near-resonant laser field: Analytic results,” *Phys. Rev. A* **48**, 2443 (1993).
- [GAO94A] Bo Gao, “Effects of Zeeman degeneracy on the steady-state properties of an atom interacting with a near-resonant laser field: Probe spectra,” *Phys. Rev. A* **49**, 3391 (1994).
- [GAO94B] Bo Gao, “Effects of Zeeman degeneracy on the steady-state properties of an atom interacting with a near-resonant laser field: Resonance fluorescence,” *Phys. Rev. A* **50**, 4139 (1994).
- [GARDINER97] S. A. Gardiner, J. I. Cirac, and P. Zoller, “Quantum Chaos in an Ion Trap: The Delta-Kicked Harmonic Oscillator,” *Phys. Rev. Lett.* **79**, 4790 (1997).
- [GARDINER00] Simon Alexander Gardiner, *Quantum Measurement, Quantum Chaos, and Bose–Einstein Condensates*, Doctoral dissertation, Leopold–Franzens–Universität Innsbruck (2000).
- [GARDNER95] J. R. Gardner, R. A. Cline, J. D. Miller, D. J. Heinzen, H. M. J. M. Boesten, and B. J. Verhaar, “Collisions of Doubly Spin-Polarized, Ultracold ^{85}Rb Atoms,” *Phys. Rev. Lett.* **74**, 3764 (1995).
- [GEISEL87] T. Geisel, A. Zacherl, and G. Radons, “Generic $1/f$ Noise in Chaotic Hamiltonian Dynamics,” *Phys. Rev. Lett.* **59**, 2503 (1987).
- [GEORGEOT00] B. Georgeot and D. L. Shepelyansky, “Emergence of Quantum Chaos in Quantum Computer Core and How to Manage It,” arXiv.org preprint quant-ph/0005015 (2000).
- [GHOSE01] Shohini Ghose, Paul M. Alsing, and Ivan H. Deutsch, “Atomic motion in magneto-optical double-well potentials: A new testing ground for quantum chaos,” arXiv.org preprint quant-ph/0102085 (2001).
- [GIBBLE93] Kurt Gibble and Steven Chu, “Laser-Cooled Cs Frequency Standard and a Measurement of the Frequency Shift due to Ultracold Collisions,” *Phys. Rev. Lett.* **70**, 1771 (1993).

- [GILTNER95] David M. Giltner, Roger W. McGowan, and Siu Au Lee, "Theoretical and experimental study of the Bragg scattering of atoms from a standing light wave," *Phys. Rev. A* **52**, 3966 (1995).
- [GIULINI92] D. Giulini, E. Joos, C. Kiefer, J. Kupsch, I.-O. Stamatescu, and H. D. Zeh, *Decoherence and the Appearance of a Classical World in Quantum Theory* (Wiley, New York, 1992).
- [GLASS86] Leon Glass, Alvin Shrier, and Jacques Bélair, "Chaotic cardiac rhythms," in *Chaos*, Arun V. Holden, Ed. (Princeton University Press, Princeton, 1986).
- [GMACHL98] Claire Gmachl, Federico Capasso, E. E. Narimanov, Jens U. Nöckel, A. Douglas Stone, Jérôme Faist, Deborah L. Sivco, and Alfred Y. Cho, "High-Power Directional Emission from Microlasers with Chaotic Resonators," *Science* **280**, 1556 (1998).
- [GODUN00] R. M. Godun, M. B. d'Arcy, M. K. Oberthaler, G. S. Summy, and K. Burnett, "Quantum accelerator modes: A tool for atom optics," *Phys. Rev. A* **62**, 013411 (2000).
- [GONG99] Jiangbin Gong and Paul Brumer, "Decoherence and correspondence in conservative chaotic dynamics," *Phys. Rev. E* **60**, 1643 (1999).
- [GORDON80] J. P. Gordon and A. Ashkin, "Motion of atoms in a radiation trap," *Phys. Rev. A* **21**, 1606 (1980).
- [GRAHAM92] R. Graham, M. Schlautmann, and P. Zoller, "Dynamical localization of atomic-beam deflection by a modulated standing light wave," *Phys. Rev. A* **45**, R19 (1992).
- [GREBOGI90] Celso Grebogi, Stephen M. Hammel, James A. Yorke, and Tim Sauer, "Shadowing of Physical Trajectories in Chaotic Dynamics: Containment and Refinement," *Phys. Rev. Lett.* **65**, 1527 (1990).
- [GREENE79] John M. Greene, "A method for determining a stochastic transition," *J. Math. Phys.* **20**, 1183 (1979).
- [GREMPEL84] D. R. Grempel, R. E. Prange, and Shmuel Fishman, "Quantum dynamics of a nonintegrable system," *Phys. Rev. A* **29**, 1639 (1984).
- [GROBE87] R. Grobe and F. Haake, "Dissipative Death of Quantum Coherences in a Spin System," *Z. Phys. B* **68**, 503 (1987).
- [GROSSMAN91] F. Grossman, T. Dittrich, P. Jung, and P. Hänggi, "Coherent Destruction of Tunneling," *Phys. Rev. Lett.* **67**, 516 (1991).

- [GROSSMANN93] Frank Grossmann, Thomas Dittrich, Peter Jung, and Peter Hänggi, “Coherent Transport in a Periodically Driven Bistable System,” *J. Stat. Phys.* **70**, 229 (1993).
- [GRYNBERG93] G. Grynberg, B. Lounis, P. Verkerk, J.-Y. Courtois, and C. Salomon, “Quantized motion of cold cesium atoms in two- and three-dimensional optical potentials,” *Phys. Rev. Lett.* **70**, 2249 (1993).
- [GUTZWILLER90] Martin C. Gutzwiller, *Chaos in Classical and Quantum Mechanics* (Springer-Verlag, New York, 1990).
- [HAAKE01] Fritz Haake, *Quantum Signatures of Chaos*, second ed. (Springer-Verlag, Berlin, 2001).
- [HABIB98A] Salman Habib, Hideo Mabuchi, Kosuke Shizume, and Bala Sundaram, “Comment on ‘Quantum Delta-Kicked Rotor: Experimental Observation of Decoherence,’” unpublished (1998).
- [HABIB98B] Salman Habib, Kosuke Shizume, and Wojciech Hubert Zurek, “Decoherence, Chaos, and the Correspondence Principle,” *Phys. Rev. Lett.* **80**, 4361 (1998).
- [HABIB00] Salman Habib, Kurt Jacobs, Hideo Mabuchi, Robert Ryne, Kosuke Shizume, and Bala Sundaram, “The Quantum-Classical Transition in Nonlinear Dynamical Systems,” arXiv.org preprint quant-ph/0010093 (2000).
- [HAMANN98] S. E. Hamann, D. L. Haycock, G. Klose, P. H. Pax, I. H. Deutsch, and P. S. Jessen, “Resolved-Sideband Raman Cooling to the Ground State of an Optical Lattice,” *Phys. Rev. Lett.* **80**, 4149 (1998).
- [HAN01] D. J. Han, Marshall T. DePue, and David S. Weiss, “Loading and compressing Cs atoms in a very far-off-resonant trap,” *Phys. Rev. A* **63**, 023405 (2001).
- [HÄNSCH75] T. Hänsch and A. Schawlow, “Cooling of gases by laser radiation,” *Opt. Comm.* **13**, 68 (1975).
- [HÄNSCH80] T. W. Hänsch and B. Couillaud, “Laser frequency stabilization by polarization spectroscopy of a reflecting reference cavity,” *Opt. Comm.* **35**, 441 (1980).
- [HAYCOCK00] D. L. Haycock, P. M. Alsing, I. H. Deutsch, J. Grondalski, and P. S. Jessen, “Mesoscopic Quantum Coherence in an Optical Lattice,” *Phys. Rev. Lett.* **85**, 3365 (2000).
- [HAZELTINE92] R. D. Hazeltine and J. D. Meiss, *Plasma confinement* (Addison-Wesley, Redwood City, 1992).

- [HELLER84] Eric J. Heller, "Bound-State Eigenfunctions of Classically Chaotic Hamiltonian Systems: Scars of Periodic Orbits," *Phys. Rev. Lett.* **53**, 1515 (1984).
- [HELLER91] Eric J. Heller, "Wavepacket Dynamics and Quantum Chaology," in *Chaos and Quantum Physics: Proceedings of the Les Houches Summer School, Session LII, 1–31 August 1989*, M.-J. Giannoni, A. Voros, and J. Zinn-Justin, Eds. (North-Holland, Amsterdam, 1991).
- [HELLER99] E. J. Heller, "The Many Faces of Tunneling," *J. Phys. Chem.* **103**, 10433 (1999).
- [HELMKAMP96] B. S. Helmkamp and D. A. Browne, "Role of the Environment in Chaotic Quantum Dynamics," *Phys. Rev. Lett.* **76**, 3691 (1996).
- [HENSINGER00] W. K. Hensinger, A. G. Truscott, B. Upcroft, N. R. Heckenberg, and H. Rubinsztein-Dunlop, "Atoms in an amplitude-modulated standing wave – dynamics and pathways to quantum chaos," *J. Opt. B: Quant. Semiclass. Opt.* **2**, 659 (2000).
- [HENSINGER01] W. K. Hensinger, H. Häffner, A. Browaeys, N. R. Heckenberg, K. Helmerson, C. McKenzie, G. J. Milburn, W. D. Phillips, S. L. Rolston, H. Rubinsztein-Dunlop, and B. Upcroft, "Dynamical tunneling of ultracold atoms," *Nature* **412**, 52 (2001).
- [HILBORN94] Robert C. Hilborn, *Chaos and Nonlinear Dynamics: An Introduction for Scientists and Engineers* (Oxford University Press, Oxford, 1994).
- [HILLERY84] M. Hillery, R. F. O'Connell, M. O. Scully, and E. P. Wigner, "Distribution Functions in Physics: Fundamentals," *Phys. Rep.* **106**, 121 (1984).
- [HOGG82] T. Hogg and B. A. Huberman, "Recurrence Phenomena in Quantum Dynamics," *Phys. Rev. Lett.* **48**, 711 (1982).
- [HOLTZCLAW86] Karl W. Holtzclaw and David W. Pratt, "Prominent, and restricted, vibrational state mixing in the fluorescence excitation spectrum of benzophenone," *J. Chem. Phys.* **84**, 4713 (1986).
- [HUG01] M. Hug and G. J. Milburn, "Quantum slow motion," *Phys. Rev. A* **63**, 023413 (2001).
- [HUIBERS98] A. G. Huibers, M. Switkes, C. M. Marcus, K. Campman, and A. C. Gossard, "Dephasing in Open Quantum Dots," *Phys. Rev. Lett.* **81**, 200 (1998).
- [HUNTER88] L. R. Hunter, D. Krause, Jr., S. Murthy, and T. W. Sung, "Precision measurement of the Stark shift of the cesium *D* lines," *Phys. Rev. A* **37**, 3283 (1988).
- [ISHIZAKI91] Ryuji Ishizaki, Takehiko Horita, Tatsuharu Kobayashi, and Hazime Mori, "Anomalous Diffusion Due to Accelerator Modes in the Standard Map," *Prog. Theor. Phys.* **85**, 1013 (1991).

- [IZRAILEV79] F. M. Izrailev and D. L. Shepelyanskii, "Quantum resonance for a rotor in a nonlinear periodic field," *Sov. Phys. Dokl.* **24**, 996 (1979).
- [IZRAILEV80] F. M. Izrailev and D. L. Shepelyanskii, "Quantum Resonance for a Rotator in a Nonlinear Periodic Field," *Theor. Math. Phys.* **43**, 553 (1980).
- [JAVANAINEN92] J. Javanainen, "Quasi-Elastic Scattering in Fluorescence from Real Atoms," *Europhys. Lett.* **20**, 395 (1992).
- [JESSEN96] P. S. Jessen and I. H. Deutsch, "Optical Lattices," *Adv. At. Mol. Opt. Phys.* **37**, 95 (1996).
- [JOOS85] E. Joos and H. D. Zeh, "The Emergence of Classical Properties Through Interaction with the Environment," *Z. Phys. B* **59**, 223 (1985).
- [KARKUSZEWSKI01] Zbyszek P. Karkuszewski, Jakub Zakrzewski, and Wojciech H. Zurek, "Breakdown of correspondence in chaotic systems: Ehrenfest versus localization times," nlin.CD/0012048 v3 (2001).
- [KARNEY82] Charles F. F. Karney, "Effect of Noise on the Standard Mapping," *Physica D* **4**, 425 (1982).
- [KARNEY83] Charles F. F. Karney, "Long-Time Correlations in the Stochastic Regime," *Physica D* **8**, 585 (1983).
- [KASEVICH91] Mark Kasevich and Steven Chu, "Atomic Interferometry using Stimulated Raman Transitions," *Phys. Rev. Lett.* **67**, 181 (1991).
- [KASEVICH92A] Mark Kasevich and Steven Chu, "Laser cooling below a photon recoil with three-level atoms," *Phys. Rev. Lett.* **69**, 1741 (1992).
- [KASEVICH92B] Mark Adams Kasevich, *Atom interferometry in an atomic fountain*, Ph.D. dissertation, Stanford University (1992).
- [KASTBERG95] A. Kastberg, W. D. Phillips, S. L. Rolston, and R. J. C. Spreeuw, "Adiabatic Cooling of Cesium to 700 nK in an Optical Lattice," *Phys. Rev. Lett.* **74**, 1542 (1995).
- [KEITH91] David W. Keith, Christopher R. Ekstrom, Quentin A. Turchette, and David E. Pritchard, "An interferometer for atoms," *Phys. Rev. Lett.* **66**, 2693 (1991).
- [KENNEDY94] T. A. Brian Kennedy, private communication (1994).
- [KERMAN00] Andrew J. Kerman, Vladan Vuletić, Cheng Chin, and Steven Chu, "Beyond Optical Molasses: 3D Raman Sideband Cooling of Atomic Cesium to High Phase-Space Density," *Phys. Rev. Lett.* **84**, 439 (2000).

- [KETTERLE93] Wolfgang Ketterle, Kendall B. Davis, Michael A. Joffe, Alex Martin, and David E. Pritchard, "High Densities of Cold Atoms in a *Dark* Spontaneous-Force Optical Trap," *Phys. Rev. Lett.* **70**, 2253 (1993).
- [KING99] Brian E. King, *Quantum State Engineering and Information Processing with Trapped Ions*, Ph.D. thesis, University of Colorado at Boulder (1999).
- [KLAFTER96] Joseph Klafter, Michael F. Schlesinger, and Gert Zumofen, "Beyond Brownian Motion," *Physics Today* p. 33 (February 1996).
- [KLAPPAUF98A] B. G. Klappauf, W. H. Oskay, D. A. Steck, and M. G. Raizen, "Experimental Study of Quantum Dynamics in a Regime of Classical Anomalous Diffusion," *Phys. Rev. Lett.* **81**, 4044 (1998).
- [KLAPPAUF98B] B. G. Klappauf, W. H. Oskay, D. A. Steck, and M. G. Raizen, "Observation of Noise and Dissipation Effects on Dynamical Localization," *Phys. Rev. Lett.* **81**, 1203 (1998). Also **82**, 241(E) (1998).
- [KLAPPAUF98C] Bruce George Klappauf, *Experimental Studies of Quantum Chaos with Trapped Cesium*, Ph.D. dissertation, The University of Texas at Austin (1998).
- [KLAPPAUF99] B. G. Klappauf, W. H. Oskay, D. A. Steck, and M. G. Raizen, "Quantum Chaos with Cesium Atoms: Pushing the Boundaries," *Physica D* **131**, 78 (1999).
- [KLEINPOPPEN97] Hans Kleinpoppen, "Atoms," in Ludwig Bergmann and Clemens Schaefer, *Constituents of Matter: Atoms, Molecules, Nuclei, and Particles*, Wilhelm Raith, Ed. (Walter de Gruyter, Berlin, 1997).
- [KOCH92] Peter M. Koch, "Experimental evidence for the influence of 'scars' in hydrogen atoms driven by strong magnetic fields," *Chaos* **2**, 131 (1992).
- [KOCH95] Peter M. Koch, "Microwave 'ionization' of excited hydrogen atoms: How nonclassical local stability brought about by scarred separatrix states is affected by broadband noise and by varying the pulse envelope," *Physica D* **83**, 178 (1995).
- [KOCH01] P. M. Koch, L. Sirko, and R. Blümel, private communication (2001).
- [KOHLE98] Sigmund Kohler, Ralf Utermann, Peter Hänggi, and Thomas Dittrich, "Coherent and incoherent chaotic tunneling near singlet-doublet crossings," *Phys. Rev. E* **58**, 7219 (1998).
- [KOKOROWSKI01] David A. Kokorowski, Alexander D. Cronin, Tony D. Roberts, and David E. Pritchard, "From Single- to Multiple-Photon Decoherence in an Atom Interferometer," *Phys. Rev. Lett.* **86**, 2191 (2001).

- [KOOLEN00] Armand Eugène Albert Koolen, *Dissipative Atom Optics with Cold Metastable Helium Atoms*, Doctoral thesis, Technische Universiteit Eindhoven (2000).
- [KOZUMA99] 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).
- [KUDROLLI01] A. Kudrolli, Mathew C. Abraham, and J. P. Gollub, "Scarred patterns in surface waves," *Phys. Rev. E* **63**, 026208 (2001).
- [LABZOWSKY99] Leonti Labzowsky, Igor Goidenko, and Pekka Pyykkö, "Estimates of the bound-state QED contributions to the g -factor of valence ns electrons in alkali metal atoms," *Phys. Lett. A* **258**, 31 (1999).
- [LAN94] Boon Leong Lan, "Wave-packet initial motion, spreading, and energy in the periodically kicked pendulum," *Phys. Rev. E* **50**, 764 (1994).
- [LANDAU77] L. D. Landau and E. M. Lifshitz, *Quantum Mechanics: Non-Relativistic Theory* (Pergamon, Oxford, 1977).
- [LATKA94A] Mirosław Latka, Paolo Grigolini, and Bruce J. West, "Chaos and avoided level crossings," *Phys. Rev. E* **50**, 596 (1994).
- [LATKA94B] Mirosław Latka, Paolo Grigolini, and Bruce J. West, "Control of dynamical tunneling in a bichromatically driven pendulum," *Phys. Rev. E* **50**, R3299 (1994).
- [LEEB79] Walter R. Leeb, "Algorithm 537: Characteristic Values of Mathieu's Differential Equation," *ACM Trans. Math. Soft.* **5**, 112 (1979).
- [LI75] Tien-Yien Li and James A. Yorke, "Period Three Implies Chaos," *Am. Math. Monthly* **82**, 985 (1975).
- [LICHTENBERG92] A. J. Lichtenberg and M. A. Leiberman, *Regular and Chaotic Dynamics*, second ed. (Springer-Verlag, New York, 1992).
- [LIDE00] David R. Lide (Ed.), *CRC Handbook of Chemistry and Physics*, 81st ed. (CRC Press, Boca Raton, 2000).
- [LIN90] W. A. Lin and L. E. Ballentine, "Quantum Tunneling and Chaos in a Driven Anharmonic Oscillator," *Phys. Rev. Lett.* **65**, 2927 (1990).
- [LINDELOF86] P. E. Lindelof, J. Nørregaard, and J. Hanberg, "New Light on the scattering mechanisms in Si inversion layers by weak localization experiments," *Phys. Scr.* **T14**, 17 (1986).

- [LORENZ63] Edward N. Lorenz, "Deterministic Nonperiodic Flow," *J. Atmos. Sci.* **20**, 130 (1963).
- [LOUDON83] R. Loudon, *The Quantum Theory of Light*, 2nd ed. (Oxford University Press, 1983).
- [MACADAM92] K. B. MacAdam, A. Steinbach, and C. Wieman, "A narrow-band tunable diode laser system with grating feedback, and a saturated absorption spectrometer for Cs and Rb," *Am. J. Phys.* **60**, 1098 (1992).
- [MADISON97] K. W. Madison, C. F. Bharucha, P. R. Morrow, S. R. Wilkinson, Q. Niu, Bala Sundaram, and M. G. Raizen, "Quantum Transport of Ultra-Cold Atoms in an Accelerating Optical Potential," *Appl. Phys. B* **65**, 693 (1997).
- [MADISON98A] K. W. Madison, M. C. Fischer, R. B. Diener, Qian Niu, and M. G. Raizen, "Dynamical Bloch band suppression in an optical lattice," *Phys. Rev. Lett.* **81**, 5093 (1998).
- [MADISON98B] Kirk William Madison, *Quantum Transport in Optical Lattices*, Ph.D. dissertation, The University of Texas at Austin (1998).
- [MADISON99] K. W. Madison, M. C. Fischer, and M. G. Raizen, "Observation of the Wannier-Stark fan and the fractional ladder in an accelerating optical lattice," *Phys. Rev. A* **60**, R1767 (1999).
- [MAIN91] J. Main, G. Wiebusch, and K. H. Welge, "Spectroscopy of the classically chaotic hydrogen atom in magnetic fields," *Comm. At. Mol. Phys.* **25**, 233 (1991).
- [MARCUS92] C. M. Marcus, A. J. Rimberg, R. M. Westervelt, P. F. Hopkins, and A. C. Gossard, "Conductance Fluctuations and Chaotic Scattering in Ballistic Microstructures," *Phys. Rev. Lett.* **69**, 506 (1992).
- [MARTIN88] Peter J. Martin, Bruce G. Oldaker, Andrew H. Miklich, and David E. Pritchard, "Bragg scattering of atoms from a standing light wave," *Phys. Rev. Lett.* **60**, 515 (1988).
- [MATHUR68] B. S. Mathur, H. Tang, and W. Happer, "Light Shifts in the Alkali Atoms," *Phys. Rev.* **171**, 11 (1968).
- [MCCLELLAND93] J. J. McClelland, R. E. Scholten, E. C. Palm, and R. J. Celotta, "Laser Focused Atomic Deposition," *Science* **262**, 877 (1993).
- [MCDONALD79] Steven W. McDonald and Allan N. Kaufman, "Spectrum and Eigenfunctions for a Hamiltonian with Stochastic Trajectories," *Phys. Rev. Lett.* **42**, 1189 (1979).

- [MCNICHOLL85] Patrick McNicholl and Harold J. Metcalf, "Synchronous cavity mode and feedback wavelength scanning in dye laser oscillators with gratings," *Appl. Opt.* **24**, 2757 (1985).
- [METCALF99] Harold J. Metcalf and Peter van der Straten, *Laser Cooling and Trapping* (Springer, New York, 1999).
- [MEYSTRE96] Pierre Meystre, "Light-Matter Interaction," in *Atomic, Molecular, and Optical Physics Handbook*, Gordon W. F. Drake, Ed. (American Institute of Physics Press, Woodbury, 1996).
- [MIGDALL85] Alan L. Migdall, John V. Prodan, William D. Phillips, Thomas H. Bergeman, and Harold J. Metcalf, "First Observation of Magnetically Trapped Neutral Atoms," *Phys. Rev. Lett.* **54**, 2596 (1985).
- [MILLER00] Thomas M. Miller, "Atomic and Molecular Polarizabilities," in *CRC Handbook of Chemistry and Physics*, David R. Lide, Ed., 81st ed. (CRC Press, Boca Raton, 2000).
- [MILNER00] V. Milner, D. A. Steck, W. H. Oskay, and M. G. Raizen, "Recovery of classically chaotic behavior in a noise-driven quantum system," *Phys. Rev. E* **61**, 7223 (2000).
- [MILONNI83] P. W. Milonni, J. R. Ackerhalt, and H. W. Galbraith, "Chaos in the Semiclassical N -Atom Jaynes-Cummings Model: Failure of the Rotating-Wave Approximation," *Phys. Rev. Lett.* **50**, 966 (1983). Also **51**, 1108(E) (1983).
- [MIRSKY90] L. Mirsky, *An Introduction to Linear Algebra* (Dover, Mineola, 1990).
- [MOHR00] Peter J. Mohr and Barry N. Taylor, "CODATA recommended values of the fundamental physical constants: 1998," *Rev. Mod. Phys.* **72**, 351 (2000).
- [MONROE90] C. Monroe, W. Swann, H. Robinson, and C. Wieman, "Very Cold Trapped Atoms in a Vapor Cell," *Phys. Rev. Lett.* **65**, 1571 (1990).
- [MONROE92] Christopher Roy Monroe, *Experiments with Optically and Magnetically Trapped Cesium Atoms*, Ph.D. thesis, University of Colorado (1992).
- [MOORE91] John H. Moore, Christopher C. Davis, and Michael A. Coplan, *Building Scientific Apparatus*, second ed. (Perseus Books, Reading, 1991).
- [MOORE94] F. L. Moore, J. C. Robinson, C. Bharucha, P. E. Williams, and M. G. Raizen, "Observation of Dynamical Localization in Atomic Momentum Transfer: A New Testing Ground for Quantum Chaos," *Phys. Rev. Lett.* **73**, 2974 (1994).

- [MOORE95] F. L. Moore, J. C. Robinson, C. F. Bharucha, Bala Sundaram, and M. G. Raizen, "Atom Optics Realization of the Quantum δ -Kicked Rotor," *Phys. Rev. Lett.* **75**, 4598 (1995).
- [MORRISON96] Philip J. Morrison, class notes for PHY 385K: Classical Mechanics, The University of Texas at Austin (Spring, 1996).
- [MORRISON98] P. J. Morrison, "Hamiltonian description of the ideal fluid," *Rev. Mod. Phys.* **70**, 467 (1998).
- [MORROW96] Patrick Russel Morrow, *Quantum Tunneling of Atoms in an Optical Potential*, Ph.D. dissertation, The University of Texas at Austin (1996).
- [MOSER73] Jürgen Moser, *Stable and Random Motions in Dynamical Systems* (Princeton University Press, Princeton, 1973).
- [MOSER78] Jürgen Moser, "Is the Solar System Stable?" *Math. Intell.* **1**, 65 (1978).
- [MOUCHET01] A. Mouchet, C. Miniatura, R. Kaiser, B. Grémaud, and D. Delande, "Chaos assisted tunnelling with cold atoms," *Phys. Rev. E* **64**, 016221 (2001).
- [MOYAL49] J. E. Moyal, "Quantum Mechanics as a Statistical Theory," *Proc. Cambridge Phil. Soc.* **45**, 99 (1949).
- [MYATT00] C. J. Myatt, B. E. King, Q. A. Turchette, C. A. Sackett, D. Kielpinski, W. M. Itano, C. Monroe, and D. J. Wineland, "Decoherence of quantum superpositions through coupling to engineered reservoirs," *Nature* **403**, 269 (2000).
- [NEICU01] T. Neicu, K. Schaadt, and A. Kudrolli, "Spectral properties of a mixed system using an acoustical resonator," *Phys. Rev. E* **63**, 026206 (2001).
- [NESMEYANOV63] A. N. Nesmeyanov, *Vapor Pressure of the Chemical Elements* (Elsevier, Amsterdam, 1963). English edition edited by Robert Gary.
- [NEUHAUSER78] W. Neuhauser, M. Hohenstatt, P. Toschek, and H. Dehmelt, "Optical-Sideband Cooling of Visible Atom Cloud Confined in Parabolic Well," *Phys. Rev. Lett.* **41**, 233 (1978).
- [NIU96] Qian Niu, Xian-Geng Zhao, G. A. Georgakis, and M. G. Raizen, "Atomic Landau-Zener Tunneling and Wannier-Stark Ladders in Optical Potentials," *Phys. Rev. Lett.* **76**, 4504 (1996).
- [NÖCKEL97] Jens U. Nöckel and A. Douglas Stone, "Ray and wave chaos in asymmetric resonant optical cavities," *Nature* **385**, 45 (1997).

- [OBERTHALER99] M. K. Oberthaler, R. M. Godun, M. B. d'Arcy, G. S. Summy, and K. Burnett, "Observation of Quantum Accelerator Modes," *Phys. Rev. Lett.* **83**, 4447 (1999).
- [OHANIAN90] Hans C. Ohanian, *Principles of Quantum Mechanics* (Prentice Hall, Englewood Cliffs, 1990).
- [OSKAY00] W. H. Oskay, D. A. Steck, V. Milner, B. G. Klappauf, and M. G. Raizen, "Ballistic Peaks at Quantum Resonance," *Opt. Comm.* **179**, 137 (2000).
- [OSKAY01A] Windell H. Oskay, Daniel A. Steck, and Mark G. Raizen, in preparation (2001).
- [OSKAY01B] Windell Haven Oskay, Ph.D. dissertation (in preparation), The University of Texas at Austin (2001).
- [OTT84] E. Ott, T. M. Antonsen, Jr., and J. D. Hanson, "Effect of Noise on Time-Dependent Quantum Chaos," *Phys. Rev. Lett.* **53**, 2187 (1984).
- [OTT93] Edward Ott, *Chaos in Dynamical Systems* (Cambridge University Press, Cambridge, 1993).
- [OZORIO DE ALMEIDA88] Alfredo M. Ozorio de Almeida, *Hamiltonian Systems: Chaos and Quantization* (Cambridge University Press, Cambridge, 1988).
- [PAPPAS80] P. G. Pappas, M. M. Burns, D. D. Hinshelwood, M. S. Feld, and D. E. Murnick, "Saturation spectroscopy with laser optical pumping in atomic barium," *Phys. Rev. A* **21**, 1955 (1980).
- [PARKS87] T. W. Parks and C. S. Burrus, *Digital Filter Design* (Wiley, New York, 1987).
- [PAZ93] Juan Pablo Paz, Salman Habib, and Wojciech H. Zurek, "Reduction of the wave packet: Preferred observable and decoherence time scale," *Phys. Rev. D* **47**, 488 (1993).
- [PAZ99] Juan Pablo Paz and Wojciech Hubert Zurek, "Quantum Limit of Decoherence: Environment Induced Superselection of Energy Eigenstates," *Phys. Rev. Lett.* **82**, 5181 (1999).
- [PERES91A] Asher Peres, "Dynamical Quasidegeneracies and Quantum Tunneling," *Phys. Rev. Lett.* **67**, 158 (1991). This paper is a comment on [Lin90]; see also the response by Lin and Ballentine, *Phys. Rev. Lett.* **67**, 159 (1991).
- [PERES91B] Asher Peres, "Instability of Quantum Motion of a Chaotic System," in *Chaos and Quantum Chaos: Proceedings of the Adriatico Research Conference on Quantum Chaos*, H. A. Cerdeira, R. Ramaswamy, M. C. Gutzwiller, and G. Casati, Eds. (World Scientific, Singapore, 1991).

- [PERES93] Asher Peres, *Quantum Theory: Concepts and Methods* (Kluwer Academic Publishers, Dordrecht, 1993).
- [PERES96] Asher Peres, "Chaotic evolution in quantum mechanics," *Phys. Rev. E* **53**, 4524 (1996).
- [PETERSON93] Ivars Peterson, *Newton's Clock: Chaos in the Solar System* (W. H. Freeman, New York, 1993).
- [PETRICH94] W. Petrich, M. H. Anderson, J. R. Ensher, and E. A. Cornell, "Behavior of Atoms in a Compressed Magneto-optical Trap," *J. Opt. Soc. Am. B* **11**, 1332 (1994).
- [PHILLIPS82] William D. Phillips and Harold Metcalf, "Laser Deceleration of an Atomic Beam," *Phys. Rev. Lett.* **48**, 596 (1982).
- [POLDER76] D. Polder and M. F. H. Schuurmans, "Resonance fluorescence from a $j = 1/2$ to $j = 1/2$ transition," *Phys. Rev. A* **14**, 1468 (1976).
- [RAAB87] E. L. Raab, M. Prentiss, Alex Cable, Steven Chu, and D. E. Pritchard, "Trapping of Neutral Sodium Atoms with Radiation Pressure," *Phys. Rev. Lett.* **59**, 2631 (1987).
- [RAFAC94] R. J. Rafac, C. E. Tanner, A. E. Livingston, K. W. Kukla, H. G. Berry, and C. A. Kurtz, "Precision lifetime measurements of the $6p^2P_{1/2,3/2}$ states in atomic cesium," *Phys. Rev. A* **50**, R1976 (1994).
- [RAFAC97] Robert J. Rafac and Carol E. Tanner, "Measurement of the ^{133}Cs $6p^2P_{1/2}$ state hyperfine structure," *Phys. Rev. A* **56**, 1027 (1997).
- [RAFAC98] Robert J. Rafac and Carol E. Tanner, "Measurement of the ratio of the cesium D -line transition strengths," *Phys. Rev. A* **58**, 1087 (1998).
- [RAFAC99] Robert J. Rafac, Carol E. Tanner, A. Eugene Livingston, and H. Gordon Berry, "Fast-beam laser lifetime measurements of the cesium $6p^2P_{1/2,3/2}$ states," *Phys. Rev. A* **60**, 3648 (1999).
- [RECHESTER80] A. B. Rechester and R. B. White, "Calculation of Turbulent Diffusion for the Chirikov-Taylor Model," *Phys. Rev. Lett.* **44**, 1586 (1980).
- [RECHESTER81] A. B. Rechester, M. N. Rosenbluth, and R. B. White, "Fourier-space paths applied to the calculation of diffusion for the Chirikov-Taylor model," *Phys. Rev. A* **23**, 2664 (1981).
- [REICHEL94] J. Reichel, O. Morice, G. M. Tino, and C. Salomon, "Subrecoil Raman Cooling of Cesium Atoms," *Europhys. Lett.* **28**, 477 (1994).

- [REICHEL95] J. Reichel, F. Bardou, M. Ben Dahan, E. Peik, S. Rand, C. Salomon, and C. Cohen-Tannoudji, "Raman Cooling of Cesium below 3 nK: New Approach Inspired by Lévy Flight Statistics," *Phys. Rev. Lett.* **75**, 4575 (1995).
- [REICHEL96] Jakob Reichel, *Refroidissement Raman et vols de Lévy: atomes de césium au nanokelvin*, Thèse de doctorat, École Normale Supérieure (1996).
- [REICHL92] L. E. Reichl, *The Transition to Chaos in Conservative Classical Systems: Quantum Manifestations* (Springer-Verlag, New York, 1992).
- [RINGOT00] J. Ringot, P. Szriftgiser, J. C. Garreau, and D. Delande, "Experimental Evidence of Dynamical Localization and Delocalization in a Quasiperiodic Driven System," *Phys. Rev. Lett.* **85**, 2741 (2000).
- [ROBINSON95A] J. C. Robinson, C. Bharucha, F. L. Moore, R. Jahnke, G. A. Georgakis, Q. Niu, M. G. Raizen, and Bala Sundaram, "Study of Quantum Dynamics in the Transition from Classical Stability to Chaos," *Phys. Rev. Lett.* **74**, 3963 (1995).
- [ROBINSON95B] John Charles Robinson, *Atom Optics: A New Testing Ground for Quantum Chaos*, Ph.D. dissertation, The University of Texas at Austin (1995).
- [ROBINSON96] J. C. Robinson, C. F. Bharucha, K. W. Madison, F. L. Moore, Bala Sundaram, S. R. Wilkinson, and M. G. Raizen, "Can a Single-Pulse Standing Wave Induce Chaos in Atomic Motion?" *Phys. Rev. Lett.* **76**, 3304 (1996).
- [RONCAGLIA94] Roberto Roncaglia, Luca Bonci, Felix M. Izrailev, Bruce J. West, and Paolo Grigolini, "Tunneling versus Chaos in the Kicked Harper Model," *Phys. Rev. Lett.* **73**, 802 (1994).
- [ROSEN00] Amir Rosen, Baruch Fischer, Alexander Bekker, and Shmuel Fishman, "Optical kicked system exhibiting localization in the spatial frequency domain," *J. Opt. Soc. Am. B* **17**, 1579 (2000).
- [ROY92] Rajarshi Roy, T. W. Murphy, Jr., T. D. Maier, Z. Gills, and E. R. Hunt, "Dynamical Control of a Chaotic Laser: Experimental Stabilization of a Globally Coupled System," *Phys. Rev. Lett.* **68**, 1259 (1992).
- [RYDBERG72] S. Rydberg and S. Svanberg, "Investigation of the $np^2P_{3/2}$ Level Sequence in the Cs I Spectrum by Level Crossing Spectroscopy," *Physica Scripta* **5**, 209 (1972).
- [SAGLE96] J. Sagle, R. K. Namiotka, and J. Huennekens, "Measurement and modelling of intensity dependent absorption and transit relaxation on the cesium D₁ line," *J. Phys. B* **29**, 2629 (1996).

- [SAICHEV97] Alexander I. Saichev and George M. Zaslavsky, "Fractional kinetic equations: solutions and applications," *Chaos* **7**, 753 (1997).
- [SALOMON90] C. Salomon, J. Dalibard, W. D. Phillips, A. Clairon, and S. Guellati, "Laser Cooling of Cesium Atoms below $3\mu\text{K}$," *Europhys. Lett.* **12**, 683 (1990).
- [SANDERS89] B. C. Sanders and G. J. Milburn, "The effect of measurement on the quantum features of a chaotic system," *Z. Phys. B* **77**, 497 (1989).
- [SATIJA99] Indubala I. Satija, Bala Sundaram, and Jukka A. Ketoja, "Localization and fluctuations in quantum kicked rotors," *Phys. Rev. E* **60**, 453 (1999).
- [SAUER91] Tim Sauer and James A. Yorke, "Rigorous verification of trajectories for the computer simulation of dynamical systems," *Nonlinearity* **4**, 961 (1991).
- [SAUER97] Tim Sauer, Celso Grebogi, and James A. Yorke, "How Long Do Numerical Chaotic Solutions Remain Valid?" *Phys. Rev. Lett.* **79**, 59 (1997).
- [SCHACK93] Rüdiger Schack and Carlton M. Caves, "Hypersensitivity to Perturbations in the Quantum Baker's Map," *Phys. Rev. Lett.* **71**, 525 (1993).
- [SCHACK94] Rüdiger Schack, Giacomo M. D'Ariano, and Carlton M. Caves, "Hypersensitivity to Perturbations in the quantum kicked top," *Phys. Rev. E* **50**, 972 (1994).
- [SCHACK95] Rüdiger Schack, "Comment on 'Exponential Sensitivity and Chaos in Quantum Systems,'" *Phys. Rev. Lett.* **75**, 581 (1995). A comment on [Blümel94].
- [SCHAFFER86] W. M. Schaffer and M. Kot, "Differential systems in ecology and epidemiology," in *Chaos*, Arun V. Holden, Ed. (Princeton University Press, Princeton, 1986).
- [SCHARF92] Rainer Scharf and Bala Sundaram, "Periodic orbits in quantum standard maps," *Phys. Rev. A* **46**, 3164 (1992).
- [SCHARF94] Rainer Scharf and Bala Sundaram, "Role of parametric noise in nonintegrable quantum dynamics," *Phys. Rev. E* **49**, R2509 (1994).
- [SCHLEICH01] Wolfgang P. Schleich, *Quantum Optics in Phase Space* (Wiley, New York, 2001).
- [SCHMIEDER71] Robert W. Schmieder, Allen Lurio, and W. Happer, "Quadratic Stark Effect in the $^2P_{3/2}$ States of the Alkali Atoms," *Phys. Rev. A* **3**, 1209 (1971).
- [SCHMIEDER72] Robert W. Schmieder, "Matrix Elements of the Quadratic Stark Effect on Atoms with Hyperfine Structure," *Am. J. Phys.* **40**, 297 (1972).

- [SCHRÖDINGER26] E. Schrödinger, "Der stetige Übergang von der Mikro- zur Makromechanik," *Naturwissenschaften* **14**, 664 (1926).
- [SCOTT01] A. J. Scott and G. J. Milburn, "Quantum nonlinear dynamics of continuously measured systems," *Phys. Rev. A* **63**, 042101 (2001).
- [SCULLY97] Marlan O. Scully and M. Suhail Zubairy, *Quantum Optics* (Cambridge University Press, Cambridge, 1997).
- [SESKO91] D. W. Sesko, T. G. Walker, and C. E. Wieman, "Behavior of neutral atoms in a spontaneous force trap," *J. Opt. Soc. Am. B* **8**, 946 (1991).
- [SHEPELYANSKI182] D. L. Shepelyanskii, "Dynamical Stochasticity in Nonlinear Quantum Systems," *Theor. Math. Phys.* **49**, 925 (1982).
- [SHEPELYANSKY83] D. L. Shepelyansky, "Some Statistical Properties of Simple Classically Stochastic Quantum Systems," *Physica D* **8**, 208 (1983).
- [SHEPELYANSKY87] D. L. Shepelyansky, "Localization of Diffusive Excitation in Multi-Level Systems," *Physica D* **28**, 103 (1987).
- [SHIMIZU01] Fujio Shimizu, "Specular Reflection of Very Slow Metastable Neon Atoms from a Solid Surface," *Phys. Rev. Lett.* **86**, 987 (2001).
- [SHIOKAWA95] K. Shiokawa and B. L. Hu, "Decoherence, delocalization, and irreversibility in quantum chaotic systems," *Phys. Rev. E* **52**, 2497 (1995).
- [SHIRTS93A] Randall B. Shirts, "Algorithm 721: MTIEU1 and MTIEU2: Two Subroutines to Compute Eigenvalues and Solutions of Mathieu's Differential Equation for Noninteger and Integer Order," *ACM Trans. Math. Soft.* **19**, 391 (1993).
- [SHIRTS93B] Randall B. Shirts, "The Computation of Eigenvalues and Solutions of Mathieu's Differential Equation for Noninteger Order," *ACM Trans. Math. Soft.* **19**, 377 (1993).
- [SIMOYI82] Reuben H. Simoyi, Alan Wolf, and Harry L. Swinney, "One-Dimensional Dynamics in a Multicomponent Chemical Reaction," *Phys. Rev. Lett.* **49**, 245 (1982).
- [SIRKO93] L. Sirko, M. R. W. Bellermand, A. Haffmans, P. M. Koch, and D. Richards, "Probing Quantal Dynamics of Mixed Phase Space Systems with Noise," *Phys. Rev. Lett.* **71**, 2895 (1993).
- [SIRKO96] L. Sirko, A. Haffmans, M. R. W. Bellermand, and P. M. Koch, "Microwave 'ionization' of excited hydrogen atoms: frequency dependence in a resonance zone," *Europhys. Lett.* **33**, 181 (1996).

- [SIRKO00] L. Sirko, Sz. Bauch, Y. Hlushchuk, P. M. Koch, R. Blümel, M. Barth, U. Kuhl, and H.-J. Stöckmann, "Observation of dynamical localization in a rough microwave cavity," *Phys. Lett. A* **266**, 331 (2000).
- [SPILLER94] T. P. Spiller and J. F. Ralph, "The emergence of chaos in an open quantum system," *Phys. Lett. A* **194**, 235 (1994).
- [SRIDHAR91] S. Sridhar, "Experimental observation of scarred eigenfunctions of chaotic microwave cavities," *Phys. Rev. Lett.* **67**, 785 (1991).
- [SRIDHAR92] S. Sridhar and E. J. Heller, "Physical and numerical experiments on the wave mechanics of classically chaotic systems," *Phys. Rev. A* **46**, R1728 (1992).
- [STEANE97] Andrew Steane, "Quantum computing," arXiv.org preprint quant-ph/9708022 (1997).
- [STECK98] Daniel A. Steck, "The Angular Distribution of Resonance Fluorescence from a Zeeman-Degenerate Atom: Formalism," (1998). Unpublished, available on-line at the time of writing at <http://www.ph.utexas.edu/~quantopt>.
- [STECK00] Daniel A. Steck, Valery Milner, Windell H. Oskay, and Mark G. Raizen, "Quantitative study of amplitude noise effects on dynamical localization," *Phys. Rev. E* **62**, 3461 (2000).
- [STECK01] Daniel A. Steck, Windell H. Oskay, and Mark G. Raizen, "Observation of Chaos-Assisted Tunneling between Islands of Stability," *Science* **293**, 274 (2001).
- [STENHOLM86] Stig Stenholm, "The semiclassical theory of laser cooling," *Rev. Mod. Phys.* **58**, 699 (1986).
- [STÖCKMANN90] H.-J. Stöckmann and J. Stein, "'Quantum' Chaos in Billiards Studied by Microwave Absorption," *Phys. Rev. Lett.* **64**, 2215 (1990).
- [STÖCKMANN99] H.-J. Stöckmann, *Quantum Chaos: An Introduction* (Cambridge University Press, Cambridge, 1999).
- [SUGIHARA90] George Sugihara and Robert M. May, "Nonlinear forecasting as a way of distinguishing chaos from measurement error in time series," *Nature* **344**, 734 (1990).
- [SUNDARAM99A] Bala Sundaram and G. M. Zaslavsky, "Anomalous transport and quantum-classical correspondence," *Phys. Rev. E* **59**, 7231 (1999).
- [SUNDARAM99B] Bala Sundaram and G. M. Zaslavsky, "Wave analysis of ray chaos in underwater acoustics," *Chaos* **9**, 483 (1999).

- [TABOR89] Michael Tabor, *Chaos and Integrability in Nonlinear Dynamics: An Introduction* (Wiley, New York, 1989).
- [TAICHENACHEV01] A. V. Taichenachev, A. M. Tumaikin, V. I. Yudin, and L. Hollberg, "Two-dimensional sideband Raman cooling and Zeeman-state preparation in an optical lattice," *Phys. Rev. A* **63**, 033402 (2001).
- [TANNER88A] Carol E. Tanner and Carl Wieman, "Precision measurement of the hyperfine structure of the ^{133}Cs $6P_{3/2}$ state," *Phys. Rev. A* **38**, 1616 (1988).
- [TANNER88B] Carol E. Tanner and Carl Wieman, "Precision measurement of the Stark shift in the $6S_{1/2} \rightarrow 6P_{3/2}$ cesium transition using a frequency-stabilized laser diode," *Phys. Rev. A* **38**, 162 (1988).
- [TANNER92] C. E. Tanner, A. E. Livingston, R. J. Rafac, F. G. Serpa, K. W. Kukla, H. G. Berry, L. Young, and C. A. Kurtz, "Measurement of the $6p\ ^2P_{3/2}$ State Lifetime in Atomic Cesium," *Phys. Rev. Lett.* **69**, 2765 (1992).
- [TANNER95] Carol E. Tanner, "Precision Measurements of Atomic Lifetimes," in *Atomic Physics 14: The Fourteenth International Conference on Atomic Physics*, D. J. Wineland, C. E. Wieman, and S. J. Smith, Eds. (AIP Press, 1995).
- [TIMP92] G. Timp, R. E. Behringer, D. M. Tennant, J. E. Cunningham, M. Prentiss, and K. K. Berggren, "Using light as a lens for submicron, neutral-atom lithography," *Phys. Rev. Lett.* **69**, 1636 (1992).
- [TODA87] M. Toda and K. Ikeda, "Quantal Lyapunov Exponent," *Phys. Lett. A* **124**, 165 (1987).
- [TOMSOVIC94] Steven Tomsovic and Denis Ullmo, "Chaos-assisted tunneling," *Phys. Rev. E* **50**, 145 (1994).
- [TOMSOVIC01] Steven Tomsovic, "Tunneling and Chaos," *Physica Scripta* **T90**, 162 (2001).
- [TOWNSEND95] C. G. Townsend, N. H. Edwards, C. J. Cooper, K. P. Zetie, C. J. Foot, A. M. Steane, P. Szriftgiser, H. Perrin, and J. Dalibard, "Phase-space density in the magneto-optical trap," *Phys. Rev. A* **52**, 1423 (1995).
- [TSONIS92] A. A. Tsonis and J. B. Elsner, "Nonlinear prediction as a way of distinguishing chaos from random fractal sequences," *Nature* **358**, 217 (1992).
- [TURCHETTE00] Q. A. Turchette, C. J. Myatt, B. E. King, C. A. Sackett, D. Kielpinski, W. M. Itano, C. Monroe, and D. J. Wineland, "Decoherence and decay of motional quantum states of a trapped atom coupled to engineered reservoirs," *Phys. Rev. A* **62**, 053807 (2000).

- [UDEM99] Th. Udem, J. Reichert, R. Holzwarth, and T. W. Hänsch, "Absolute Optical Frequency Measurement of the Cesium D_1 Line with a Mode-Locked Laser," *Phys. Rev. Lett.* **82**, 3568 (1999).
- [UDEM00] Th. Udem, J. Reichert, T. W. Hänsch, and M. Kourogi, "Absolute optical frequency measurement of the cesium D_2 line," *Phys. Rev. A* **62**, 031801 (2000).
- [UTERMANN94] R. Utermann, T. Dittrich, and P. Hänggi, "Tunneling and the onset of chaos in a driven bistable system," *Phys. Rev. E* **49**, 273 (1994).
- [VANT99] K. Vant, G. Ball, H. Ammann, and N. Christensen, "Experimental evidence for the role of cantori as barriers in a quantum system," *Phys. Rev. E* **59**, 2846 (1999).
- [VERDEYEN95] Joseph T. Verdeyen, *Laser Electronics*, third ed. (Prentice Hall, Englewood Cliffs, 1995).
- [VOROBEICHIK98] Ilya Vorobeichik, Meir Orenstein, and Nimrod Moiseyev, "Quantum accelerator modes: A tool for atom optics," *IEEE J. Quant. Electron.* **34**, 1772 (1998).
- [VULETIĆ98] Vladan Vuletić, Cheng Chin, Andrew J. Kerman, and Steven Chu, "Degenerate Raman Sideband Cooling of Trapped Cesium Atoms at Very High Atomic Densities," *Phys. Rev. Lett.* **81**, 5768 (1998).
- [WALKER69] Grayson H. Walker and Joseph Ford, "Amplitude Instability and Ergodic Behavior for Conservative Nonlinear Oscillator Systems," *Phys. Rev.* **188**, 416 (1969).
- [WEAVER89] R. L. Weaver, "Spectral statistics in elastodynamics," *J. Acoust. Soc. Am.* **85**, 1005 (1989).
- [WEBER87] K.-H. Weber and Craig J. Sansonetti, "Accurate energies of nS , nP , nD , nF , and nG levels of neutral cesium," *Phys. Rev. A* **35**, 4650 (1987).
- [WEIGERT93] Stefan Weigert, "Quantum chaos in the configurational quantum cat map," *Phys. Rev. A* **48**, 1780 (1993).
- [WEISS91] D. Weiss, M. L. Roukes, A. Menschig, P. Grambow, K. von Klitzing, and G. Weimann, "Electron Pinball and Commensurate Orbits in a Periodic Array of Scatterers," *Phys. Rev. Lett.* **66**, 2790 (1991).
- [WEISS93] D. Weiss, K. Richter, A. Menschig, R. Bergmann, H. Schweizer, K. von Klitzing, and G. Weimann, "Quantized Periodic Orbits in Large Antidot Arrays," *Phys. Rev. Lett.* **70**, 4118 (1993).

- [WHEELER93] John Archibald Wheeler and Wojciech Hubert Zurek (Eds.), *Quantum Theory and Measurement* (Princeton University Press, Princeton, 1993).
- [WIEMAN91] Carl E. Wieman and Leo Hollberg, "Using diode lasers for atomic physics," *Rev. Sci. Instr.* **62**, 1 (1991).
- [WIEMAN95] Carl Wieman, Gwenn Flowers, and Sarah Gilbert, "Inexpensive laser cooling and trapping experiment for undergraduate laboratories," *Am. J. Phys.* **63**, 317 (1995).
- [WIGNER32] E. Wigner, "On the Quantum Correction For Thermodynamic Equilibrium," *Phys. Rev.* **40**, 749 (1932).
- [WILCOX67] R. M. Wilcox, "Exponential Operators and Parameter Differentiation in Quantum Physics," *J. Math. Phys.* **8**, 962 (1967).
- [WILKINSON96A] P. B. Wilkinson, T. M. Fromhold, L. Eaves, F. W. Sheard, N. Miura, and T. Takamasu, "Observation of 'scarred' wavefunctions in a quantum well with chaotic electrons dynamics," *Nature* **380**, 608 (1996).
- [WILKINSON96B] S. R. Wilkinson, C. F. Bharucha, K. W. Madison, Qian Niu, and M. G. Raizen, "Observation of Atomic Wannier-Stark Ladders in an Accelerating Optical Potential," *Phys. Rev. Lett.* **76**, 4512 (1996).
- [WILKINSON97] S. R. Wilkinson, C. F. Bharucha, M. C. Fischer, K. W. Madison, P. R. Morrow, Qian Niu, Bala Sundaram, and M. G. Raizen, "Experimental evidence for non-exponential decay in quantum tunnelling," *Nature* **387**, 575 (1997).
- [WINELAND75] D. Wineland and H. Dehmelt, "Proposed $10^{14} \Delta\nu < \nu$ laser fluorescence spectroscopy on TI^+ mono-ion oscillator III," *Bull. Am. Phys. Soc.* **20**, 637 (1975).
- [WINELAND78] D. J. Wineland, R. E. Drullinger, and F. L. Walls, "Radiation-Pressure Cooling of Bound Resonant Absorbers," *Phys. Rev. Lett.* **40**, 1639 (1978).
- [WINOTO99A] S. Lukman Winoto, Marshall T. DePue, Nathan E. Bramall, and David S. Weiss, "Laser cooling at high density in deep far-detuned optical lattices," *Phys. Rev. A* **59**, R19 (1999).
- [WINOTO99B] Sugiharto Lukman Winoto, *Laser Cooling of Cesium Atoms in Far-Detuned Optical Lattices*, Ph.D. dissertation, University of California, Berkeley (1999).
- [WOLF00] Steffen Wolf, Steven J. Oliver, and David S. Weiss, "Suppression of Recoil Heating by an Optical Lattice," *Phys. Rev. Lett.* **85**, 4249 (2000).

- [YOUNG94] L. Young, W. T. Hill III, S. J. Sibener, Stephen D. Price, C. E. Tanner, C. E. Wieman, and Stephen R. Leone, "Precision lifetime measurements of Cs $6p^2P_{1/2}$ and $6p^2P_{3/2}$ levels by single-photon counting," *Phys. Rev. A* **50**, 2174 (1994).
- [ZAKRZEWSKI98] Jakub Zakrzewski, Dominique Delande, and Andreas Buchleitner, "Ionization via chaos assisted tunneling," *Phys. Rev. E* **57**, 1458 (1998).
- [ZANARDI95] Enrique M. Zanardi, Javier Gutiérrez, and Jose M. Gomez Llorente, "Mixed dynamics and tunneling," *Phys. Rev. E* **52**, 4736 (1995).
- [ZASLAVSKY81] George M. Zaslavsky, "Stochasticity in Quantum Systems," *Phys. Rep.* **80**, 157 (1981).
- [ZASLAVSKY97] G. M. Zaslavsky, M. Edelman, and B. A. Niyazov, "Self-similarity, renormalization, and phase space nonuniformity of Hamiltonian chaotic dynamics," *Chaos* **7**, 159 (1997).
- [ZASLAVSKY99] George M. Zaslavsky, "Chaotic Dynamics and the Origin of Statistical Laws," *Physics Today* p. 39 (August 1999).
- [ZENER32] Clarence Zener, "Non-Adiabatic Crossing of Energy Levels," *Proc. R. Soc. London A* **137**, 696 (1932).
- [ZHONG01] Jianxin Zhong, R. B. Diener, Daniel A. Steck, Windell H. Oskay, Mark G. Raizen, E. Ward Plummer, Zhenyu Zhang, and Qian Niu, "Shape of the Quantum Diffusion Front," *Phys. Rev. Lett.* **86**, 2485 (2001).
- [ZUMOFEN99] G. Zumofen and J. Klafter, "Comment on 'Self-similarity and transport in the standard map,'" *Phys. Rev. E* **59**, 3756 (1999).
- [ZUREK81] W. H. Zurek, "Pointer basis of quantum apparatus: Into what mixture does the wave packet collapse?" *Phys. Rev. D* **24**, 1516 (1981).
- [ZUREK82] W. H. Zurek, "Environment-induced superselection rules," *Phys. Rev. D* **26**, 1862 (1982).
- [ZUREK91] Wojciech H. Zurek, "Decoherence and the Transition from Quantum to Classical," *Physics Today* p. 36 (October 1991). See also the follow-up discussion in *Physics Today* (April 1993).
- [ZUREK93] Wojciech H. Zurek, Salman Habib, and Juan Pablo Paz, "Coherent States via Decoherence," *Phys. Rev. Lett.* **70**, 1187 (1993).

- [ZUREK94] Wojciech Hubert Zurek and Juan Pablo Paz, "Decoherence, Chaos, and the Second Law," *Phys. Rev. Lett.* **72**, 2508 (1994).
- [ZUREK95] Wojciech Hubert Zurek and Juan Pablo Paz, "Zurek and Paz Reply," *Phys. Rev. Lett.* **75**, 351 (1995). A reply to the comment on [Zurek94] by [Casati95].
- [ZUREK01] Wojciech Hubert Zurek, "Sub-Planck structure in phase space and its relevance for quantum decoherence," *Nature* **412**, 712 (2001).



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Vita

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