

## References

### Books

- [1] S. A. Schelkunoff, *Electromagnetic Waves*, Van Nostrand, New York, 1943.
- [2] S. A. Schelkunoff and H. T. Friis, *Antennas, Theory and Practice*, Wiley, New York, 1952.
- [3] R. W. P. King, *The Theory of Linear Antennas*, Harvard Univ. Press, Cambridge, MA, 1956.
- [4] R. W. P. King, R. B. Mack, and S. S. Sandler, *Arrays of Cylindrical Dipoles*, Cambridge Univ. Press, Cambridge, 1968.
- [5] J. D. Kraus, *Antennas*, 2nd ed., McGraw-Hill, New York, 1988.
- [6] C. A. Balanis, *Antenna Theory, Analysis and Design*, 2nd ed., Wiley, New York, 1996.
- [7] W. L. Stutzman and G. A. Thiele, *Antenna Theory and Design*, 2nd ed., Wiley, New York, 1998.
- [8] R. S. Elliott, *Antenna Theory and Design*, Prentice Hall, Upper Saddle River, NJ, 1981.
- [9] R. E. Collin and F. J. Zucker, eds., *Antenna Theory*, parts 1 and 2, McGraw-Hill, New York, 1969.
- [10] A. W. Rudge, K. Milne, A. D. Olver, and P. Knight, eds., *The Handbook of Antenna Design*, vols. 1 and 2, 2nd ed., Peter Peregrinus Ltd., London, 1986.
- [11] R. C. Johnson, ed., *Antenna Engineering Handbook*, 3d ed., McGraw-Hill, New York, 1993.
- [12] T. S. M. Maclean, *Principles of Antennas: Wire and Aperture*, Cambridge Univ. Press, Cambridge, 1986.
- [13] J. R. Wait, *Introduction to Antennas and Propagation*, Peter Peregrinus, Ltd, London, 1986.
- [14] T. A. Milligan, *Modern Antenna Design*, McGraw-Hill, New York, 1985.
- [15] R. C. Hansen, *Microwave Scanning Antennas*, Academic Press, New York, vol. I, 1964, vols II and III, 1966.
- [16] R. C. Hansen, *Phased Array Antennas*, Wiley, New York, 1998.
- [17] E. Brookner, ed., *Practical Phased Array Antenna Systems*, Artech House, Boston, 1991.
- [18] R. J. Mailloux, *Phased Array Antenna Handbook*, Artech House, Norwood, MA, 1994.
- [19] R. E. Collin, *Antennas and Radiowave Propagation*, McGraw-Hill, New York, 1985.
- [20] H. Mott, *Antennas for Radar and Communications: A Polarimetric Approach*, Wiley, New York, 1992.
- [21] S. Silver, ed., *Microwave Antenna Theory and Design*, Peter Peregrinus, Ltd, London, 1984.
- [22] R. F. Harrington, *Time-Harmonic Electromagnetic Fields*, McGraw-Hill, New York, 1961.
- [23] G. S. Smith, *An Introduction to Classical Electromagnetic Radiation*, Cambridge Univ. Press, Cambridge, 1997.
- [24] C. G. Someda, *Electromagnetic Waves*, Chapman and Hall, London, 1998.
- [25] E. J. Rothwell and M. J. Cloud, *Electromagnetics*, CRC Press, Boca Raton, FL, 2001.
- [26] L. B. Felsen and N. Marcuvitz, *Radiation and Scattering of Waves*, IEEE Press, New York, 1994.
- [27] L. Tsang, J. A. Kong, and K-H. Ding, *Scattering of Electromagnetic Waves*, Wiley, New York, 2000.
- [28] S. Drabowitch, A. Papernik, H. Griffiths, and J. Encinas, *Modern Antennas*, Chapman & Hall, London, 1998.
- [29] A. D. Olver, *Microwave and Optical Transmission*, Wiley, Chichester, England, 1992.
- [30] J. A. Kong, *Electromagnetic Wave Theory*, 2nd ed., Wiley, New York, 1990.
- [31] H. C. Chen, *Theory of Electromagnetic Waves*, McGraw Hill, New York, 1983.

- [32] G. Tylas, *Radiation and Propagation of Electromagnetic Waves*, Academic Press, New York, 1969.
- [33] D. H. Staelin, A. W. Morgenthaler, and J. A. Kong, *Electromagnetic Waves*, Prentice Hall, Upper Saddle River, NJ, 1994.
- [34] E. C. Jordan and K. G. Balmain, *Electromagnetic Waves and Radiating Systems*, 2nd ed., Prentice Hall, Upper Saddle River, NJ, 1968.
- [35] W. L. Weeks, *Antenna Engineering*, McGraw-Hill, New York, 1968.
- [36] S. Ramo, J. R. Whinnery, and T. Van Duzer, *Fields and Waves in Communication Electronics*, 3d ed., Wiley, New York, 1994.
- [37] J. D. Kraus, *Electromagnetics*, 3d ed., McGraw-Hill, New York, 1984.
- [38] D. J. Griffiths, *Introduction to Electrodynamics*, 3/e, Prentice Hall, Upper Saddle River, NJ, 1999.
- [39] C. A. Balanis, *Advanced Engineering Electromagnetics*, Wiley, New York, 1989.
- [40] J. D. Jackson, *Classical Electrodynamics*, 3d ed., Wiley, New York, 1998.
- [41] M. A. Heald and J. B. Marion, *Classical Electromagnetic Radiation*, 3d ed., Saunders College Publishing, New York, 1995.
- [42] A. A. Smith, *Radio Frequency Principles and Applications*, IEEE Press, Piscataway, NJ, 1998.
- [43] R. D. Straw, ed., *The ARRL Antenna Book*, 18th ed., American Radio Relay League, Newington, CT, 1997.
- [44] P. Danzer, ed., *The ARRL Handbook*, 75th ed., American Radio Relay League, Newington, CT, 1998.
- [45] F. A. Benson and T. M. Benson, *Fields, Waves and Transmission Lines*, Chapman and Hall, London, 1991.
- [46] A. F. Wickersham, *Microwave and Fiber Optics Communications*, Prentice Hall, Upper Saddle River, NJ, 1988.
- [47] A. V. Oppenheim, R. W. Schafer, and J. R. Buck, *Discrete-Time Signal Processing*, 2nd ed., Prentice Hall, Upper Saddle River, NJ, 1999.
- [48] S. J. Orfanidis, *Introduction to Signal Processing*, Prentice Hall, Upper Saddle River, NJ, 1996.
- [49] D. K. Lynch and W. Livingston, *Color and Light in Nature*, Oxford Univ. Press, New York, 1995.
- [50] M. Minnaert, *Light and Color in the Outdoors*, translated and revised by L. Seymour, Springer-Verlag, New York, 1993.
- [51] A. Meinel and M. Meinel, *Sunsets, Twilights, and Evening Skies*, Cambridge University Press, Cambridge, 1983.
- [52] G. P. Können, *Polarized Light in Nature*, Cambridge University Press, Cambridge, 1985.
- [53] D. H. Towne, *Wave Phenomena*, Dover Publications, New York, 1988.
- [54] W. C. Elmore and M. A. Heald, *Physics of Waves*, Dover Publications, New York, 1985.
- [55] J. R. Peirce, *Almost All About Waves*, MIT Press, Cambridge, MA, 1974.

### History, Reviews, Physical Constants, Units, and IEEE Standards

- [56] H. Hertz, *Electric Waves*, Dover Publications, New York, 1962.
- [57] M. R. Cohen and I. E. Drabkin, *A Source Book in Greek Science*, Harvard University Press, Cambridge, MA, 1969.
- [58] A. M. Smith, "Ptolemy's Search for a Law of Refraction: A Case Study in the Classical Methodology of 'Saving the Appearances' and its Limitations", *Arch. Hist. Exact Sci.*, 26, 221 (1982).
- [59] L. S. Taylor, "Gallery of Electromagnetic Personalities: A Vignette History of Electromagnetics," see web site Ref. [1301].
- [60] L. S. Taylor, "Optics Highlights: An Anecdotal History of Optics from Aristophanes to Zernike," see web site Ref. [1302].
- [61] J. Hecht, "Illuminating the Origin of Light Guiding," *Optics & Photonics News*, 10, no.10, 26 (1999).
- [62] H. Crew, "Thomas Young's Place in the History of the Wave Theory of Light," *J. Opt. Soc. Am.*, 20, 3 (1930).
- [63] E. Weber, "The Evolution of Scientific Electrical Engineering," *IEEE Antennas and Propagation Mag.*, 33, 12, February 1991.

- [64] J. J. Roche, "A Critical Study of the Vector Potential," in *Physicists Look Back, Studies in the History of Physics*, J. J. Roche, ed., Adam Hilger, Bristol, 1990.
- [65] J. Van Bladel, "Lorentz or Lorenz?," *IEEE Antennas and Propagation Mag.*, 33, 69, April 1991.
- [66] J. D. Jackson and L. B. Okun, "Historical Roots of Gauge Invariance," *Rev. Mod. Phys.*, 73, 663 (2001).
- [67] R. Nevels and C-S. Shin, "Lorenz, Lorentz, and the Gauge," *IEEE Antennas and Propagation Mag.*, 43, 70, April 2001.
- [68] M. Pihl, "The Scientific Achievements of L. V. Lorenz," *Centaurus*, 17, 83 (1972).
- [69] Ludvig Lorenz and Nineteenth Century Optical Theory: The Work of a Great Danish Scientist," *Appl. Opt.*, 30, 4688 (1991).
- [70] O. Keller, "Optical Works of L. V. Lorenz," in *Progress in Optics*, vol.43, E. Wolf, ed., Elsevier, Amsterdam, 2002.
- [71] R. W. P. King, "The Linear Antenna—Eighty Years of Progress," *Proc. IEEE*, 55, 2 (1967).
- [72] Chen-To Tai, "On the Presentation of Maxwell's Theory," *Proc. IEEE*, 60, 936 (1972).
- [73] J. A. Kong, "Theorems of Bianisotropic Media," *Proc. IEEE*, 60, 1036 (1972).
- [74] S. A. Schelkunoff, "Forty Years Ago: Maxwell's Theory Invades Engineering—and Grows with It," *IEEE Trans. Educ.*, E-15, 2 (1972).
- [75] S. A. Schelkunoff, "On Teaching the Undergraduate Electromagnetic Theory," *IEEE Trans. Educ.*, E-15, 2 (1972).
- [76] J. E. Brittain, "The Smith Chart," *IEEE Spectrum*, 29, 65, Aug. 1992.
- [77] G. McElroy, "Opening Lines: A Short History of Coaxial cable," *QST*, 85, 62, Aug. 2001.
- [78] V. J. Katz, "The History of Stokes' Theorem," *Math. Mag.*, 52, 146 (1979).
- [79] J. R. Jones, "A Comparison of Lightwave, Microwave, and Coaxial Transmission Technologies," *IEEE Trans. Microwave Theory Tech.*, MTT-30, 1512 (1982).
- [80] D. K. Barton, "A Half Century of Radar," *IEEE Trans. Microwave Theory Tech.*, MTT-32, 1161 (1984).
- [81] M. Kahrs, "50 Years of RF and Microwave Sampling," *IEEE Trans. Microwave Theory Tech.*, MTT-51, 1787 (2003).
- [82] C. A. Balanis, "Antenna Theory: A Review," *Proc. IEEE*, 80, 7 (1992).
- [83] W. Stutzman, "Bibliography for Antennas," *IEEE Antennas and Propagation Mag.*, 32, 54, August 1990.
- [84] J. F. Mulligan, "The Influence of Hermann von Helmholtz on Heinrich Hertz's Contributions to Physics," *Am. J. Phys.*, 55, 711 (1987).
- [85] C-T. Tai and J. H. Bryant, "New Insights in Hertz's Theory of Electromagnetism," *Radio Science*, 29, 685 (1994).
- [86] R. Cecchini and G. Pelosi, "Diffraction: The First Recorded Observation," *IEEE Antennas and Propagation Mag.*, 32, 27, April 1990.
- [87] O. M. Bucci and G. Pelosi, "From Wave Theory to Ray Optics," *IEEE Antennas and Propagation Mag.*, 36, 35, August 1994.
- [88] A. A. Penzias, "Measurement of Cosmic Microwave Background Radiation," *IEEE Trans. Microwave Theory Tech.*, MTT-16, 608 (1968).
- [89] E. R. Cohen, "The 1986 CODATA Recommended Values of the Fundamental Physical Constants," *J. Res. Natl. Bur. Stand.*, 92, 85, (1987).
- [90] C. W. Allen, *Astrophysical Quantities*, Athlone Press, University of London, London, 1976.
- [91] "IEEE Standard Test Procedures for Antennas," IEEE Std 149-1965, *IEEE Trans. Antennas Propagat.*, AP-13, 437 (1965). Revised IEEE Std 149-1979.
- [92] "IEEE Standard Definitions of Terms for Antennas," IEEE Std 145-1983, *IEEE Trans. Antennas Propagat.*, AP-31, pt.II, p.5, (1983). Revised IEEE Std 145-1993.
- [93] "IRE Standards on Antennas and Waveguides: Definitions and Terms, 1953," *Proc. IRE*, 41, 1721 (1953). Revised IEEE Std 146-1980.
- [94] "IRE Standards on Methods of Measuring Noise in Linear Twoports, 1959," *Proc. IRE*, 48, 60 (1960).
- [95] IRE Subcommittee 7.9 on Noise, "Representation of Noise in Linear Twoports," *Proc. IRE*, 48, 69 (1960).

- [96] "IRE Standards on Electron Tubes: Definitions of Terms, 1962 (62 IRE 7. S2)," *Proc. IRE*, **51**, 434 (1963).
- [97] IRE Subcommittee 7.9 on Noise, "Description of the Noise Performance of Amplifiers and Receiving Systems," *Proc. IEEE*, **51**, 436 (1963).
- [98] C. K. S. Miller, W. C. Daywitt, and M. G. Arthur, "Noise Standards, Measurements, and Receiver Noise Definitions," *Proc. IEEE*, **55**, 865 (1967).
- [99] A. R. Kerr, "Suggestions for Revised Definitions of Noise Quantities, Including Quantum Effects," *Proc. IEEE*, **47**, 325 (1999).
- [100] E. S. Weibel, "Dimensionally Correct Transformations Between Different Systems of Units," *Am. J. Phys.*, **36**, 1130 (1968).
- [101] B. Leroy, "How to Convert the Equations of Electromagnetism from Gaussian to SI Units in Less Than No Time," *Am. J. Phys.*, **53**, 589 (1985).
- [102] E. A. Desloge, "Relation Between Equations in the International, Electrostatic, Electromagnetic, Gaussian, and Heaviside-Lorentz Systems," *Am. J. Phys.*, **62**, 602 (1994), and references therein on units.
- [103] *NRL Plasma Formulary*, 2000 Revised Edition, see web site [1330].
- [104] "IEEE Standard Radar Definitions," IEEE Std 686-1997.
- [105] "IEEE Standard Letter Designations for Radar-Frequency Bands," IEEE Std 521®-2002.

### Green's Functions

- [106] J. Van Bladel, "Some Remarks on Green's Dyadic for Infinite Space," *IRE Trans. Antennas Propagat.*, **AP-9**, 563 (1961).
- [107] K-M. Chen, "A Simple Physical Picture of Tensor Green's Function in Source Region," *Proc. IEEE*, **65**, 1202 (1977).
- [108] A. D. Yaghjian, "Electric Dyadic Green's Functions in the Source Region," *Proc. IEEE*, **68**, 248 (1980). See also the comment by C. T. Tai, *ibid.*, **69**, 282 (1981).
- [109] A. D. Yaghjian, "Maxwellian and Cavity Electromagnetic Fields Within Continuous Sources," *Am. J. Phys.*, **53**, 859 (1985).
- [110] M. Silberstein, "Application of a Generalized Leibniz Rule for Calculating Electromagnetic Fields Within Continuous Source Regions," *Radio Sci.*, **26**, 183 (1991).
- [111] C. P. Frahm, "Some Novel Delta-Function Identities," *Am. J. Phys.*, **51**, 826 (1983).
- [112] J. M. Aguirregabiria, A. Hernández, and M. Rivas, "Delta-Function Converging Sequences," *Am. J. Phys.*, **70**, 180 (2002).

### Material Properties, Relaxation, and Screening

- [113] R. M. Pope and E. S. Fry, "Absorption Spectrum (380–700 nm) of Pure Water. II. Integrating Cavity Measurements," *Appl. Opt.*, **36**, 8710 (97).
- [114] N. E. Bengtsson and T. Ohlsson, "Microwave Heating in the Food Industry," *Proc. IEEE*, **62**, 44 (1974).
- [115] W. M. Saslow and G. Wilkinson, "Expulsion of Free Electronic Charge from the Interior of a Metal," *Am. J. Phys.*, **39**, 1244 (1971).
- [116] N. Ashby, "Relaxation of Charge Imbalances in Conductors," *Am. J. Phys.*, **43**, 553 (1975).
- [117] H. C. Ohanian, "On the Approach to Electro- and Magneto-Static Equilibrium," *Am. J. Phys.*, **51**, 1020 (1983).
- [118] E. J. Bochove and J. F. Walkup, "A Communication on Electrical Charge Relaxation in Metals," *Am. J. Phys.*, **58**, 131 (1990).
- [119] S. Fahy, C. Kittel, and S. G. Louie, "Electromagnetic Screening by Metals," *Am. J. Phys.*, **56**, 989 (1988).
- [120] A. R. von Hippel, *Dielectrics and Waves*, MIT Press, Cambridge, MA, 1954.
- [121] S. A. Korff and G. Breit, "Optical Dispersion," *Rev. Mod. Phys.*, **4**, 471 (1932).
- [122] G. Breit, "Quantum Theory of Dispersion," *Rev. Mod. Phys.*, **4**, 504 (1932), and *ibid.*, **5**, 91 (1933).
- [123] R. Ladenburg, "Dispersion in Electrically Excited Gases," *Rev. Mod. Phys.*, **5**, 243 (1933).

- [124] I. H. Malitson, "Interspecimen Comparison of the Refractive Index of Fused Silica," *J. Opt. Soc. Am.*, **55**, 1205 (1965).
- [125] P. B. Johnson and R. W. Christy, "Optical Constants of the Noble Metals," *Phys. Rev.*, **B-6**, 4370 (1972).
- [126] G. M. Hale and M. R. Querry, "Optical Constants of Water in the 200-nm to 200- $\mu$ m Wavelength Region," *Appl. Opt.*, **12**, 555 (1973).
- [127] W. J. Tropf, M. E. Thomas, and T. J. Harris, "Properties of Crystal and Glasses," in M. Bass, Ed., *Handbook of Optics*, vol. II, McGraw-Hill, New York, 1995. And, R. A. Paquin, "Properties of Metals," *ibid.*
- [128] A. K. Jonscher, "Dielectric Relaxation in Solids," *J. Phys. D: Appl. Phys.*, **32** R57 (1999).
- [129] J. J. Makosz and P. Urbanowicz, "Relaxation and Resonance Absorption in Dielectrics," *Z. Naturforsch.*, **57-A**, 119 (2002).

### Group Velocity, Energy Velocity, Momentum, and Radiation Pressure

- [130] L. D. Landau, E. M. Lifshitz, and L. P. Pitaevskii, *Electrodynamics of Continuous Media*, 2/e, Elsevier Science, Burlington, MA, 1985.
- [131] W. Pauli, *Optics and the Theory of Electrons*, Dover Publications, Mineola, NY, 1973.
- [132] H. Pelzer, "Energy Density of Monochromatic Radiation in a Dispersive Medium," *Proc. Roy. Soc. London. Ser. A*, **208**, 365 (1951).
- [133] M. A. Biot, "General Theorems on the Equivalence of Group Velocity and Energy Transport," *Phys. Rev.*, **105**, 1129 (1957).
- [134] R. Loudon, "The Propagation of Electromagnetic Energy through an Absorbing Dielectric," *J. Phys. A*, **3**, 233 (1970).
- [135] J. P. Gordon, "Radiation Forces and Momenta in Dielectric Media," *Phys. Rev.*, **A-8**, 14 (1973).
- [136] M. V. Berry, "On the Ubiquity of the Sine Wave," *Am. J. Phys.*, **43**, 91 (1975).
- [137] K. E. Oughstun and S. Shen, "Velocity of Energy Transport for a Time-Harmonic Field in a Multiple-Resonance Lorentz Medium," *J. Opt. Soc. Am.*, **B-5**, 2395 (1988).
- [138] G. C. Sherman and K. E. Oughstun, "Energy Velocity Description of Pulse Propagation in Absorbing, Dispersive Dielectrics," *J. Opt. Soc. Am.*, **B-12**, 229 (1995).
- [139] G. Diener, "Energy Transport in Dispersive Media and Superluminal Group Velocities," *Phys. Lett.*, **A-235**, 118 (1997).
- [140] K. M. Awati and T. Howes, "Question #52. Group Velocity and Energy Propagation," *Am. J. Phys.*, **64**, 1353 (1996), and the answers by K. T. McDonald, *ibid.*, **66**, 656 (1998); C. S. Helrich, *ibid.*, p. 658; R. J. Mather, *ibid.*, p. 659; S. Wong and D. Styer, *ibid.*, p. 659; and A. Bers, *ibid.*, **68**, 482 (2000).
- [141] J. Peatross, S. A. Glasgow, and M. Ware, "Average Energy Flow of Optical Pulses in Dispersive Media," *Phys. Rev. Lett.*, **84**, 2370 (2000).
- [142] S. Glasgow, M. Ware, and J. Peatross, "Poynting's Theorem and Luminal Total Energy Transport in Passive Dielectric Media," *Phys. Rev.*, **E-64**, 046610 (2001).
- [143] C-G. Huang and Y-Z. Zhang, "Poynting Vector, Energy Density, and Energy Velocity in an Anomalous Dispersion Medium," *Phys. Rev.*, **A-65**, 015802 (2001).
- [144] R. Ruppin, "Electromagnetic Energy Density in a Dispersive and Absorptive Material," *Phys. Lett.*, **A-299**, 309 (2002).
- [145] D. F. Nelson, "Momentum, Pseudomomentum, and Wave Momentum: Toward Resolving the Minkowski-Abraham Controversy," *Phys. Rev.*, **A-44**, 3985 (1991).
- [146] R. H. Romer, "Question #26. Electromagnetic Field Momentum," *Am. J. Phys.*, **63**, 777 (1995), and the answers by K. T. McDonald, *ibid.*, **64**, 15 (1996); F. Rohrlich, *ibid.*, p. 16; B. R. Holstein, *ibid.*, p. 17;
- [147] R. Loudon, L. Allen and D. F. Nelson, "Propagation of Electromagnetic Energy and Momentum Through an Absorbing Dielectric," *Phys. Rev.*, **E-55**, 1071 (1997).
- [148] R. Loudon, "Theory of the Radiation Pressure on Dielectric Surfaces," *J. Mod. Opt.*, **49**, 821 (2002).
- [149] M. Mansuripur, "Radiation Pressure and the Linear Momentum of the Electromagnetic Field," *Opt. Express*, **12**, 5375 (2004).

- [150] B. A. Kemp, T. M. Gregorczyk, and J. A. Kong, "Ab Initio Study of the Radiation Pressure on Dielectric and Magnetic Media," *Opt. Express*, **13**, 9280 (2005).
- [151] S. Stallinga, "Energy and Momentum of Light in Dielectric Media," *Phys. Rev.*, **E-73**, 026606 (2006).
- [152] M. Scalora, et al., "Radiation Pressure of Light Pulses and Conservation of Linear Momentum in Dispersive Media," *Phys. Rev.*, **E-73**, 056604 (2006).
- [153] R. N. C. Pfeifer, et al., "Momentum of an electromagnetic wave in dielectric media," *Rev. Mod. Phys.*, **79**, 1179 (2007).

### Pulse Propagation, Spreading, and Dispersion Compensation

- [154] L. Brillouin, *Wave Propagation and Group Velocity*, Academic Press, New York, 1960.
- [155] A. Papoulis, *The Fourier Integral and its Applications*, McGraw-Hill, New York, 1962.
- [156] G. A. Campbell and R. M. Foster, *Fourier Integrals for Practical Applications*, Van Nostrand, New York, 1948.
- [157] A. Ghatak and K. Thyagarajan, *Introduction to Fiber Optics*, Cambridge Univ. Press, Cambridge, 1998.
- [158] R. W. Boyd, *Nonlinear Optics* Academic, New York, 2003.
- [159] H. M. Nussenzveig, *Causality and Dispersion Relations*, Academic Press, New York, 1972.
- [160] V. Ginzburg, *The Propagation of Electromagnetic Waves in Plasmas*, 2nd ed., Pergamon Press, New York, 1970.
- [161] L. A. Vainshtein, "Propagation of Pulses," *Usp. Fiz. Nauk*, **118**, 339 (1976).
- [162] J. Weber, "Phase, Group, and Signal Velocity," *Am. J. Phys.*, **22**, 618 (1954).
- [163] M. P. Forrer, "Analysis of Millimicrosecond RF Pulse Transmission," *Proc. IRE*, **46**, 1830 (1958).
- [164] R. E. Haskell and C. T. Case, "Transient Signal Propagation in Lossless, Isotropic Plasmas," *IEEE Trans. Antennas Propagat.*, **AP-15**, 458 (1967).
- [165] S. Aksornkitti, H. C. S. Hsuan, and K. E. Lonngren, "Dispersion of an Electromagnetic Pulse," *Am. J. Phys.*, **37**, 783 (1969).
- [166] R. L. Smith, "The Velocities of Light," *Am. J. Phys.*, **38**, 978 (1970).
- [167] J. Jones, "On the Propagation of a Pulse through a Dispersive Medium," *Am. J. Phys.*, **42**, 43 (1974).
- [168] D. York, "Graphical Approach to Dispersion," *Am. J. Phys.*, **43**, 725 (1975).
- [169] W. V. Prestwich, "Precise Definition of Group Velocity," *Am. J. Phys.*, **43**, 832 (1975). See also the comment by E. E. Bergmann, *ibid.*, **44**, 890 (1976).
- [170] H. M. Bradford, "Propagation and Spreading of a Pulse or Wave Packet," *Am. J. Phys.*, **44**, 1058 (1976).
- [171] S. C. Bloch, "Eighth Velocity of Light," *Am. J. Phys.*, **45**, 538 (1977).
- [172] H. M. Bradford, "Propagation of a Step in the Amplitude or Envelope of a Pulse or Wave Packet," *Am. J. Phys.*, **47**, 688 (1979).
- [173] C. Almeida and A. Jabs, "Spreading of a Relativistic Wave Packet," *Am. J. Phys.*, **52**, 921 (1984).
- [174] J. M. Saca, "Addition of Group Velocities," *Am. J. Phys.*, **173** (1985).
- [175] J. A. Lock, "The Temporary Capture of Light by a Dielectric Film," *Am. J. Phys.*, **53**, 968 (1985).
- [176] P. C. Peters, "Does a Group Velocity Larger than  $c$  Violate Relativity?", *Am. J. Phys.*, **56**, 129 (1988).
- [177] R. A. Bachman, "Relativistic Phase Velocity Transformation," *Am. J. Phys.*, **57**, 628 (1989).
- [178] W-C. Wang and C-M. Chen, "About the Statistical Meaning of Group Velocity," *Am. J. Phys.*, **58**, 744 (1990).
- [179] A. Albareda, et al., "Simulation of Dispersion Propagation in Dispersive Media using FFT," *Am. J. Phys.*, **58**, 844 (1990).
- [180] F. S. Johnson, "Physical Cause of Group Velocity in Normally Dispersive, Nondissipative Media," *Am. J. Phys.*, **58**, 1044 (1990).
- [181] M. Tanaka, "Description of a Wave Packet Propagating in Anomalous Dispersion Media—A New Expression of Propagation Velocity," *Plasma Phys. & Contr. Fusion*, **31** 1049 (1989).
- [182] C. J. Gibbins, "Propagation of Very Short Pulses Through the Absorptive and Dispersive Atmosphere," *IEE Proc., Pt. H*, **137**, 304 (1990).

- [183] P. Stenius and B. York, "On the Propagation of Transients in Waveguides," *IEEE Ant. Propag. Mag.*, **37**, p. 339, April 1995.
- [184] S. L. Dvorak and D. G. Dudley, "Propagation of Ultra-Wide-Band Electromagnetic Pulses Through Dispersive Media," *IEEE Trans. Electrom. Compat.*, **37**, 192 (1995). See also the comment by S. He, *ibid.*, **38**, 202 (1996).
- [185] P. Hillion, "Propagation of Electromagnetic Pulses in an Infinite Drude Medium," *IEEE Trans. Electromagn. Compat.*, **39** 361 (1997).
- [186] J. Leander, "On the Relation Between the Wavefront Speed and the Group Velocity Concept," *J. Acoust. Soc. Am.*, **100**, 3503 (1996).
- [187] P. Loughlin and L. Cohen, "Local Properties of Dispersive Pulses," *J. Mod. Opt.*, **49**, 2645 (2002).
- [188] L. Yang and I. R. Epstein, "Chemical Wave Packet Propagation, Reflection, and Spreading," *J. Phys. Chem.*, **A-106**, 11676 (2002).
- [189] S. A. Ramakrishna and A. D. Armour, "Propagating and Evanescent Waves in Absorbing Media," *Am. J. Phys.*, **71**, 562 (2003).
- [190] Y. Pinhasi, et al., "Study of Ultrawide-Band Transmission in the Extremely High Frequency (EHF) Band," *IEEE Trans. Antennas Propagat.*, **52**, 2833 (2004).
- [191] F. S. Crawford, "Chirped Handclaps," *Am. J. Phys.*, **38**, 378 (1970).
- [192] F. S. Crawford, "Douglas Fir Echo Chamber," *Am. J. Phys.*, **38**, 1477 (1970).
- [193] F. S. Crawford, "Culvert Whistlers," *Am. J. Phys.*, **39**, 610 (1971).
- [194] P. M. Rinard, "Rayleigh, Echoes, Chirps, and Culverts," *Am. J. Phys.*, **40**, 923 (1972).
- [195] D. Marcuse, "Pulse Distortion in Single-Mode Fibers," *Appl. Opt.*, **19**, 1653 (1980).
- [196] D. Marcuse, "Pulse Distortion in Single-Mode Fibers. Part 2," *Appl. Opt.*, **20**, 2969 (1981).
- [197] D. Marcuse, "Pulse Distortion in Single-Mode Fibers. 3: Chirped Pulses," *Appl. Opt.*, **20**, 3573 (1981).
- [198] T. L. Koch and R. C. Alferness, "Dispersion Compensation by Active Predistorted Signal Synthesis," *J. Lightwave Tech.*, **LT-3**, 800 (1985).
- [199] D. Anderson and M. Lisak, "Analytic Study of Pulse Broadening in Dispersive Optical Fibers," *Phys. Rev.*, **A-35**, 184 (1987).
- [200] J. E. Roman and K. A. Winick, "Waveguide Grating Filters for Dispersion Compensation and Pulse Compression," *IEEE J. Quant. Electr.*, **29**, 975 (1993).
- [201] B. Jopson and A. Gnauck, "Dispersion Compensation for Optical Fiber Systems," *IEEE Comm. Mag.*, **33**, no.6, 96 (1995).
- [202] H. A. Haus, "Optical Fiber Solitons, Their Properties and Uses," *Proc. IEEE*, **81**, 970 (1993).
- [203] J. M. Arnold, "Solitons in Communications," *Electr. & Commun. Eng. J.*, **8**, no. 2, 88 (1996).
- [204] H. A. Haus, "Group Velocity, Energy, and Polarization Mode Dispersion," *J. Opt. Soc. Am.*, **B-16**, 1863 (1999).
- [205] P. Lazaridis, G. Debarge, and P. Gallion, "Discrete Orthogonal Gauss-Hermite Transform for Optical Pulse Propagation Analysis," *J. Opt. Soc. Am.*, **B-20**, 1508 (2003).
- [206] ITU-T Recommendation G.652, 6/2005, available from [www.itu.int](http://www.itu.int).

### Precursors

- [207] K. E. Oughstun and G. C. Sherman, *Electromagnetic Pulse Propagation in Causal Dielectrics*, Springer-Verlag, Berlin, 1994.
- [208] H. G. Baerwald, "Über die Fortpflanzung von Signalen in Dispergierenden Systemen," *Ann. Physik*, **7**, 731 (1930).
- [209] P. Pleshko and I. Palócz, "Experimental Observation of Sommerfeld and Brillouin Precursors in the Microwave Domain," *Phys. Rev. Lett.*, **22**, 1201 (1969).
- [210] D. B. Trizna and T. A. Weber, "Brillouin Revisited: Signal Velocity Definition for Pulse Propagation in a Medium with Resonant Anomalous Dispersion," *Radio Sci.*, **17**, 1169 (1982).
- [211] R. Albanese, J. Penn, and R. Medina, "Short-Rise-Time Microwave Pulse Propagation Through Dispersive Biological Media," *J. Opt. Soc. Am.*, **A-6**, 1441 (1989).

- [212] K. E. Oughstun, "Pulse Propagation in a Linear, Causally Dispersive Medium," *Proc. IEEE*, **79**, 1379 (1991).
- [213] C. M. Balitsis and K. E. Oughstun, "Uniform Asymptotic Description of Ultrashort Gaussian-Pulse Propagation in a Causal, Dispersive Dielectric," *Phys. Rev.*, **E-47**, 3645 (1993).
- [214] C. M. Balitsis and K. E. Oughstun, "Generalized Asymptotic Description of the Propagated Field Dynamics in Gaussian Pulse Propagation in a Linear, Causally Dispersive Medium," *Phys. Rev.*, **E-55**, 1910 (1997).
- [215] F. J. Ribeiro and M. L. Cohen, "Amplifying Sommerfeld Precursors and Producing a Discontinuous Index of Refraction with Gains and Losses," *Phys. Rev.*, **E-64**, 046602 (2001).
- [216] K. E. Oughstun and N. A. Cartwright, "Dispersive Pulse Dynamics and Associated Pulse Velocity Measures," *J. Optics A: Pure Appl. Opt.*, **4**, S125 (2002).
- [217] S-H. Choi and U. Österberg, "Observation of Optical Precursors in Water," *Phys. Rev. Lett.*, **92**, 193903 (2004).
- [218] H. Jeong, A. M.C. Dawes, and D. J. Gauthier "Direct Observation of Optical Precursors in a Region of Anomalous Dispersion," *Phys. Rev. Lett.*, **96**, 143901 (2006).
- [219] R. Safian, M. Mojahedi, and C. D. Sarris, "Asymptotic Description of Wave Propagation in an Active Lorentzian Medium," *Phys. Rev.*, **E-75**, 066611 (2007).

### Slow, Fast, and Negative Group Velocity

- [220] P. W. Milonni, *Fast Light, Slow Light and Left-Handed Light*, IOP Publishing, London, 2005.
- [221] A. Icesvgi and W. E. Lamb, "Propagation of Light Pulses in a Laser Amplifier," *Phys. Rev.*, **185**, 517 (1969).
- [222] C. G. B. Garrett and D. E. McCumber, "Propagation of a Gaussian Light Pulse through an Anomalous Dispersion Medium," *Phys. Rev.*, **A-1**, 305 (1970).
- [223] M. D. Crisp, "Concept of Group Velocity in Resonant Pulse Propagation , " *Phys. Rev.*, **A-4**, 2104 (1971).
- [224] M. D. Crisp, "Propagation of Small-Area Pulses of Coherent Light through a Resonant Medium," *Phys. Rev.*, **A-1**, 1604 (1971).
- [225] L. Caspelson and A. Yariv, "Pulse Propagation in a High-Gain Medium," *Phys. Rev. Lett.*, **26**, 293 (1971).
- [226] J. Jones, "On the Propagation of a Pulse Through a Dispersive Medium," *Am. J. Phys.*, **42**, 43 (1974).
- [227] D. Anderson, J. Askne, and M. Lisak, "Wave Packets in an Absorptive and Strongly Dispersive Medium," *Phys. Rev.*, **A-12**, 1546 (1975).
- [228] S. Chu and S. Wong, "Linear Pulse Propagation in an Absorbing Medium , " *Phys. Rev. Lett.*, **48**, 738 (1982).
- [229] B. Ségard and B. Macke, "Observation of Negative Velocity Pulse Propagation," *Phys. Lett. A*-**109**, 213 (1985).
- [230] M. Tanaka, M. Fujiwara, and H. Ikegami, "Propagation of a Gaussian Wave Packet in an Absorbing Medium , " *Phys. Rev.*, **A-34**, 4851 (1986).
- [231] R. Y. Chiao, "Superluminal (but causal) Propagation of Wave Packets in Transparent Media with Inverted Atomic Populations," *Phys. Rev.*, **A-48**, R34 (1993).
- [232] E. L. Bolda, R. Y. Chiao, and J. C. Garrison, "Two Theorems for the Group Velocity in Dispersive Media , " *Phys. Rev.*, **A-48**, 3890 (1993).
- [233] J. M. Deutch and F. E. Low, "Barrier Penetration and Superluminal Velocity," *Ann. Phys.*, **228**, 184 (1993).
- [234] E. L. Bolda, J. C. Garrison, and R. Y. Chiao, "Optical Pulse Propagation at Negative Group Velocities due to a Nearby Gain Line," *Phys. Rev.*, **A-49**, 2938 (1994).
- [235] A. M. Steinberg and R. Y. Chiao, "Dispersionless, Highly Superluminal Propagation in a Medium with a Gain Doublet," *Phys. Rev.*, **A-49**, 2071 (1994).
- [236] Wang Yun-ping and Zhang Dian-lin, "Reshaping, Path Uncertainty, and Superluminal Traveling," *Phys. Rev.*, **A-52**, 2597 (1995).

- [237] R. Y. Chiao, "Population Inversion and Superluminality," in *Amazing Light*, R. Y. Chiao, ed., Springer, New York, 1996.
- [238] Y. Japha and G. Kurizki, "Superluminal Delays of Coherent Pulses in Nondissipative Media: A Universal Mechanism," *Phys. Rev.*, **A-53**, 586 (1996).
- [239] G. Diener, "Superluminal Group Velocities and Information Transfer," *Phys. Lett.*, **A-223**, 327 (1996).
- [240] R. Y. Chiao and A. M Steinberg, "Tunneling Times and Superluminality," in E. Wolf, ed., *Progr. Optics*, vol. XXXVII, Elsevier, New York, 1997.
- [241] Y. Aharonov, B. Reznik, and A. Stern, "Quantum Limitations on Superluminal Propagation," *Phys. Rev. Lett.*, **81**, 2190 (1998).
- [242] M. Büttikerl, H. Thomas, "Front Propagation in Evanescent Media," *Ann. Phys. (Leipzig)*, **7**, 602 (1998).
- [243] G. Nimtz, "Superluminal Signal Velocity," *Ann. Phys. (Leipzig)*, **7**, 618 (1998).
- [244] F. E. Low, "Comments on Apparent Superluminal Propagation," *Ann. Phys. (Leipzig)*, **7**, 660 (1998).
- [245] B. Segev, P. W. Milonni, J. F. Babb, and R. Y. Chiao, "Quantum Noise and Superluminal Propagation," *Phys. Rev.*, **A-62**, 62, 022114 (2000).
- [246] M. A. I. Talukder, Y. Amagishi, and M. Tomita, "Superluminal to Subluminal Transition in the Pulse Propagation in a Resonantly Absorbing Medium," *Phys. Rev. Lett.*, **86**, 3546 (2000).
- [247] L. J. Wang, A. Kuzmich, and A. Dogariu, "Gain-Assisted Superluminal Light Propagation," *Nature*, **406**, 277 (2000).
- [248] A. Dogariu, A. Kuzmich, and L. J. Wang, "Transparent Anomalous Dispersion and Superluminal Light-Pulse Propagation at a Negative Group Velocity," *Phys. Rev.*, **A-63**, 053806 (2001).
- [249] J. Marangos, "Faster Than a Speeding Photon," *Nature*, **406**, 243 (2000).
- [250] K. T. McDonald, "Negative group velocity," *Am. J. Phys.*, **69**, 607 (2001).
- [251] P. Sprangle, J. R. Peñano, and B. Hafizi "Apparent Superluminal Propagation of a Laser Pulse in a Dispersive Medium," *Phys. Rev.*, **E-64**, 026504 (2001).
- [252] T. Sauter, "Superluminal Signals: an Engineer's Perspective," *Phys. Lett.*, **A-282**, 145 (2001).
- [253] A. D. Jackson A. Lande, and B. Lautrup, "Apparent Superluminal Behavior in Wave Propagation," *Phys. Rev.*, **A-64**, 044101 (2001).
- [254] T. Sauter, "Gaussian Pulses and Superluminality," *J. Phys. A: Math. Gen.*, **35**, 6743 (2002).
- [255] C-G Huang and Y-Z Zhang, "Negative Group Velocity and Distortion of a Pulse in an Anomalous Dispersion Medium," *J. Opt. A: Pure Appl. Opt.*, **4**, 263 (2002).
- [256] R. Y. Chiao and P. W. Milonni, "Fast Light, Slow Light," *Opt. Photon. News*, p. 27, June 2002.
- [257] J. E. Heebner and R. W. Boyd, "'Slow' and 'Fast' Light in Resonator-Coupled Waveguides," *J. Mod. Opt.*, **49**, 2629 (2002).
- [258] G. Nimtz and A. Haibel, "Basics of Superluminal Signals," *Ann. Phys. (Leipzig)*, **11**, 163 (2002).
- [259] W. M. Robertson, J. Ash, and J. M. McGaugh, "Breaking the Sound Barrier: Tunneling of Acoustic Waves Through the Forbidden Transmission Region of a One-Dimensional Acoustic Band Gap Array," *Am. J. Phys.*, **70**, 689 (2002).
- [260] H. Tanaka, et al., "Propagation of Optical Pulses in a Resonantly Absorbing Medium: Observation of Negative Velocity in Rb Vapor," *Phys. Rev.*, **A-68**, 053801 (2003).
- [261] H. Cao, A. Dogariu, and L. J. Wang, "Negative Group Delay and Pulse Compression in Superluminal Pulse Propagation," *IEEE J. Sel. Top. Quant. Electr.*, **9**, 52 (2003).
- [262] B. Macke and B. Ségard, "Propagation of Light-Pulses at a Negative Group Velocity," *Eur. Phys. J.*, **D 23**, 125 (2003).
- [263] M. D. Stenner, D. J. Gauthier, and M. A. Neifeld, "The Speed of Information in a 'fast-light' Optical Medium," *Nature*, **425**, 695 (2003).
- [264] H. G. Winful, "Nature of 'Superluminal' Barrier Tunneling," *Phys. Rev. Lett.*, **90**, 023901 (2003).
- [265] M. Büttiker and S. Washburn, "Ado About Nothing Much?," *Nature*, **422**, 271 (2003).
- [266] H. G. Winful, "Mechanism for 'Superluminal' Tunneling," *Nature*, **424**, 638 (2003).
- [267] Z. M. Zhang and K. Park, "On the Group Front and Group Velocity in a Dispersive Medium Upon Refraction From a Nondispersing Medium," *J. Heat Transf.*, **126**, 244 (2004).

- [268] J. N. Munday and R. H. Henderson, "Superluminal Time Advance of a Complex Audio Signal," *Appl. Phys. Lett.*, **85**, 503 (2004).
- [269] A. Ranfagni, D. Mugnai, and M. A. Vitali, "Real-Time Analysis of the Telegrapher's Equation for Tunneling Processes," *Phys. Rev. E*-**69**, 057603 (2004).
- [270] M. D. Stenner, D. J. Gauthier, and M. A. Neifeld, "Fast Causal Information Transmission in a Medium with a Slow Group Velocity," *Phys. Rev. Lett.*, **94**, 053902 (2005).
- [271] Y. Okawachi, et al., "Tunable All-Optical Delays via Brillouin Slow Light in an Optical Fiber," *Phys. Rev. Lett.*, **94**, 153902 (2005).
- [272] J. R. Klauder, "Signal Transmission in Passive Media," *IEE Proc.-Radar Sonar Navig.*, **152**, 23 (2005).
- [273] G. A. Mourou, T. Tajima, and S. V. Bulanov, "Optics in the Relativistic Regime," *Rev. Mod. Phys.*, **78**, 309 (2006).
- [274] W. Guo, "Understanding Subluminal and Superluminal Propagation Through Superposition of Frequency Components," *Phys. Rev. E*-**73**, 016605 (2006).
- [275] G. M. Gehring, et al., "Observation of Backward Pulse Propagation Through a Medium with a Negative Group Velocity," *Science*, **312**, 895 (2007).
- [276] M. W. Mitchell and R. Y. Chiao, "Causality and Negative Group Delays in a Simple Bandpass Amplifier," *Am. J. Phys.*, **66**, 14 (1998). See also, *Phys. Lett. A*-**230**, 133 (1997).
- [277] J. C. Garrison, M. W. Mitchell, R. Y. Chiao, E. L. Bolda, "Superluminal Signals: Causal Loop Paradoxes Revisited," *Phys. Lett. A*-**245**, 19 (1998).
- [278] D. Solli, R. Y. Chiao, and J. M. Hickmann, "Superluminal Effects and Negative Group Delays in Electronics, and their Applications," *Phys. Rev. E*-**66**, 056601 (2002).
- [279] M. Kitano, T. Nakanishi, and K. Sugiyama, "Negative Group Delay and Superluminal Propagation: An Electronic Circuit Approach," *IEEE J. Sel. Top. Quant. Electr.*, **9**, 43 (2003). 046604 (2001).
- [280] T. Nakanishi, K. Sugiyama, and M. Kitano, "Simulation of Slow Light with Electronic Circuits," *Am. J. Phys.*, **73**, 323 (2005).
- [281] S. E. Harris, "Electromagnetically Induced Transparency," *Phys. Today*, **50**, no.7, 36 (1997).
- [282] O. A. Kocharovskaya and Y. I. Khanin, "Coherent Amplification of an Ultrashort Pulse in a Three-Level Medium Without a Population Inversion," *JETP Lett.*, **48**, 630 (1988).
- [283] S. E. Harris, "Lasers Without Inversion—Interference of Lifetime-Broadened Resonances," *Phys. Rev. Lett.*, **62**, 10336 (1989).
- [284] O. Kocharovskaya, "Amplification and Lasing Without Inversion," *Phys. Rep.*, **219**, 175 (1992).
- [285] S. E. Harris, J. E. Field, and A. Kasapi, "Dispersive Properties of Electromagnetically Induced Transparency," *Phys. Rev. A*-**46**, R29 (1992).
- [286] A. Kasapi, M. Jain, G. Y. Yin, and S. E. Harris, "Electromagnetically Induced Transparency: Propagation Dynamics," *Phys. Rev. Lett.*, **74**, 2447 (1995).
- [287] S. E. Harris, "Electromagnetically Induced Transparency in an Ideal Plasma," *Phys. Rev. Lett.*, **77**, 5357 (1996).
- [288] M. M. Kash, et al., "Ultraslow Group Velocity and Enhanced Nonlinear Optical Effects in a Coherently Driven Hot Atomic Gas," *Phys. Rev. Lett.*, **82**, 5229 (1999).
- [289] 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).
- [290] K. T. McDonald, "Slow Light," *Am. J. Phys.*, **68**, 293 (2000).
- [291] D. F. Phillips, et al., "Storage of Light in Atomic Vapor," *Phys. Rev. Lett.*, **86**, 783 (2001).
- [292] O. Kocharovskaya, Y. Rostovtsev, and M. O. Scully, "Stopping Light via Hot Atoms," *Phys. Rev. Lett.*, **86**, 628 (2001).
- [293] M. D. Lukin and A. Imamoglu, "Controlling Photons Using Electromagnetically Induced Transparency," *Nature*, **413**, 273 (2001).
- [294] T. Pang, "Electromagnetically Induced Transparency," *Am. J. Phys.*, **69**, 604 (2001).
- [295] A. V. Turukhin, et al., "Observation of Ultraslow and Stored Light Pulses in a Solid," *Phys. Rev. Lett.*, **88**, 23602 (2002).
- [296] R. W. Boyd and D. J. Gauthier, "Slow and Fast Light," in *Progress in Optics*, vol.43, E. Wolf, ed., Elsevier, Amsterdam, 2002.

- [297] C. L. G. Alzar, M. A. G. Martinez, and P. Nussenzveig, "Classical Analog of Electromagnetically Induced Transparency," *Am. J. Phys.*, **70**, 37 (2002).
- [298] A. V. Turukhin et al., "Observation of Ultraslow and Stored Light Pulses in a Solid," *Phys. Rev. Lett.*, **88**, 023602 (2002).
- [299] A. G. Litvak and M. D. Tokman, "Electromagnetically Induced Transparency in Ensembles of Classical Oscillators," *Phys. Rev. Lett.*, **88**, 095003 (2002).
- [300] M. Bajcsy, A. S. Zibrov, and M. D. Lukin, "Stationary Pulses of Light in an Atomic Medium," *Nature*, **426**, 638 (2003).
- [301] M. O. Scully, "Light at a Standstill," *Nature*, **426**, 610 (2003).
- [302] M. S. Bigelow, N. N. Lepeshkin, R. W. Boyd, "Observation of Ultraslow Light Propagation in a Ruby Crystal at Room Temperature," *Phys. Rev. Lett.*, **90**, 113903 (2003).
- [303] F. L. Kien, J. Q. Liang, and K. Hakuta, "Slow Light Produced by Far-Off-Resonance Raman Scattering," *IEEE J. Sel. Top. Quant. Electr.*, **9**, 93 (2003).
- [304] A. M. Akulshin, et al., "Light Propagation in an Atomic Medium with Steep and Sign-Reversible Dispersion," *Phys. Rev. A*-**67**, 011801(R) (2003).
- [305] M. D. Lukin, "Trapping and Manipulating Photon States in Atomic Ensembles," *Rev. Mod. Phys.*, **75**, 457 (2003).
- [306] M. F. Yanik and S. Fan, "Stopping Light All Optically," *Phys. Rev. Lett.*, **92**, 083901 (2004).
- [307] D. D. Smith, et al., "Coupled-Resonator-Induced Transparency," *Phys. Rev. A*-**69**, 063804 (2004).
- [308] M. Fleischhauer, A. Imamoglu, and J. P. Marangos, "Electromagnetically Induced Transparency: Optics in Coherent Media," *Rev. Mod. Phys.*, **77**, 633 (2005).
- [309] R. W. Boyd, D. J. Gauthier and A. L. Gaeta "Applications of Slow Light in Telecommunications," *Opt. Photon. News*, April 2006, p. 19.
- [310] H. A. Haus and E. P. Ippen, "Group Velocity of Solitons," *Opt. Lett.*, **26**, 1654 (2001).
- [311] Joe T. Mok, et al., "Dispersionless Slow Light Using Gap Solitons," *Nature Phys.*, **2**, 775 (2006).
- [312] D. J. Gauthier, "Solitons Go Slow," *Nature Photonics*, **1**, 92 (2007).
- Chirp Radar and Pulse Compression**
- [313] M. I. Skolnik, ed., *Radar Handbook*, McGraw-Hill, New York, 1970.
- [314] M. I. Skolnik, *Introduction to Radar Principles*, McGraw-Hill, New York, 1980.
- [315] C. E. Cook and M. Bernfeld, *Radar Signals*, Artech House, Boston, 1993.
- [316] N. Levanon and E. Mozeson, *Radar Signals*, Wiley, New York, 2004.
- [317] M. A. Richards, *Fundamentals of Radar Signal Processing*, McGraw-Hill, New York, 2005.
- [318] C. E. Cook, "Pulse Compression—Key to More Efficient Radar Transmission," *Proc. IRE*, **48**, 310 (1960).
- [319] J. E. Chin and C. E. Cook, "The Mathematics of Pulse Compression," *Sperry Eng. Review*, **12**, 11, October 1959.
- [320] J. R. Klauder, A. C. Price, S. Darlington, and W. J. Albersheim, "The Theory and Design of Chirp Radars," *Bell Syst. Tech. J.*, **39**, 745 (1960).
- [321] J. R. Klauder, "The Design of Radar Signals Having Both High Range Resolution and High Velocity Resolution," *Bell Syst. Tech. J.*, **39**, 809 (1960).
- [322] A. B. Boehmer, "Binary Pulse Compression Codes," *IEEE Trans. Inform.*
- [323] G. L. Turin, "An Introduction to Matched Filters," *IRE Trans. Inf. Th.*, **6**, 311 (1960). See also, G. L. Turin, "An Introduction to Digital Matched Filters," *Proc. IEEE*, **64**, 1092 (1976).
- [324] C. E. Cook, "General Matched Filter Analysis of Linear FM Pulse Compression," *Proc. IRE*, **49**, 831 (1961).
- [325] H. O. Ramp and E. R. Wingrove, "Principles of Pulse Compression," *IEEE Trans. Military Electr.*, **5**, 109 (1961).
- [326] M. Bernfeld, et al., "Matched Filtering, Pulse Compression, and Waveform Design," *Microwave Journal*, vol. 7, 57, October 1964; ibid., vol. 7, 81, November 1964; ibid., vol. 7, 70, December 1964; ibid., vol. 8, 73, January 1965;

- [327] E. N. Fowle, et al., "A Pulse Compression System Employing a Linear FM Gaussian Signal," Proc. IEEE, **51**, 304 (1963).
- [328] E. N. Fowle, "The Design of FM Pulse Compression Signals," IEEE Trans. Inform. Th., **10**, 61 (1964).
- [329] R. O. Rowlands, "Detection of a Doppler-Invariant FM Signal by Means of a Tapped Delay Line," J. Acoust. Soc. Am., **37**, 608 (1965).
- [330] J. J. Kroszczyński, "Pulse Compression by Means of Linear-Period Modulation," Proc. IEEE, **57**, 1260 (1969). Th., IT-**13**, 156 (1967).
- [331] W. E. Kock, "Pulse Compression with Periodic Gratings and Zone Plate Gratings," Proc. IEEE, **58**, 1395 (1970).
- [332] R. A. Altes and E. L. Titlebaum, "Bat Signals as Optimally Doppler Tolerant Waveforms," J. Acoust. Soc. Am., **48** 1014 (1970).
- [333] J. D. Rhodes, "Matched-Filter Theory for Doppler-Invariant Pulse Compression," IEEE Trans. Circ. Th., CT-**19**, 53 (1972).
- [334] S. C. Bloch, "Introduction to Chirp Concepts with a Cheap Chirp Radar," Am. J. Phys., **41**, 857 (1973).
- [335] H. M. Gerard, et al., "The Design and Applications of Highly Dispersive Acoustic Surface-Wave Filters," IEEE Trans. Microwave Theory Tech., MTT-**21**, 176 (1973).
- [336] D. Hazony and Y. Hazony, "Doppler Invariant Pulse Compressors," J. Franklin Inst., **309**, 215 (1980).
- [337] B. L. Lewis and F. F. Kretschmer, "A New Class of Polyphase Pulse Compression Codes and Techniques," IEEE Trans. Aerosp. Electr. Syst., AES-**17**, 364 (1981).
- [338] B. L. Lewis and F. F. Kretschmer, "Linear Frequency Modulation Derived Polyphase Pulse Compression Codes," IEEE Trans. Aerosp. Electr. Syst., AES-**18**, 637 (1982).
- [339] K. M. El-Shennawy, O. A. Alim, and M. A. Ezz-El-Arab, "Sidelobe Suppression in Low and High Time-Bandwidth Products of Linear FM Pulse Compression Filters," IEEE Trans. Microwave Theory Tech., MTT-**35** 807 (1987). See also the comment by M. K. Roy, *ibid.*, MTT-**36**, 1458 (1988).
- [340] S. J. Rabinowitz, et al., "Applications of Digital Technology to Radar," Proc. IEEE, **73**, 325 (1985).
- [341] H. G. Winful, "Pulse Compression in Optical Fiber Filters," Appl. Phys. Lett., **46**, 527 (1985).
- [342] C. E. Cook and W. M. Siebert, "The Early History of Pulse Compression Radar," IEEE Trans. Aerosp. Electr. Syst., **24**, 825 (1988).
- [343] S. R. Gottesman, P. G. Grieve, and S. W. Golomb, "A Class of Pseudonoise-Like Pulse Compression Codes," IEEE Trans. Aerosp. Electr. Syst., **28**, 355 (1992).
- [344] A. W. Lohmann and D. Mendlovic, "Temporal Filtering with Time Lenses," Appl. Opt., **31**, 6212 (1992).
- [345] J. W. Arthur, "Modern SAW-Based Pulse Compression Systems for Radar Applications, Part 1," Electr. & Commun. Eng. J., **7**, 236 (1995); and "Part 2," *ibid.*, **8**, 57 (1996).
- [346] P. W. Smith, "Power SAWs," IEEE Potentials, **14**, no. 5, 18 (1995).
- [347] Y. Tomizawa, et al., "Archaeological Survey Using Pulse Compression Subsurface Radar," Archeol. Prospect., **7**, 241 (2000).
- [348] T. Misaridis and J. A. Jensen, "Use of Modulated Excitation Signals in Medical Ultrasound. Part I," IEEE Trans. Ultrason., Ferroel., Freq. Contr., **52**, 177 (2005); and "Part II," *ibid.*, p. 192; and "Part III," *ibid.*, p. 208.
- [349] J. Yang and T. K. Sarkar, "Doppler-Invariant Property of Hyperbolic Frequency Modulated Waveforms," Microw. Opt. Tech. Lett., **48**, 1174 (2006).
- [350] A. W. Doerry, "Generating Nonlinear FM Chirp Waveforms for Radar," Sandia National Labs., Report SAND2006-5856, 2006, available from <http://www.osti.gov/energycitations>.
- [351] J. van Howe and C. Xu, "Ultrafast Optical Signal Processing Based Upon Space-Time Dualities," J. Lightwave Tech., **24**, 2649 (2006).
- [352] J. A. Boehm, III and J. S. Debroux, "Distortion of a Received Radar Pulse due to High Target Velocity," J. Appl. Phys., **99**, 124907 (2006).

### Negative-Index Media

- [353] V. G. Veselago, "The Electrodynamics of Substances with Simultaneously Negative Values of  $\epsilon$  and  $\mu$ ," Sov. Phys. Uspekhi, **10**, 509 (1968).

- [354] R. N. Bracewell, "Analogues of An Ionized Medium: Applications to the Ionosphere," Wireless Eng. (Illi & Sons Ltd., London, 1954), p. 320-326.
- [355] W. Rotman, "Plasma Simulation by Artificial Dielectrics and Parallel-Plate Media," IEEE Trans. Antennas Propagat., **10**, 82 (1962).
- [356] J. B. Pendry, et al., "Extremely Low Frequency Plasmons in Metallic Mesostructures," Phys. Rev. Lett., **76**, 4773 (1996).
- [357] D. R. Smith, et al., "Loop-wire medium for investigating plasmons at microwave frequencies," Appl. Phys. Lett., **75**, 1425 (1999).
- [358] J. B. Pendry, "Magnetism from Conductors and Enhanced Nonlinear Phenomena," IEEE Trans. Microwave Theory Tech., **47**, 2075 (1999).
- [359] D. R. Smith, et al., "Composite Medium with Simultaneously Negative Permeability and Permittivity," Phys. Rev. Lett., **84**, 4184 (2000).
- [360] J. B. Pendry, "Negative Refraction Makes a Perfect Lens," Phys. Rev. Lett., **85**, 3966 (2000).
- [361] D. R. Smith and N. Kroll, "Negative Refractive Index in Left-Handed Materials," Phys. Rev. Lett., **85**, 2933 (2000).
- [362] R. A. Shelby, D. R. Smith, and S. Schultz, "Experimental Verification of a Negative Index of Refraction," Science, **292**, 7779 (2001).
- [363] R. W. Ziolkowski, "Superluminal Transmission of Information through an Electromagnetic Metamaterial," Phys. Rev., E-**63**, 046604 (2001).
- [364] R. W. Ziolkowski and E. Heyman, "Wave Propagation in Media Having Negative Permittivity and Permeability," Phys. Rev., E-**64**, 056625 (2001).
- [365] I. V. Lindell, et al., "BW Media—Media with Negative Parameters, Capable of Supporting Backward Waves," Microw. Opt. Tech. Lett., **31**, 129 (2001).
- [366] K. R. Rao, "Back to Basics: Reflections on Refraction," Current Sci., **81**, 875 (2001).
- [367] G. V. Eleftheriades, A. K. Iyer, and P. C. Kremer, "Planar Negative Refractive Index Media Using Periodically L-C Loaded Transmission Lines," IEEE Trans. Microwave Theory Tech., **50**, 2702 (2002).
- [368] R. Ruppin, "Surface polaritons of a left-handed medium," Phys. Lett., A-**277**, 61 (2000).
- [369] R. Ruppin, "Surface polaritons of a left-handed material slab," J. Phys.: Condens. Matter, **13**, 1811 (2001).
- [370] F. D. M. Haldane, "Electromagnetic Surface Modes at Interfaces with Negative Refractive Index Make a 'Not-Quite-Perfect' Lens," arXiv, cond-mat/020420, (2002).
- [371] M. Feise, P. J. Bevelacqua, and J. B. Schneider, "Effects of surface waves on the behavior of perfect lenses," Phys. Rev., B-**66**, 035113 (2002).
- [372] P. R. Berman, "Goos-Hänchen shift in negatively refractive media," Phys. Rev., E-**69**, 066167 (2004).
- [373] N. Garcia and M. Nieto-Vesperinas, "Left-Handed Materials Do Not Make a Perfect Lens," Phys. Rev. Lett., **88**, 207403 (2002); and *ibid.*, **90**, 229903 (2003); and Pendry's reply, *ibid.*, **91**, 099701 (2003).
- [374] M. W. McCall, A. Lakhtakia, and W. S. Weiglhofer, "The Negative Index of Refraction Demystified," Eur. J. Phys., **23**, 353 (2002).
- [375] D. R. Smith, et al., "Determination of effective parameters and permeability of metamaterials from reflection and transmission coefficients," Phys. Rev., B-**65**, 195104 (2002).
- [376] Z. Ye, "Optical transmission and reflection of perfect lenses by left handed materials," Phys. Rev., B-**67**, 193106 (2003).
- [377] D. R. Smith, et al., "Limitations on subdiffraction imaging with a negative refractive index slab," Appl. Phys. Lett., **82**, 1506 (2003).
- [378] M. Mojahedi, et al., "Abnormal Wave Propagation in Passive Media," IEEE J. Sel. Top. Quant. Electr., **9**, 30 (2003).
- [379] C. R. Simovski and B. Sauvage, "On focusing left-handed materials by arbitrary layers," Microw. Opt. Tech. Lett., **39**, 64 (2003).
- [380] X. S. Rao and C. K. Ong, "Amplification of evanescent waves in a lossy left-handed material slab," Phys. Rev., B-**68**, 113103 (2003).
- [381] X. S. Rao and C. K. Ong, "Subwavelength imaging by a left-handed material superlens," Phys. Rev., E-**68**, 067601 (2003).

- [382] G. Gómez-Santos, "Universal Features of the Time Evolution of Evanescent Modes in a Left-Handed Perfect Lens," *Phys. Rev. Lett.*, **90**, 077401 (2003).
- [383] C. G. Parazzoli, et al., "Experimental Verification and Simulation of Negative Index of Refraction Using Snell's Law," *Phys. Rev. Lett.*, **90**, 107401 (2003).
- [384] A. A. Houck, J. B. Borck, and I. L. Chuang, "Experimental Observations of a Left-Handed Material Thatobeys Snell's Law," *Phys. Rev. Lett.*, **90**, 137401 (2003).
- [385] J. B. Pendry and S. A. Ramakrishna, "Focusing light using negative refraction," *J. Phys.: Condens. Matter*, **15**, 6345 (2003).
- [386] S. A. Cummer, "Simulated causal subwavelength focusing by a negative refractive index slab," *Appl. Phys. Lett.*, **82**, 1503 (2003).
- [387] S. Foteinopoulou and C. M. Soukoulis, "Negative refraction and left-handed behavior in two-dimensional photonic crystals," *Phys. Rev.*, **B-67**, 235107 (2003).
- [388] E. Cubukcu, et al., "Subwavelength Resolution in a Two-Dimensional Photonic-Crystal-Based Super-lens," *Phys. Rev. Lett.*, **91**, 207401 (2003).
- [389] E. Cubukcu, et al., "Electromagnetic waves: Negative refraction by photonic crystals," *Nature*, **423**, 604 (2003).
- [390] P. V. Parimi, "Photonic crystals: Imaging by flat lens using negative refraction," *Nature*, **426**, 404 (2003).
- [391] C. Luo, et al., "Subwavelength imaging in photonic crystals," *Phys. Rev.*, **B-68**, 045115 (2003).
- [392] A. Grbic and G. V. Eleftheriades, "Subwavelength Focusing Using a Negative-Refractive-Index Transmission Line Lens," *IEEE Ant. Wireless Prop. Lett.*, **2**, 186 (2003).
- [393] A. Grbic and G. V. Eleftheriades, "Overcoming the Diffraction Limit with a Planar Left-Handed Transmission-Line Lens," *Phys. Rev. Lett.*, **92**, 117403 (2004).
- [394] C. Caloz and T. Itoh, "Transmission line approach of left-handed (LH) materials and microstrip implementation of an artificial LH transmission line," *IEEE Trans. Antennas Propagat.*, **52**, 1159 (2004).
- [395] J. B. Pendry, "A Chiral Route to Negative Refraction," *Science*, **306**, 1353 (2004).
- [396] D. R. Smith, J. B. Pendry, and M. C. K. Wiltshire, "Metamaterials and Negative Refractive Index," *Science*, **305**, 788 (2004).
- [397] M. Nieto-Vesperinas, "Problem of image superresolution with a negative-index slab," *J. Opt. Soc. Am.*, **A-21**, 491 (2004).
- [398] K. Y. Bliokh and Y. P. Bliokh, "What are the left-handed media and what is interesting about them?", *Phys.-Uspekhi*, **47**, 393 (2004).
- [399] J. F. Woodley and M. Mojahedi, "Negative Group Velocity and Group Delay in Left-Handed Media," *Phys. Rev.*, **E-70**, 046603 (2004).
- [400] S. Dutta Gupta, R. Arun, and G. S. Agarwal, "Subluminal to Superluminal Propagation in a Left-Handed Medium," *Phys. Rev.*, **B-69**, 113104 (2004).
- [401] O. F. Siddiqui, et al., "Time-Domain Measurement of Negative Group Delay in Negative-Refractive-Index Transmission-Line Metamaterials," *IEEE Trans. Microwave Theory Tech.*, **52**, 1449 (2004).
- [402] R. A. Depine and A. Lakhtakia, "A New Condition to Identify Isotropic Dielectric-Magnetic Materials Displaying Negative Phase Velocity," *Microw. Opt. Technol. Lett.*, **41**, 315 (2004).
- [403] X. Chen, et al., "Robust method to retrieve the constitutive effective parameters of metamaterials," *Phys. Rev.*, **E-70**, 016608 (2004).
- [404] H. Cory and C. Zach, "Wave Propagation in Metamaterial Multi-Layered Structures," *Microw. Opt. Tech. Lett.*, **40**, 460 (2004).
- [405] V. M. Agranovich, et al., "Linear and nonlinear wave propagation in negative refraction metamaterials," *Phys. Rev.*, **B-69**, 165112 (2004).
- [406] J. B. Pendry and D. R. Smith, "Reversing Light with Negative Refraction," *Phys. Today*, **57**, no. 6, 37 (2004).
- [407] X. Chen and C-F. Li, "Lateral shift of the transmitted light beam through a left-handed slab," *Phys. Rev.*, **E-69**, 066617 (2004).
- [408] X. Huang and W. L. Schaich, "Wave packet propagation into a negative index medium," *Am. J. Phys.*, **72**, 1232 (2004).

- [409] S. A. Ramakrishna, "Physics of negative refractive index materials," *Rep. Prog. Phys.*, **68**, 449 (2005).
- [410] J. R. Thomas and A. Ishimaru, "Wave Packet Incident on Negative-Index Media," *IEEE Trans. Antennas Propagat.*, **53**, 1591 (2005).
- [411] N. Engheta and R. W. Ziolkowski, "A Positive Future for Double-Negative Metamaterials," *IEEE Trans. Microwave Theory Tech.*, **53**, 1535 (2005).
- [412] C. Fu, Z. M. Zhang, and P. N. First, "Brewster angle with a negative-index material," *Appl. Opt.*, **44**, 3716 (2005).
- [413] S. A. Ramakrishna and O. J. F. Martin, "Resolving the wave vector in negative refractive index media," *Opt. Lett.*, **30**, 2626 (2005).
- [414] G. V. Eleftheriades and K. G. Balmain, *Negative Refraction Metamaterials: Fundamental Principles and Applications*, Wiley-IEEE Press, New York, 2005.
- [415] A. D. Boardman, N. King, and L. Velasco, "Negative Refraction in Perspective," *Electromagnetics*, **25**, 365 (2005).
- [416] J. J. Chen, et al., "Role of evanescent waves in the positive and negative Goos-Hänchen shifts with left-handed material slabs," *J. Appl. Phys.*, **98**, 094905 (2005).
- [417] T. Koschny, R. Moussa, and C. M. Soukoulis, "Limits on the amplification of evanescent waves of left-handed materials," *arXiv*, cond-mat/0504349, (2005).
- [418] K. Aydin, I. Bulu, and E. Ozbay, "Verification of Impedance Matching at the Surface of Left-handed Materials," *Microw. Opt. Tech. Lett.*, **48**, 2548 (2006).
- [419] B-I. Popa and S. A. Cummer, "Direct measurement of evanescent wave enhancement inside passive metamaterials," *Phys. Rev.*, **E-73**, 016617 (2006).
- [420] T. J. Cui, et al., "Experiments on evanescent-wave amplification and transmission using metamaterial structures," *Phys. Rev.*, **B-73**, 245119 (2006).
- [421] V. Veselago, et al., "Negative Refractive Index Materials," *J. Comput. Theor. Nanosci.*, **3**, 1 (2006).
- [422] G. Dolling, et al., "Simultaneous Negative Phase and Group Velocity of Light in a Metamaterial," *Science*, **312**, 892 (2006).
- [423] Y-F. Chen, P. Fischer, and F. W. Wise, "Sign of the Refractive Index in a Gain Medium with Negative Permittivity and Permeability," *J. Opt. Soc. Am.*, **B-23**, 45 (2006).
- [424] C. M. Soukoulis, "Bending Back Light: The Science of Negative Index Materials," *Opt. Photon. News*, **17**, no. 6, 16 (2006).
- [425] C. M. Soukoulis, M. Kafesaki, and E. N. Economou, "Negative-Index Materials: New Frontiers in Optics," *Adv. Mater.*, **18**, 1941 (2006).
- [426] W. J. Padilla, D. R. Smith, and D. N. Basov, "Spectroscopy of metamaterials from infrared to optical frequencies," *J. Opt. Soc. Am.*, **B-23**, 404 (2006).
- [427] C. Caloz and T. Itoh, *Electromagnetic Metamaterials*, Wiley-Interscience, Hoboken, NJ, 2006.
- [428] A. V. Kats, et al., "Left-Handed Interfaces for Electromagnetic Surface Waves," *Phys. Rev. Lett.*, **98**, 073901 (2007).
- [429] B. A. Kemp, J. A. Kong, and T. M. Grzegorczyk, "Reversal of Wave Momentum in Isotropic Left-Handed Media," *Phys. Rev.*, **A-75**, 053810 (2007).
- [430] W. J. Padilla, "Group theoretical description of artificial electromagnetic metamaterials," *Opt. Expr.*, **15**, 1639 (2007).
- [431] N. Engheta, "Circuits with Light at Nanoscales: Optical Nanocircuits Inspired by Metamaterials," *Science*, **317**, 1698 (2007).
- [432] A. Alù, et al., "Single-negative, Double-Negative, and Low-Index Metamaterials and their Electromagnetic Applications," *IEEE Antennas Propagat. Mag.*, **49**, no. 1, 23 (2007).
- [433] A. A. Tretyakov and S. I. Maslovsky, "Veselago Materials: What is Possible and Impossible about the Dispersion of the Constitutive Parameters," *IEEE Antennas Propagat. Mag.*, **49**, no. 1, 37 (2007).
- [434] G. V. Eleftheriades, "Enabling RF/Microwave Devices Using Negative-Reflective-Index Transmission-Line (NRI-TL) Metamaterials," *IEEE Antennas Propagat. Mag.*, **49**, no. 2, 34 (2007).

- [435] A. Einstein, "Zur Elektrodynamik Bewegter Körper," *Ann. Physik* (Leipzig), **17**, 891 (1905). Reprinted in [436].
- [436] *The Principle of Relativity*, A Collection of Original Memoirs on the Special and General Theory of Relativity, by H. A. Lorentz, A. Einstein, H. Minkowski, and H. Weyl, Translated by W. Perrett and G. B. Jeffery, Dover Publications, New York, 1952.
- [437] J. Van Bladel, *Relativity and Engineering*, Springer-Verlag, Berlin, 1984.
- [438] C. T. Tai, "A Study of Electrodynamics of Moving Media," *Proc. IEEE*, **52**, 685 (1964).
- [439] C. Yeh, "Reflection and Transmission of Electromagnetic Waves by a Moving Dielectric Medium," *J. Appl. Phys.*, **36**, 3513 (1965).
- [440] C. Yeh, "Reflection and Transmission of Electromagnetic Waves by a Moving Plasma Medium," *J. Appl. Phys.*, **37**, 3079 (1966).
- [441] C. Yeh and K. F. Casey, "Reflection and Transmission of Electromagnetic Waves by a Moving Dielectric Slab," *Phys. Rev.*, **144**, 665 (1966).
- [442] V. P. Pyati, "Reflection and Refraction of Electromagnetic Waves by a Moving Dielectric Medium," *J. Appl. Phys.*, **38**, 652 (1967).
- [443] T. Shiozawa, K. Hazama, and N. Kumagai, "Reflection and Transmission of Electromagnetic Waves by a Dielectric Half-Space Moving Perpendicular to the Plane of Incidence," *J. Appl. Phys.*, **38**, 4459 (1967).
- [444] C. T. Tai, "Present View on Electrodynamics of Moving Media," *Radio Sci.*, **2**, 245 (1967).
- [445] J. F. Holmes and A. Ishimaru, "Relativistic Communication Effects Associated with Moving Space Antennas," *IEEE Trans. Antennas Propagat.*, **AP-17**, 484 (1967).
- [446] P. Daly and H. Gruenber, "Energy Relations for Plane Waves Reflected from Moving Media," *J. Appl. Phys.*, **38**, 4486 (1967).
- [447] D. Censor, "Scattering of a Plane Wave at a Plane Interface Separating Two Moving Media," *Radio Sci.*, **4**, 1079 (1969).
- [448] W. J. Noble and C. K. Ross, "The Reflection and Transmission of Electromagnetic Waves by a Moving Dielectric Slab," *Am. J. Phys.*, **37**, 1249 (1969), and *ibid.*, p.1253.
- [449] R. G. Newburgh and T. E. Phipps, Jr., "Brewster Angle and the Einstein Velocity Addition Theorem," *Am. J. Phys.*, **39**, 1079 (1971).
- [450] I. Lerche, "Reflection and Refraction of Light from a Moving Block of Glass," *Phys. Rev.*, **D-11**, 740 (1975).
- [451] M. Saca, "Brewster Angle in a Semi-Infinite Dielectric Moving Perpendicularly to the Interface," *Am. J. Phys.*, **48**, 237 (1980).
- [452] K. Tanaka, "Reflection and Transmission of Electromagnetic Waves by a Linearly Accelerated Dielectric Slab," *Phys. Rev.*, **A-25**, 385 (1982).
- [453] J. R. Van Meter, S. Carlip, and F. V. Hartemann, "Reflection of Plane Waves from a Uniformly Accelerating Mirror," *Am. J. Phys.*, **69**, 783 (2001).
- [454] J. P. Costella, B. H. J. McKellar, and A. A. Rawlinson, "The Thomas Rotation," *Am. J. Phys.*, **69**, 837 (2001).
- [455] H. L. Berk, K. Chaicherdsakul, and T. Udagawa, "The Proper Lorentz Transformation Operator  $e^L = e^{-\omega \cdot s - \xi \cdot k}$ : Where's It Going, What's the 'Twist?'," *Am. J. Phys.*, **69**, 996 (2001).
- [456] F. J. Tischer, "Doppler Phenomena in Space Communications," *IRE Trans. Comm. Syst.*, **7**, 25 (1959).
- [457] U. Leonhardt and P. Piwnicki, "Relativistic Effects of Light in Moving Media with Extremely Low Group Velocity," *Phys. Rev. Lett.*, **84**, 822 (2000).

### Ewald-Oseen Extinction Theorem

- [458] P. P. Ewald, "Zur Begründung der Kristalloptik," *Ann. Physik*, Ser. 4, **49**, 1 (1916). See also, *Fortsch. Chem. Phys. Phys. Chem.*, Ser. B, **18**, 491 (1925).
- [459] C. W. Oseen, "Über die Wechselwirkung zwischen zwei elektrischen Dipolen und über die Drehung der Polarisationsebene in Kristallen und Flüssigkeiten," *Ann. Physik*, Ser. 4, **48**, 1 (1915).
- [460] L. Rosenfeld, *Theory of Electrons*, North Holland Publishing Comp., Amsterdam, 1951.

- [461] A. S. Pine, "Self-Consistent Field Theory of Linear and Nonlinear Crystalline Dielectrics Including Local-Field Effects," *Phys. Rev.*, **139**, no. 3A, A901 (1965).
- [462] P. P. Ewald, "Crystal Optics for Visible Light and X-Rays," *Reviews of Modern Physics*, **37**, 46 (1965).
- [463] V. A. Kizel, "Modern Status of the Theory of Light Reflection," *Sov. Phys. Uspekhi*, **10**, 485 (1968).
- [464] J. J. Sein, "A Note on the Ewald-Oseen Extinction Theorem," *Opt. Commun.*, **2**, 170 (1970).
- [465] R. K. Bullough, "Many-Body Optics III. The Optical Extinction Theorem," *J. Phys. A*, **3**, 708 (1970).
- [466] J. J. Sein, "Boundary Conditions in the Exciton Absorption Region," *J. Opt. Soc. Am.*, **62**, 1037 (1972).
- [467] J. J. Sein, "Optics of Polaritons in Bounded Media," *Phys. Rev.*, **B-6**, 2482 (1972).
- [468] E. Lalor and E. Wolf, "Exact Solution of the Equations of Molecular Optics for Refraction and Reflection of an Electromagnetic Wave on a Semi-Infinite Dielectric," *J. Opt. Soc. Am.*, **62**, 1165 (1972).
- [469] D. N. Pattanyak and E. Wolf, "General Form and a New Interpretation of the Ewald-Oseen Extinction Theorem," *Opt. Commun.*, **6**, 217 (1972).
- [470] J. De Goede and P. Mazur, "On the Extinction Theorem in Electrodynamics," *Physica*, **58**, 568 (1972).
- [471] J. J. Sein, "General Extinction Theorems," *Opt. Commun.*, **14**, 157 (1975).
- [472] J. Van Kranendonk and J. E. Sipe, "Foundations of the Macroscopic Electromagnetic Theory of Dielectric Media," in *Progress in Optics*, vol. XV, E. Wolf, ed., North-Holland Publishing Co., Amsterdam, 1977.
- [473] D. Dialetis, "Equivalence of the Ewald-Oseen Extinction Theorem as a Nonlocal Boundary-Value Problem with Maxwell's Equations and Boundary Conditions," *J. Opt. Soc. Am.*, **68**, 602 (1978).
- [474] D. E. Aspnes, "Local-Field Effects and Effective-Medium Theory: A Microscopic Perspective," *Am. J. Phys.*, **50**, 704 (1982).
- [475] A. T. Friberg and E. Wolf, "Angular Spectrum Representation of Scattered Electromagnetic Fields," *J. Opt. Soc. Am.*, **73**, 26 (1983).
- [476] J. J. Sein, "Solutions to Time-Harmonic Maxwell Equations with a Hertz Vector," *Am. J. Phys.*, **57**, 834 (1989).
- [477] G. P. M. Poppe and C. M. J. Wijers, "Exact Solution of the Optical Response of Thick Slabs in the Discrete Dipole Approach," *Physica B*, **167**, 221 (1990).
- [478] R. K. Bullough and F. Hyne, "Ewald's Optical Extinction Theorem," in *P. P. Ewald and his Dynamical Theory of X-ray Diffraction*, D. W. Cruickshank and H. J. Juretschke, eds., Oxford Univ. Press, New York, 1992.
- [479] R. P. Feynman, R. B. Leighton, and M. Sands, *The Feynman Lectures on Physics*, vol.1, Addison-Wesley, Reading, MA, 1963.
- [480] F. L. Markley, "The Index of Refraction," *Am. J. Phys.*, **40**, 1799 (1972).
- [481] K. S. Kunz and E. Gemots, "A Simple Model to Explain the Slowing Down of Light in a Crystalline Medium," *Am. J. Phys.*, **44**, 264 (1976).
- [482] N. E. Hill, "Reflection and Transmission in Terms of Polarization," *Am. J. Phys.*, **48**, 752 (1980).
- [483] R. K. Wangness, "Effect of Matter on the Phase Velocity of an Electromagnetic Wave," *Am. J. Phys.*, **49**, 950 (1981).
- [484] G. C. Real, "Exact Solution of the Equations of Molecular Optics for Refraction and Reflection of an Electromagnetic Wave on a Semi-Infinite Dielectric," *J. Opt. Soc. Am.*, **72**, 1421 (1982).
- [485] G. C. Real, "Reflection from Dielectric Materials," *Am. J. Phys.*, **50**, 1133 (1982).
- [486] M. Schwartz, *Principles of Electrodynamics*, Dover Publications, New York, 1987.
- [487] G. C. Real, "Reflection, Refraction, and Transmission of Plane Electromagnetic Waves from a Lossless Dielectric Slab," *Am. J. Phys.*, **60**, 532 (1992).
- [488] M. B. James and D. J. Griffiths, "Why the Speed of Light is Reduced in a Transparent Medium," *Am. J. Phys.*, **60**, 309 (1992). See also Comment by J. B. Diamond, *ibid.*, **63**, 179 (1995).
- [489] B. G. de Groot, "Why Is the Propagation Velocity of a Photon in a Transparent Medium Reduced?" *Am. J. Phys.*, **65**, 1156 (1997).
- [490] M. Mansuripur, "The Ewald-Oseen Extinction Theorem," *Optics & Photonics News*, **9** (8), 50 (1998). Reprinted in Ref. [1155].
- [491] H. Fearn, D. F. V. James, and P. W. Milonni, "Microscopic Approach to Reflection, Transmission, and the Ewald-Oseen Extinction Theorem," *Am. J. Phys.*, **64**, 986 (1996). See also Comment by H. J. Juretschke, *ibid.*, **67**, 929 (1999).

- [492] V. C. Ballenegger and T. A. Weber, "The Ewald-Oseen Extinction Theorem and Extinction Lengths," *Am. J. Phys.*, **67**, 599 (1999).
- [493] H. M. Lai, Y. P. Lau, and W. H. Wong, "Understanding Wave Characteristics via Linear Superposition of Retarded Fields," *Am. J. Phys.*, **70**, 173 (2002).

### Near-Field Optics

- [494] S. V. Sukhov and K. V. Krutitsky, "Discrete Structure of Ultrathin Dielectric Films and their Surface Optical Properties," *Phys. Rev.*, **B-65**, 115407 (2002).
- [495] H. F. Arnoldus and J. T. Foley, "Uniform Asymptotic Approximation of the Evanescent Part of the Green's Tensor," *Opt. Commun.*, **207**, 7 (2002).
- [496] T. Setälä, M. Kaivola, and A. T. Friberg, "Evanescent and Propagating Electromagnetic Fields in Scattering from Point-Dipole Structures," *J. Opt. Soc. Am.*, **A-18**, 678 (2001). See also, *ibid.*, **A-19**, 1449 (2002), and M. Xiao, *ibid.*, **A-19**, 1447 (2002).
- [497] C. Girard, C. Joachim, and S. Gauthier, "The Physics of the Near Field," *Rep. Progr. Phys.*, **63**, 657 (2000).
- [498] A. Lakhtakia and W. S. Weiglhofer, "Evanescent Plane Waves and the Far Field: Resolution of a Controversy," *J. Mod. Opt.*, **47**, 759 (2000).
- [499] M. Ohtsu and H. Hori, *Near-Field Nano-Optics*, Kluwer, New York, 1999.
- [500] A. V. Shchegrov and P. S. Carney, "Far-Field Contribution of Evanescent Modes to the Electromagnetic Green Tensor," *J. Opt. Soc. Am.*, **A-16**, 2583 (1999).
- [501] O. Keller, "Attached and Radiated Electromagnetic Fields of an Electric Dipole," *J. Opt. Soc. Am.*, **B-16**, 835 (1999).
- [502] T. Setälä, M. Kaivola, and A. T. Friberg, "Decomposition of the Point-Dipole Field into Homogeneous and Evanescent Parts," *Phys. Rev.*, **E-59**, 1200 (1999).
- [503] E. Wolf and J. T. Foley, "Do Evanescent Waves Contribute to the Far Field?," *Opt. Lett.*, **23**, 16 (1998).
- [504] A. V. Ghiner and G. I. Surduvovich, "Discreteness and Local Fields in Weakly Rarefied Media," *Phys. Rev.*, **E-56**, 6123 (1997).
- [505] K. V. Krutitsky and S. V. Suhov, "Near-Field Effect in Classical Optics of Ultra-Thin Films," *J. Phys.*, **B-30**, 5341 (1997).
- [506] J.-J. Greffet and R. Carminati, "Image Formation in Near-Field Optics," *Progr. Surf. Sci.*, **56**, 133 (1997).
- [507] C. Girard and A. Dereux, "Near-Field Optics Theories," *Rep. Progr. Phys.*, **59**, 657 (1996).
- [508] D. Courjon and C. Bainier, "Near Field Microscopy and Near Field Optics," *Rep. Progr. Phys.*, **57**, 989 (1994).
- [509] A. V. Ghiner and G. I. Surduvovich, "Method of Integral Equations and an Extinction Theorem in Bulk and Surface Phenomena in Nonlinear Optics," *Phys. Rev.*, **A-49**, 1313 (1993).
- [510] E. Betzig and J. K. Trautman, "Near-Field Optics: Microscopy, Spectroscopy, and Surface Modification Beyond the Diffraction Limit," *Science*, **257**, 189 (1992).
- [511] L. E. C. van de Leemput and H. van Kempen, "Scanning Tunneling Microscopy," *Rep. Progr. Phys.*, **55**, 1165 (1992).
- [512] E. Betzig, J. K. Trautman, T. D. Harris, J. S. Weiner, and R. L. Kostelak, "Breaking the Diffraction Barrier: Optical Microscopy on a Nanometric Scale," *Science*, **251**, 1468 (1991).
- [513] A. Johner and P. Schaaf, "Calculation of the Reflection Coefficients at Interfaces: A Scattering Approach," *Phys. Rev.*, **B-42**, 5516 (1990).
- [514] U. Dürig, D. W. Pohl, and F. Rohner, "Near-Field Optical-Scanning Microscopy," *J. Appl. Phys.*, **59**, 3318 (1986).
- [515] H. Weyl, "Ausbreitung elektromagnetischer Wellen über einem ebenen Leiter," *Ann. Physik*, Ser. 4, **60**, 481 (1919).

### Total Internal Reflection

- [516] F. Goos and H. Hänchen, *Ann. Physik*, (Leipzig), **1**, 333 (1947).

- [517] K. Artmann, "Berechnung der Seitenversetzung des totalreflektierten Strahles," *Ann. Physik*, (Leipzig), **2**, 87 (1948).
- [518] J. Fahrenfort, "Attenuated Total Reflection. A New Principle for the Production of Useful Infra-Red Reflection Spectra of Organic Compounds," *Spectrochimica Acta*, **17**, 698 (1961).
- [519] R. H. Renard, "Total Reflection: A New Evaluation of the Goos-Hänchen Shift," *J. Opt. Soc. Am.*, **54**, 1190 (1964).
- [520] N. J. Harrick, *Internal Reflection Spectroscopy*, Wiley, New York, 1967.
- [521] P. W. Baumeister, "Optical Tunneling and its Application to Optical Filters," *Appl. Opt.*, **6**, 897 (1967).
- [522] H. K. V. Lotsch, "Reflection and Refraction of a Beam of Light at a Plane Interface," *J. Opt. Soc. Am.*, **58**, 551 (1968).
- [523] B. R. Horowitz and T. Tamir, "Lateral Displacement of a Light Beam at a Dielectric Interface," *J. Opt. Soc. Am.*, **61**, 586 (1971).
- [524] C. Imbert, "Calculation and Experimental Proof of the Transverse Shift Induced by Total Internal Reflection of a Circularly Polarized Light Beam," *Phys. Rev.*, **D-5**, 787 (1972).
- [525] A. W. Snyder and J. D. Love, "Goos-Hänchen shift," *Appl. Opt.*, **15**, 236 (1976).
- [526] M. McGuirk and C. K. Carniglia, "An angular spectrum representation approach to the Goos-Hänchen shift," *J. Opt. Soc. Am.*, **67**, 103 (1977).
- [527] J. J. Cowan and B. Anicin, "Longitudinal and transverse displacements of a bounded microwave beam at total internal reflection," *J. Opt. Soc. Am.*, **67**, 1307 (1977).
- [528] S. Kozaki and H. Sakurai, "Characteristics of a Gaussian beam at a dielectric interface," *J. Opt. Soc. Am.*, **68**, 508 (1978).
- [529] G. Müller, K. Abraham, and M. Schaldach, "Quantitative ATR spectroscopy: some basic considerations," *Appl. Opt.*, **20**, 1182 (1981).
- [530] I. R. Chandler, V. P. Tomaselli, and K. D. Moller, "Attenuated total reflection method for obtaining the optical constants of powders," *Appl. Opt.*, **22**, 4099 (1983).
- [531] S. Zhu, et al., "Frustrated Total Internal Reflection: A Demonstration and Review," *Am. J. Phys.*, **54**, 601 (1986).
- [532] H. M. Lai, F. C. Cheng, and W. K. Tang, "Goos-Hänchen effect around and off the critical angle," *J. Opt. Soc. Am.*, **A-3**, 550 (1986).
- [533] C. C. Chan and T. Tamir, "Beam phenomena at and near critical incidence upon a dielectric interface," *JOSA*, **A-4**, 655 (1987).
- [534] D. Gingell, O. S. Heavens, and J. S. Mellor, "General electromagnetic theory of total internal reflection fluorescence: the quantitative basis for mapping cell-substratum topography," *J. Cell Sci.*, **87**, 677 (1987).
- [535] O. S. Heavens, "Cell studies of total internal reflection fluorescence: effect of lipid membranes," *J. Cell Sci.*, **95**, 175 (1990).
- [536] R. C. Reddick, R. J. Warmack, and T. L. Ferrell, "New Form of Scanning Optical Microscopy," *Phys. Rev.*, **B-39**, 767 (1989).
- [537] J. Navasquillo, V. Such, and F. Pomer, "A general method for treating the incidence of a plane electromagnetic wave on a plane interface between dielectrics," *Am. J. Phys.*, **57**, 1109 (1989).
- [538] F. Pomer and J. Navasquillo, "The fields of a bounded electromagnetic beam propagating through an air gap between two dielectrics for frustrated total reflection," *Am. J. Phys.*, **58**, 763 (1990).
- [539] R. C. Reddick, et al., "Photon Scanning Tunneling Microscopy," *Rev. Sci. Instrum.*, **61**, 3669 (1990).
- [540] F. Albiol, S. Navas, and M. V. Andres, "Microwave Experiments on Electromagnetic Evanescent Waves and Tunneling Effect," *Am. J. Phys.*, **61**, 165 (1993).
- [541] S. Sainov, V. Sainov, and G. Stoilov, "Interferometer based on total internal reflection," *Appl. Opt.*, **34**, 2848 (1995).
- [542] A. Salari and R. E. Young, "Application of attenuated total reflectance FTIR spectroscopy to the analysis of mixtures of pharmaceutical polymorphs," *Int. J. Pharmaceutics*, **163**, 157 (1998).
- [543] F. de Fornel, *Evanescent Waves*, Springer-Verlag, Berlin, 2000.
- [544] A. Haibel, G. Nimtz, and A. A. Stahlhofen, "Frustrated Total Reflection: The Double-Prism Revisited," *Phys. Rev.*, **E-63**, 047601 (2001).

- [545] L. Li and J. A. Dobrowolski, "High-Performance Thin-Film Polarizing Beam Splitter Operating at Angles Greater than the Critical Angle," *Appl. Opt.*, **39**, 2754 (2000).
- [546] L. Li, "The Design of Optical Thin Film Coatings with Total and Frustrated Total Internal Reflection," *Opt. & Photon. News*, p. 24, September 2003.
- [547] F. P. Zanella, et al., "Frustrated Total Internal Reflection: A Simple Application and Demonstration," *Am. J. Phys.*, **71**, 494 (2003).
- [548] D. A. Papathanassoglou and B. Vohnsen, "Direct Visualization of Evanescent Optical Waves," *Am. J. Phys.*, **71**, 670 (2003).
- [549] E. R. Van Keuren, "Refractive index measurement using total internal reflection," *Am. J. Phys.*, **73**, 611 (2005).
- Edward Richard Van Keuren
- [550] E. Marengo, "Monitoring of paintings under exposure to UV light by ATR-FT-IR spectroscopy and multivariate control charts," *Vibr. Spectrosc.*, **40**, 225 (2006).
- [551] C-F. Li, "Unified theory for Goos-Hänchen and Imbert-Fedorov effects," *Phys. Rev. A*, **76**, 013811 (2007).
- [552] C-W. Chen, et al., "Optical temperature sensing based on the Goos-Hänchen effect," *Appl. Opt.*, **46**, 5347 (2007).

### Surface Plasmons

- [553] U. Fano, "The Theory of Anomalous Diffraction Gratings and of Quasi-Stationary Waves on Metallic Surfaces (Sommerfeld's Waves)," *J. Opt. Soc. Am.*, **31**, 213 (1941).
- [554] R. H. Ritchie, "Plasma losses by fast electrons in thin films," *Phys. Rev.*, **106**, 874 (1957).
- [555] E. Kretschmann and H. Raether, "Radiative decay of nonradiative surface plasmons excited by light," *Z. Naturforsch. A*, **23**, 2135 (1968).
- [556] A. Otto, "Excitation of Nonradiative Surface Plasma Waves in Silver by the Method of Frustrated Total Reflection," *Z. Physik*, **216**, 398 (1968).
- [557] E. N. Economou, "Surface Plasmons in Thin Films," *Phys. Rev.*, **182**, 539 (1969).
- [558] E. Kretschmann, "Die Bestimmung optischer Konstanten von Metallen durch Anregung von Oberflächenplasmaschwingungen," *Z. Physik*, **241**, 313 (1971).
- [559] A. S. Barker, "An Optical Demonstration of Surface Plasmons on Gold," *Am. J. Phys.*, **42**, 1123 (1974).
- [560] M. Cardona, "Fresnel Reflection and Surface Plasmons," *Am. J. Phys.*, **39**, 1277 (1971).
- [561] H. J. Simon, D. E. Mitchell, and J. G. Watson, "Surface Plasmons in Silver Films—A Novel Undergraduate Experiment," *Am. J. Phys.*, **43**, 630 (1975).
- [562] J. D. Swalen, et al., "Plasmon surface polariton dispersion by direct optical observation," *Am. J. Phys.*, **48**, 669 (1980).
- [563] W. P. Chen and J. M. Chen, "Use of Surface Plasma Waves for Determination of the Thickness and Optical Constants of Thin Metallic Films," *J. Opt. Soc. Am.*, **71**, 189 (1981).
- [564] A. D. Boardman, ed., *Electromagnetic Surface Modes*, Wiley, New York, 1982.
- [565] F. Abeles, "Surface Plasmon (SEW) Phenomena," in *Electromagnetic Surface Excitations*, R. F. Wallis and G. I. Stegeman, eds., Springer-Verlag, Berlin, 1986.
- [566] I. J. Higgins and C. R. Lowe, "Introduction to the Principles and Applications of Biosensors," *Phil. Trans. Roy. Soc. Lond.*, **B-316**, 3 (1987).
- [567] B. Rothenhäusler and W. Knoll "Surface-plasmon microscopy," *Nature*, **332**, 615 (1988).
- [568] H. Raether, *Surface Plasmons on Smooth and Rough Surfaces and on Gratings*, Springer-Verlag, Berlin, 1988.
- [569] V. I. Baibakov, V. N. Datsko, and Y. V. Kistovich, "Experimental Discovery of Zenneck's Surface Electromagnetic Wave," *Sov. Phys. Usp.*, **32**, 378 (1989).
- [570] K. Welford, "Surface Plasmon-Polaritons and their Uses," *Opt. Quant. Electr.*, **23**, 1 (1991).
- [571] J. R. Sambles, G. W. Bradbery, and F. Yang, "Optical Excitation of Surface Plasmons: An Introduction," *Contemp. Phys.*, **32**, 173 (1991).

- [572] B. Liedberg, C. Nylander, and I. Lundström, "Biosensing with surface plasmon resonance—how it all started," *Biosens. & Bioelectron.*, **10**, no. 8, pp. i-ix, (1995).
- [573] J. J. Ramsden, "Optical Biosensors," *J. Molec. Recognition*, **10**, 109 (1997).
- [574] H. F. Ghaemi, et al., "Surface plasmons enhance optical transmission through subwavelength holes," *Phys. Rev. B*, **58**, 6779 (1998).
- [575] J. Homola, S. S. Yee, and G. Gauglitz, "Surface plasmon resonance sensors: review," *Sens. Actuators B*, **54**, 3 (1999).
- [576] L. Martin-Moreno, et al., "Theory of extraordinary optical transmission through subwavelength hole arrays," *Phys. Rev. Lett.*, **86**, 1114 (2001). (2001).
- [577] K. Kurihara, K. Nakamura, and K. Suzuki, "Asymmetric SPR Sensor Response Curve-Fitting Equation for the Accurate Determination of SPR Resonance Angle," *Sens. Actuators B*, **86**, 49 (2002).
- [578] J. Homola, "Present and future of surface plasmon resonance biosensors," *Anal. Bioanal. Chem.*, **377**, 528 (2003).
- [579] D. A. Schultz, "Plasmon resonant particles for biological detection," *Curr. Opin. Biotechnol.*, **14**, 13 (2003).
- [580] B. Lee, "Review of the Present Status of Optical Fiber Sensors," *Opt. Fiber Technol.*, **9**, 57 (2003).
- [581] W. L. Barnes, A. Dereux, and T. W. Ebbesen, "Surface Plasmon Subwavelength Optics," *Nature*, **424**, 824 (2003).
- [582] T. M. Chinowsky, et al., "Performance of the Spreeta 2000 integrated surface 4 plasmon resonance affinity sensor," *Sens. Actuators B*, **91**, 266 (2003).
- [583] A. I. Csurgay and W. Porod, "Surface Plasmon Waves in Nanoelectronic Circuits," *Int. J. Circ. Th. Appl.*, **32**, 339 (2004).
- [584] C. Girard, "Near Fields in Nanostructures," *Rep. Prog. Phys.*, **68**, 1883 (2005).
- [585] A. Ramanavicius, et al., "Biomedical Application of Surface Plasmon Resonance Biosensors (Review)," *Acta Med. Lituanica*, **12**, 1 (2005).
- [586] Y. P. Bliokh, et al., "Visualization of the complex refractive index of a conductor by frustrated total internal reflection," *Appl. Phys. Lett.*, **89**, 021908 (2006).
- [587] P. Lecaruyer, et al., "Generalization of the Rouard method to an absorbing thin-film stack and application to surface plasmon resonance," *Appl. Opt.*, **45**, 8419 (2006).
- [588] L. Novotny and B. Hecht, *Principles of Nano-Optics*, Cambridge Univ. Press, Cambridge, 2006.
- [589] S. A. Maier, *Plasmonics: Fundamentals and Applications*, Springer, New York, 2007.
- [590] H. A. Atwater, "The Promise of Plasmonics," *Sci. Amer.*, April 2007, p. 56.
- [591] J. M. Pitarke, et al., "Theory of Surface Plasmons and Surface-Plasmon Polaritons," *Rep. Progr. Phys.*, **70**, 1 (2007).

### Thin Films

- [592] O. S. Heavens, *Optical Properties of Thin Solid Films*, Butterworths Scientific Publications, London, 1955, and Dover Publications, New York, 1991.
- [593] A. Vasicek, *Optics of Thin Films*, North-Holland Publishing Co., Amsterdam, 1960.
- [594] H. A. Macleod, *Thin-Film Optical Filters*, American Elsevier, New York, 1969.
- [595] E. Hecht and A. Zajac, *Optics*, Addison-Wesley, Reading, MA, 1974.
- [596] Z. Knittl, *Optics of Thin Films*, McGraw-Hill, New York, 1976.
- [597] O. S. Heavens, *Thin Film Physics*, Methuen, London, 1970.
- [598] M. Born and E. Wolf, *Principles of Optics*, 6th ed., Pergamon Press, 1980.
- [599] A. Thelen, *Design of Optical Interference Coatings*, McGraw-Hill, New York, 1989.
- [600] J. A. Dobrowolski, "Optical Properties of Films and Coatings," in *Handbook of Optics*, vol.I, M. Bass, et al., eds., McGraw-Hill, New York, 1995.
- [601] O. S. Heavens, J. Ring, and S. D. Smith, "Interference Filters for the Infrared," *Spectrochimica Acta*, **10**, 179 (1957).
- [602] H. Van de Stadt and J. M. Muller, "Multimirror Fabry-Perot Interferometers," *J. Opt. Soc. Am.*, **A-2**, 1363 (1985).

- [603] A. Zheng, J. S. Seely, R. Hunneman, and G. J. Hawkins, "Design of Narrowband Filters in the Infrared Region," *Infrared Phys.*, **31**, 237 (1991).
- [604] J. M. Bennett, "Polarizers," in *Handbook of Optics, vol.II*, M. Bass, et al., eds., McGraw-Hill, New York, 1995. See also, J. M. Bennett, "Polarization," *ibid.*, vol. I.
- [605] H. Bach and D. Krause, eds., *Thin Films on Glass*, Springer-Verlag, Berlin, 1997.
- [606] Lord Rayleigh, "On the Reflection of Light from a Regularly Stratified Medium," *Proc. R. Soc. London, Ser. A*, **93**, 565 (1917).
- [607] M. Banning, "Practical Methods of Making and Using Multilayer Filters," *J. Opt. Soc. Am.*, **37**, 792 (1947).
- [608] R. B. Muchmore, "Optimum Band Width for Two Layer Anti-Reflection Films," *J. Opt. Soc. Am.*, **38**, 20 (1948).
- [609] F. Abelès, "Recherches sur la Propagation des Ondes Electromagnetiques Sinusoidales dans les Milieux Stratifiés," *Ann. Physique*, Ser.12, **5**, 596 (1950) and Part II, p.706.
- [610] P. J. Leurgans, "The Impedance Concept in Thin Film Optics," *J. Opt. Soc. Am.*, **41**, 714 (1951).
- [611] L. I. Epstein, "The Design of Optical Filters," *J. Opt. Soc. Am.*, **42**, 806 (1952).
- [612] L. I. Epstein, "Improvements in Heat-Reflecting Filters," *J. Opt. Soc. Am.*, **45**, 360 (1952).
- [613] P. T. Scharf, "Transmission Color in Camera Lenses," *J. SMPTE*, **59**, 191 (1952).
- [614] W. Weinstein, "Computations in Thin Film Optics," *Vacuum*, **4**, 3 (1954).
- [615] F. E. Carlson, et al., "Temperature Reduction in Motion-Picture and Television Studios Using Heat-Control Coatings," *J. SMPTE*, **65**, 136 (1956).
- [616] H. H. Schroeder and A. F. Turner, "A Commercial Cold Reflector," *J. SMPTE*, **69**, 351 (1960).
- [617] L. Young, "Synthesis of Multiple Antireflection Films Over a Prescribed Frequency Band," *J. Opt. Soc. Am.*, **51**, 967 (1961).
- [618] P. H. Berning, "Use of Equivalent Films in the Design of Infrared Multilayer Antireflection Coatings," *J. Opt. Soc. Am.*, **52**, 431 (1962).
- [619] L. A. Catalan, "Some Computed Optical Properties of Antireflection Coatings," *J. Opt. Soc. Am.*, **52**, 437 (1962).
- [620] J. Cox, G. Hass, and A. Thelen, "Triple-Layer Antireflection Coatings on Glass for the Visible and Near Infrared," *J. Opt. Soc. Am.*, **52**, 965 (1962).
- [621] F. Abelès, "Methods for Determining Optical Parameters of Thin Films," in *Progress in Optics*, vol. II, E. Wolf, ed., North-Holland Publishing Co., Amsterdam, 1963.
- [622] A. Thelen, "Multilayer Filters with Wide Transmittance Bands," *J. Opt. Soc. Am.*, **53**, 1266 (1963).
- [623] J. J. Vera, "Some Properties of Multi-Layer Films with Periodic Structure," *Opt. Acta*, **11**, 315 (1964).
- [624] A. Thelen, "Equivalent Layers in Multilayer Filters," *J. Opt. Soc. Am.*, **56**, 1533 (1966).
- [625] J. Arndt and P. Baumeister, "Reflectance and Phase Envelopes of an Iterated Multilayer," *J. Opt. Soc. Am.*, **56**, 1760 (1966).
- [626] A. F. Turner and P. W. Baumeister, "Multilayer Mirrors with High Reflectance Over an Extended Spectral Region," *Appl. Opt.*, **5**, 69 (1966).
- [627] L. Young, "Multilayer Interference Filters with Narrow Stop Bands," *Appl. Opt.*, **6**, 297 (1967).
- [628] H. F. Mahlein and G. Schollmeier, "Analysis and Synthesis of Periodic Optical Resonant Reflectors," *Appl. Opt.*, **8**, 1197 (1969).
- [629] P. B. Clapham, M. J. Downs, and R. J. King, "Some Applications of Thin Films to Polarization Devices," *Appl. Opt.*, **8**, 1965 (1969).
- [630] E. Delano and R. J. Pegis, "Methods of Synthesis for Dielectric Multilayer Filters," in *Progress in Optics*, vol. VII, E. Wolf, ed., North-Holland Publishing Co., Amsterdam, 1969.
- [631] A. Thetford, "A Method of Designing Three-Layer Anti-Reflection Coatings," *Opt. Acta*, **16**, 37 (1969).
- [632] A. Musset and A. Thelen, "Multilayer Antireflection Coatings," in *Progress in Optics*, vol. VIII, E. Wolf, ed., North-Holland Publishing Co., Amsterdam, 1970.
- [633] P. Baumeister and G. Pincus, "Optical Interference Coatings," *Sci. Amer.*, **223**, 59, Dec. 1970.
- [634] L. Young and E. G. Cristal, "Low-Pass and High-Pass Filters Consisting of Multilayer Dielectric Stacks," *IEEE Trans. Microwave Theory Tech.*, **MTT-14**, 75 (1966).
- [635] A. Thelen, "Design of Optical Minus Filters," *J. Opt. Soc. Am.*, **61**, 365 (1971).

- [636] A. Kucirkova, "Synthesis of Multiple Anti-Reflection Films by the Rational Function Method," *Opt. Acta*, **18**, 577 (1971).
- [637] J. A. Dobrowolski and S. H. C. Piotrowski, "Refractive Index as a Variable in the Numerical Design of Optical Thin Film Systems," *Appl. Opt.*, **21**, 1502 (1982).
- [638] P. H. Berning, "Principles of Design of Architectural Coatings," *Appl. Opt.*, **22**, 4127 (1983).
- [639] R. Swanepoel, "Determination of the Thickness and Optical Constants of Amorphous Silicon," *J. Phys. E: Sci. Instrum.*, **16**, 1214 (1983).
- [640] J. S. Seeley, "Simple Nonpolarizing High-Pass Filter," *Appl. Opt.*, **24**, 742 (1985).
- [641] R. Herrmann, "Quarterwave Layers: Simulation by Three Thin Layers of Two Materials," *Appl. Opt.*, **24**, 1183 (1985).
- [642] P. Baumeister, "Antireflection Coatings with Chebyshev or Butterworth Response: Design," *Appl. Opt.*, **25**, 4568 (1986).
- [643] A. V. Tikhonravov, "Some Theoretical Aspects of Thin-Film Optics and their Applications," *Appl. Opt.*, **32**, 5417 (1993).
- [644] J. Mouchart, J. Begel, and E. Duda, "Modified MacNeille Cube Polarizer for a Wide Angular Field," *Appl. Opt.*, **28**, 2847 (1989).
- [645] E. Cojocaru, "Comparison of Theoretical Performances for Different Single-Wavelength Thin-Film Polarizers," *Appl. Opt.*, **31**, 4501 (1992).
- [646] L. Li and J. A. Dobrowolski, "Visible Broadband, Wide-Angle, Thin-Film Multilayer Polarizing Beam Splitter," *Appl. Opt.*, **35**, 2221 (1996).
- [647] K. V. Popov, J. A. Dobrowolski, A. V. Tikhonravov, and B. T. Sullivan, "Broadband High-Reflection Multilayer Coatings at Oblique Angles of Incidence," *Appl. Opt.*, **36**, 2139 (1997).
- [648] P. W. Baumeister, "Rudiments of the Design of an Immersed Polarizing Beam Divider with Narrow Spectral Bandwidth and Enhanced Angular Acceptance," *Appl. Opt.*, **36**, 3610 (1997).
- [649] J. Ciosek, J. A. Dobrowolski, G. A. Clarke, and G. Laframboise, "Design and Manufacture of All-Dielectric Nonpolarizing Beam Splitters," *Appl. Opt.*, **38**, 1244 (1999).
- [650] L. Li and J. A. Dobrowolski, "High-Performance Thin-Film Polarizing Beam Splitter Operating at Angles Greater than the Critical Angle," *Appl. Opt.*, **39**, 2754 (2000).
- [651] A. Thelen, "Design Strategies for Thin Film Optical Coatings," in Ref. [605].
- [652] B. Danielzik, M. Heming, D. Krause, and A. Thelen, "Thin Films on Glass: An Established Technology," in Ref. [605].
- [653] W. T. Doyle, "Scattering Approach to Fresnel's Equations and Brewster's Law," *Am. J. Phys.*, **53**, 463 (1985).
- [654] K. Sato, et al., "Measurement of the Complex Refractive Index of Concrete at 57.5 GHz," *IEEE Trans. Antennas Propagat.*, **AP-44**, 35 (1996).
- [655] R. K. Zia, "Symmetric Fresnel Equations: An Energy Conservation Approach," *Am. J. Phys.*, **56**, 555 (1988).
- [656] O. S. Heavens and H. M. Liddell, "Staggered Broad-Band Reflecting Multilayers," *Appl. Opt.*, **5**, 373 (1966).
- [657] G. N. Henderson, T. K. Gaylord, and E. N. Glytsis, "Ballistic Electron Transport in Semiconductor Heterostructures and Its Analogies in Electromagnetic Propagation in General Dielectrics," *Proc. IEEE*, **79**, 1643 (1991).
- ### Birefringent Multilayer Films
- [658] M. F. Weber, C. A. Stover, L. R. Gilbert, T. J. Nevitt, and A. J. Ouderkirk, "Giant Birefringent Optics in Multilayer Polymer Mirrors," *Science*, **287**, 2451 (2000).
- [659] H. Schopper, "Zur Optik dünner doppelbrechender und dichroitischer Schichten," *Z. Physik*, **132**, 146 (1952).
- [660] D. A. Holmes, "Exact Theory of Retardation Plates," *J. Opt. Soc. Am.*, **54**, 1115 (1964).
- [661] D. A. Holmes and D. L. Feucht, "Electromagnetic Wave Propagation in Birefringent Multilayers," *J. Opt. Soc. Am.*, **56**, 1763 (1966).

- [662] L. P. Mosteller and F. Wooten, "Optical Properties and Reflectance of Uniaxial Absorbing Crystals," *J. Opt. Soc. Am.*, **58**, 511 (1968).
- [663] R. H. W. Graves, "Determination of Optical Constants of Anisotropic Crystals," *J. Opt. Soc. Am.*, **59**, 1225 (1969).
- [664] A. Wünsche, "Neue Formeln für die Reflexion und Brechung des Lichtes an anisotropen Medien," *Ann. Physik*, series 7, **25**, 201 (1970).
- [665] S. Teitler and B. W. Henvis, "Refraction in Stratified Anisotropic Media," *J. Opt. Soc. Am.*, **60**, 830 (1970).
- [666] A. S. Marathay, "Matrix-Operator Description of the Propagation of Polarized Light through Cholesteric Liquid Crystals," *J. Opt. Soc. Am.*, **60**, 1363 (1970).
- [667] C. Altman and S. G. Lipson, "Reciprocity Relations in Light Propagation through a Multilayer Birefringent System," *J. Opt. Soc. Am.*, **61**, 1460 (1971).
- [668] D. den Engelsen, "Ellipsometry of Anisotropic Films," *J. Opt. Soc. Am.*, **61**, 1460 (1971).
- [669] D. W. Berreman, "Optics in Stratified and Anisotropic Media: 4 × 4 Matrix Formulation," *J. Opt. Soc. Am.*, **62**, 502 (1972).
- [670] J. Schesser and G. Eichman, "Propagation of Plane Waves in Biaxially Anisotropic Layered Media," *J. Opt. Soc. Am.*, **62**, 786 (1972).
- [671] D. J. De Smet, "Ellipsometry of Anisotropic Thin Films," *J. Opt. Soc. Am.*, **64**, 631 (1974).
- [672] D. J. De Smet, "Generalized Ellipsometry and the 4 × 4 Matrix Formalism," *Surface Science*, **56**, 293 (1976).
- [673] J. J. Stammes and G. C. Sherman, "Reflection and Refraction of an Arbitrary Wave at a Plane Interface Separating Two Uniaxial Crystals," *J. Opt. Soc. Am.*, **67**, 683 (1977).
- [674] P. Yeh, "Electromagnetic Propagation in Birefringent Layered Media," *J. Opt. Soc. Am.*, **69**, 742 (1979).
- [675] P. Yeh, "Optics of Anisotropic Layered Media: A New 4 × 4 Matrix Algebra," *Surface Science*, **96**, 41 (1980).
- [676] R. M. A. Azzam and N. M. Bashara, *Ellipsometry and Polarized Light*, North-Holland Publishing Company, Amsterdam, 1977.
- [677] I. J. Hodgkinson and Q. H. Wu, *Birefringent Thin Films and Polarizing Elements*, World Scientific, Singapore, 1997.
- [678] I. J. Hodgkinson, S. Kassam, and Q. H. Wu, "Eigenequations and Compact Algorithms for Bulk and Layered Anisotropic Optical Media: Reflection and Refraction at a Crystal-Crystal Interface," *J. Comput. Phys.*, **133**, 75 (1997).

### Chiral Media

- [679] A. Lakhtakia, ed., *Selected Papers on Natural Optical Activity*, SPIE Milestone Series, vol. MS 15, SPIE Optical Engineering Press, Bellingham, WA, 1990.
- [680] M. P. Silverman, *Waves and Grains*, Princeton University Press, Princeton, NJ, 1998.
- [681] E. U. Condon, "Theories of Optical Rotatory Power," *Rev. Mod. Phys.*, **9**, 432 (1937). Reprinted in [679].
- [682] F. I. Fedorov, "On the Theory of Optical Activity in Crystals," *Optics and Spectroscopy*, **6**, 49 (1959), and *ibid.*, p.237, and with B. V. Bokut, p.342. Reprinted in [679].
- [683] B. D. H. Tellegen, "The Gyrator, A New Electrical Network Element," *Philips Res. Reports*, **3**, 81 (1948). Reprinted in [679].
- [684] M. P. Silverman and R. B. Sohn, "Effects of Circular Birefringence on Light Propagation and Reflection," *Am. J. Phys.*, **54**, 69 (1986).
- [685] M. P. Silverman, "Reflection and Refraction at the Surface of a Chiral Medium: Comparison of Gyrotropic Constitutive Relations Invariant or Noninvariant Under a Duality Transformation," *J. Opt. Soc. Am.*, **A-3**, 830 (1986).
- [686] A. Lakhtakia, V. V. Varadan, and V. K. Varadan, "A Parametric Study of Microwave Reflection Characteristics of a Planar Achiral-Chiral Interface," *IEEE Trans. Electrom. Compat.*, **EMC-28**, 90 (1986).

- [687] A. Lakhtakia, V. V. Varadan, and V. K. Varadan, "Field Equations, Huygens's Principle, Integral Equations, and Theorems for Radiation and Scattering of Electromagnetic Waves in Isotropic Chiral Media," *J. Opt. Soc. Am.*, **A-5**, 175 (1988).
- [688] S. Bassiri, C. H. Papas, and N. Engheta, "Electromagnetic Wave Propagation Through and Dielectric-Chiral Interface and Through an Chiral Slab," *J. Opt. Soc. Am.*, **A-5**, 1450 (1988).
- [689] J. C. Monson, "Radiation and Scattering in Homogeneous General Biisotropic Regions," *IEEE Trans. Antennas Propagat.*, **AP-38**, 227 (1990). Reprinted in [679].
- [690] D. L. Jaggard, A. R. Mickelson, and C. H. Papas, "On Electromagnetic Waves in Chiral Media," *Appl. Phys.*, **18**, 211 (1979).
- [691] D. L. Jaggard and X. Sun, "Theory of Chiral Multilayers," *J. Opt. Soc. Am.*, **A-9**, 804 (1992).
- [692] K. M. Flood and D. L. Jaggard, "Band-Gap Structure for Periodic Chiral Media," *J. Opt. Soc. Am.*, **A-13**, 1395 (1996).
- [693] S. F. Mason, "From Pasteur to Parity Nonconservation: Theories of the Origin of Molecular Chirality," in Ref. [694].
- [694] N. Berova, K. Nakanishi, and R. W. Woody, eds., *Circular Dichroism*, 2nd ed., Wiley-VCH, New York, 2000.
- [695] A. Lakhtakia and W. S. Weighofer, "Are Linear, Nonreciprocal, Biisotropic Media Forbidden?," *IEEE Trans. Microwave Theory Tech.*, **MTT-42**, 1715 (1994).

### Gyrotropic Media

- [696] E. V. Appleton, "Wireless Studies of the Ionosphere," *J. IEE*, **71**, 642 (1932).
- [697] D. R. Hartree, "The Propagation of Electromagnetic Waves in a Refracting Medium in a Magnetic Field," *Proc. Camb. Phil. Soc.*, **27**, 143 (1931).
- [698] R. S. Lawrence, C. G. Little, and H. J. A. Chivers, "A Survey of Ionospheric Effects Upon Earth-Space Radio Propagation," *Proc. IEEE*, **52**, 4 (1964).
- [699] K. Davies, *Ionospheric Radio Waves*, Blaisdell Publishing Co., Waltham, MA, 1969.
- [700] D. G. Swanson, *Plasma Waves*, Academic Press, San Diego, CA, 1989.
- [701] F. Bloch, "Nuclear Induction," *Phys. Rev.*, **70**, 460 (1946).
- [702] F. Bloch, W. W. Hansen, and M. Packard, "The Nuclear Induction Experiment," *Phys. Rev.*, **70**, 474 (1946).
- [703] D. Polder, "On the Theory of Ferromagnetic Resonance," *Philos. Mag.*, **40**, 99 (1949).
- [704] D. Polder, "On the Phenomenology of Ferromagnetic Resonance," *Phys. Rev.*, **73**, 1120 (1948).
- [705] W. A. Yager, J. K. Galt, F. R. Merritt, and E. A. Wood, "Ferromagnetic Resonance in Nickel Ferrite," *Phys. Rev.*, **80**, 744 (1950).
- [706] C. L. Hogan, "The Ferromagnetic Faraday Effect at Microwave Frequencies and its Applications, The Microwave Gyrator" *Bell Syst. Tech. J.*, **31**, 1 (1952).
- [707] C. L. Hogan, "The Ferromagnetic Faraday Effect at Microwave Frequencies and its Applications," *Rev. Mod. Phys.*, **25**, 253 (1953).
- [708] M. T. Weiss and A. G. Fox, "Magnetic Double Refraction at Microwave Frequencies," *Phys. Rev.*, **88**, 146 (1952).
- [709] N. Bloembergen, "Magnetic Resonance in Ferrites," *Proc. IRE*, **44**, 1259 (1956).
- [710] B. Lax and K. J. Button, *Microwave Ferrites and Ferrimagnetics*, McGraw Hill, New York, 1962.
- [711] D. M. Bolle and L. Lewin, "On the Definitions of Parameters in Ferrite-Electromagnetic Wave Interactions," *IEEE Trans. Microwave Theory Tech.*, **MTT-21**, 118 (1974).
- [712] K. Button, "Microwave Ferrite Devices: The First Ten Years," *IEEE Trans. Microwave Theory Tech.*, **MTT-32**, 1088 (1984).

### Photonic and Other Bandgaps

- [713] L. Brillouin, *Wave Propagation in Periodic Structures*, Dover, New York, 1953.
- [714] C. Elachi, "Waves in Active and Passive Periodic Structures: A Review," *Proc. IEEE*, **64**, 1666 (1976).

- [715] P. Yeh, A. Yariv, and C-S. Hong, "Electromagnetic Propagation in Periodic Stratified Media. I. General Theory," *J. Opt. Soc. Am.*, **67**, 423 (1977), and "II. Birefringence, Phase Matching, and X-Ray Lasers," *ibid.*, p. 438.
- [716] A. Yariv and P. Yeh, *Optical Waves in Crystals: Propagation and Control of Laser Radiation*, Wiley, New York, 1984.
- [717] P. Yeh, *Optical Waves in Layered Media*, Wiley, New York, 1988.
- [718] D. W. L. Sprung and H. Wu, "Scattering by a Finite Periodic Potential," *Am. J. Phys.*, **61**, 1118 (1993).
- [719] J. L. Rosner, "Reflectionless Approximations to Potentials with Band Structure," *Ann. Phys.*, **200**, 101 (1990).
- [720] Photonic Band Gap Bibliography. See web site Ref. [1320].
- [721] E. Yablonovitch, "Photonic Band-Gap Structure," *J. Opt. Soc. Am.*, **B-10**, 283 (1992).
- [722] E. Yablonovitch, "Photonic Crystals," *J. Mod. Opt.*, **41**, 173 (1994).
- [723] J. B. Pendry, "Photonic Band Structures," *J. Mod. Opt.*, **41**, 209 (1994).
- [724] P. St. J. Russel, "Photonic Band Gaps," *Phys. World*, **5**, 37, August 1992.
- [725] R. D. Meade, et al., "Novel Applications of Photonic Band Gap Materials: Low-Loss Bends and High Q Cavities," *J. Appl. Phys.*, **75**, 4753 (1994).
- [726] J. D. Joannopoulos, R. D. Meade, and J. N. Winn, *Photonic Crystals: Molding the Flow of Light*, Princeton University Press, Princeton, NJ, 1995.
- [727] C. M. Soukoulis, "Photonic Band Gap Materials: The 'Semiconductors' of the Future?," *Physica Scripta*, **T66**, 146 (1996).
- [728] J. D. Joannopoulos, P. R. Villeneuve, and S. Fan, "Photonic Crystals: Putting a New Twist on Light," *Nature*, **386**, 143 (1997).
- [729] M. Jacoby, "Photonic Crystals: Whole Lotta Holes," *Chem & Eng. News*, November 23, 1998, p. 38.
- [730] Special Issue on Electromagnetic Crystal Structures, Design, Synthesis, and Applications, *J. Lightwave Technol.*, **17**, no. 11, November 1999.
- [731] Mini-Special Issue on Electromagnetic Crystal Structures, Design, Synthesis, and Applications, *IEEE Trans. Microwave Theory Tech.*, **MTT-47**, no. 11, November 1999.
- [732] T. A. Birks, J. C. Knight, and P. St. J. Russell, "Endlessly Single-Mode Photonic Crystal Fiber," *Optics Lett.*, **22**, 961 (1997).
- [733] O. Painter, R. K. Lee, A. Scherer, A. Yariv, J. D. O'Brien, P. D. Dapkus, and I. Kim, "Two-Dimensional Photonic Band-Gap Defect Mode Laser," *Science*, **284**, 1819 (1999).
- [734] O. J. Painter, A. Husain, A. Scherer, J. D. O'Brien, I. Kim, and P. D. Dapkus, "Room Temperature Photonic Crystal Defect Lasers at Near-Infrared Wavelengths in InGaAsP," *J. Lightwave Technol.*, **17**, 2082 (1999).
- [735] Y. Fink, D. J. Ripin, S. Fan, C. Chen, J. D. Joannopoulos, and E. L. Thomas, "Guiding Optical Light in Air Using an All-Dielectric Structure," *J. Lightwave Technol.*, **17**, 2039 (1999).
- [736] Y. Fink, J. N. Winn, S. Fan, C. Chen, J. Michel, J. D. Joannopoulos, and E. L. Thomas, "A Dielectric Omnidirectional Reflector," *Science*, **282**, 1679 (1998).
- [737] D. N. Chigrin, A. V. Lavrinenko, D. A. Yarotsky, and S. V. Gaponenko, "Observation of Total Omnidirectional Reflection from a One-Dimensional Dielectric Lattice," *Appl. Phys. A*, **68**, 25 (1999).
- [738] J. N. Winn, Y. Finn, S. Fan, and J. D. Joannopoulos, "Omnidirectional Reflection from a One-Dimensional Photonic Crystal," *Opt. Lett.*, **23**, 1573 (1998).
- [739] D. N. Chigrin, A. V. Lavrinenko, D. A. Yarotsky, and S. V. Gaponenko, "All-Dielectric One-Dimensional Periodic Structures for Total Omnidirectional Reflection and Partial Spontaneous Emission Control," *J. Lightwave Technol.*, **17**, 2018 (1999).
- [740] P. St. J. Russell, S. Tredwell, and P. J. Roberts, "Full Photonic Bandgaps and Spontaneous Emission Control in 1D Multilayer Dielectric Structures," *Optics Commun.*, **160**, 66 (1999).
- [741] J. P. Dowling, "Mirror on the Wall: You're Omnidirectional After All?" *Science*, **282**, 1841 (1998).
- [742] D. Normile, "Cages for Light Go from Concept to Reality," *Science*, **286**, 1500 (1999).
- [743] J. M. Bendickson and J. P. Dowling, "Analytic Expressions for the Electromagnetic Mode Density in Finite, One-Dimensional, Photonic Band-Gap Structures," *Phys. Rev. E*, **53**, 4107 (1996).

- [744] J. P. Dowling, "Parity, Time-Reversal and Group Delay for Inhomogeneous Dielectric Slabs: Application to Pulse Propagation in Finite, One-Dimensional, Photonic Bandgap Structures," *IEE Proc. J. Optoelectron.*, **145**, 420 (1998).
- [745] J. P. Dowling, "Dipole Emission in Finite Photonic Bandgap Structures: An Exactly Solvable One-Dimensional Model," *J. Lightwave Technol.*, **17**, 2142 (1999).
- [746] [www.sspectra.com/designs/omnirefl.html](http://www.sspectra.com/designs/omnirefl.html), Software Spectra, Inc., "Dielectric Omnidirectional Reflector," February 1999.
- [747] H. Kogelnik and C. V. Shank, "Coupled-Wave Theory of Distributed Feedback Lasers," *J. Appl. Phys.*, **43**, 2327 (1972).
- [748] H. A. Haus, "Grating-Filter Transformation Chart," *Electron. Lett.*, **11**, 553 (1975).
- [749] H. Kogelnik, "Filter Response of Nonuniform Almost-Periodic Structures," *Bell Syst. Tech. J.*, **55**, 109 (1976).
- [750] L. A. Weller-Brophy and D. G. Hall, "Analysis of Waveguide Gratings: Application of Rouard's Method," *J. Opt. Soc. Am.*, **A-2**, 863 (1985).
- [751] L. A. Weller-Brophy and D. G. Hall, "Analysis of Waveguide Gratings: A Comparison of the Results of Rouard's Method and Coupled-Mode Theory," *J. Opt. Soc. Am.*, **A-4**, 60 (1987).
- [752] M. Yamada and K. Sakuda, "Analysis of Almost-Periodic Distributed Feedback Slab Waveguides via a Fundamental Matrix Approach," *Appl. Opt.*, **26**, 3474 (1987).
- [753] K. A. Winick, "Effective-Index Method and Coupled-Mode Theory for Almost-Periodic Waveguide Gratings: A Comparison," *Appl. Opt.*, **31**, 757 (1992).
- [754] N. Matuschek, F. X. Kärtner, and U. Keller, "Exact Coupled-Mode Theories for Multilayer Interference Coatings with Arbitrary Strong Index Modulations," *IEEE J. Quant. Electr.*, **QE-33**, 295 (1997).
- [755] T. Erdogan, "Fiber Grating Spectra," *J. Lightwave Technol.*, **15**, 1277 (1997).
- [756] C. R. Giles, "Lightwave Applications of Fiber Bragg Gratings," *J. Lightwave Technol.*, **15**, 1391 (1997).
- [757] H. A. Haus and C. V. Shank, "Antisymmetric Taper of Distributed Feedback Lasers," *IEEE J. Quant. Electr.*, **QE-12**, 532 (1976).
- [758] K. Utaka, S. Akiba, K. Sakai, and Y. Matsushima, "Analysis of Quarter-Wave-Shifted DFB Laser," *Electron. Lett.*, **20**, 326 (1984).
- [759] K. Utaka, S. Akiba, K. Sakai, and Y. Matsushima, " $\lambda/4$ -Shifted InGaAsP/InP DFB Lasers by Simultaneous Holographic Exposure of Positive and Negative Photoresists," *Electron. Lett.*, **20**, 326 (1984).
- [760] R. C. Alferness, C. H. Joyner, M. D. Divino, M. J. R. Martyak, and L. L. Buhl, "Narrowband Grating Resonator Filters in InGaAsP/InP Waveguides," *Appl. Phys. Lett.*, **49**, 125 (1986).
- [761] H. A. Haus and Y. Lai, "Theory of Cascaded Quarter Wave Shifted Distributed Feedback Resonators," *IEEE J. Quant. Electr.*, **QE-28**, 205 (1992).
- [762] G. P. Agrawal and S. Radic, "Phase-Shifted Fiber Bragg Gratings and their Application for Wavelength Demultiplexing," *IEEE Photon. Technol. Lett.*, **6**, 995 (1994).
- [763] R. Zengerle and O. Leminger, "Phase-Shifted Bragg-Grating Filters with Improved Transmission Characteristics," *J. Lightwave Technol.*, **13**, 2354 (1995).
- [764] L. Wei and W. Y. Lit, "Phase-Shifted Bragg Grating Filters with Symmetrical Structures," *J. Lightwave Technol.*, **15**, 1405 (1997).
- [765] F. Bakhti and P. Sansonetti, "Design and Realization of Multiple Quarter-Wave Phase-Shifts UV-Written Bandpass Filters in Optical Fibers," *J. Lightwave Technol.*, **15**, 1433 (1997).
- [766] R. Kashyap, *Fiber Bragg Gratings*, Academic Press, San Diego, CA, 1999.
- [767] S. V. Kartalopoulos, *Introduction to DWDM Technology*, IEEE Press, New York, 2000.
- [768] S. S. Mester and H. Benaroya, "A Review of Periodic and Near-Periodic Structures," *Shock and Vibration*, **2**, 69 (1995).
- [769] D. J. Mead, "Wave Propagation in Continuous Periodic Structures," *J. Sound and Vibration*, **190**, 495 (1996).
- [770] R. S. Langley, N. S. Bardell, and P. M. Loasby, "The Optimal Design of Near-Periodic Structures to Minimize Vibration Transmission and Stress Levels," *J. Sound and Vibration*, **207**, 627 (1997).
- [771] R. Martinez-Sala, et al., "Sound Attenuation by Sculpture," *Nature*, **378**, 241 (1995).
- [772] M. M. Sigalas and E. N. Economou, "Attenuation of Multiple-Scattered Sound," *Europhys. Lett.*, **36**, 241 (1996).

- [773] W. M. Robertson and J. F. Rudy, "Measurement of Acoustic Stop Bands in Two-Dimensional Periodic Scattering Arrays," *J. Acoust. Soc. Am.*, **104**, 694 (1998).
- [774] M. S. Kushwaha and Djafari-Rouhani, "Sonic Stop-Bands for Periodic Arrays of Metallic Rods: Honeycomb Structure," *J. Sound and Vibration*, **218**, 697 (1998).
- [775] C. Rubio, et al., "The Existence of Full Gaps and Deaf Bands in Two-Dimensional Sonic Crystals," *J. Lightwave Technol.*, **17**, 2202 (1999).
- [776] Z. Liu, X. Zhang, Y. Mao, Y. Y. Zhu, Z. Yang, C. T. Chang, and P. Sheng, "Locally Resonant Sonic Materials," *Science*, **289**, 1734 (2000).

### Fiber-Optic Filters

- [777] B. Moslehi, J. W. Goodman, M. Tur, and H. J. Shaw, "Fiber-Optic Lattice Signal Processing," *Proc. IEEE*, **72**, 909 (1984).
- [778] K. Jackson, S. Newton, B. Moslehi, M. Tur, C. Cutler, J. W. Goodman, and H. J. Shaw, "Optical Fiber Delay-Line Signal Processing," *IEEE Trans. Microwave Theory Tech.*, **MTT-33**, 193 (1985).
- [779] E. M. Dowling and D. L. MacFarlane, "Lightwave Lattice Filters for Optically Multiplexed Communication Systems," *J. Lightwave Technol.*, **12**, 471 (1994).
- [780] C. Madsen and J. Zhao, *Optical Filter Design and Analysis: A Signal Processing Approach*, Wiley, New York, 1999.

### Quarter-Wave Transformers

- [781] R. E. Collin, "Theory and Design of Wide-Band Multisection Quarter-Wave Transformers," *Proc. IRE*, **43**, 179 (1955).
- [782] R. E. Collin and J. Brown, "The Design of Quarter-Wave Matching Layers for Dielectric Surfaces," *Proc. IEE*, **103C**, 153 (1955).
- [783] S. B. Cohn, "Optimum Design of Stepped Transmission-Line Transformers," *IRE Trans. Microwave Theory Tech.*, **MTT-3**, 16 (1955).
- [784] H. J. Riblet, "General Synthesis of Quarter-Wave Impedance Transformers," *IRE Trans. Microwave Theory Tech.*, **MTT-5**, 36 (1957).
- [785] R. Levy, "A Guide to the Practical Application of Chebyshev Functions to the Design of Microwave Components," *Proc. IEE*, **106C**, 193 (1959).
- [786] L. Young, "Stepped-Impedance Transformers and Filter Prototypes," *IEEE Trans. Microwave Theory Tech.*, **MTT-10**, 339 (1962).
- [787] L. Young, "Unit Real Functions in Transmission-Line Circuit Theory," *IEEE Trans. Circuit Th.*, **CT-7**, 247 (1960).
- [788] R. Levy, "Tables of Element Values for the Distributed Low-Pass Prototype Filter," *IEEE Trans. Microwave Theory Tech.*, **MTT-13**, 514 (1965).
- [789] C. S. Gledhill and A. M. H. Issa, "On Synthesis of Particular Unit Real Functions of Reflection Coefficient," *IEEE Trans. Microwave Theory Tech.*, **MTT-17**, 57 (1969).
- [790] C. S. Gledhill and A. M. H. Issa, "Exact Solutions of Stepped Impedance Transformers Having Maximally Flat and Chebyshev Characteristics," *IEEE Trans. Microwave Theory Tech.*, **MTT-17**, 379 (1969).
- [791] G. L. Matthaei, L. Young, and E. M. T. Jones, *Microwave Filters, Impedance Matching Networks, and Coupling Structures*, Artech House, Dedham, MA, 1980.

### Linear Prediction, Speech, Geophysics, Network, and Function Theory

- [792] S. J. Orfanidis, *Optimum Signal Processing*, 2nd ed., McGraw-Hill, New York, 1988.
- [793] E. A. Robinson and S. Treitel, "Maximum Entropy and the Relationship of the Partial Autocorrelation to the Reflection Coefficients of a Layered System," *IEEE Trans. Acoust., Speech, Signal Process.* **ASSP-28**, 22 (1980).
- [794] L. R. Rabiner and R. W. Schafer, *Digital Processing of Speech Signals*, Prentice Hall, Upper Saddle River, NJ, 1978.

- [795] J. D. Markel and A. H. Gray, *Linear Prediction of Speech*, Springer-Verlag, New York, 1976.
- [796] J. A. Ware and K. Aki, "Continuous and Discrete Inverse Scattering Problems in a Stratified Elastic Medium, I," *J. Acoust. Soc. Am.*, **45**, 91 (1969).
- [797] H. Wakita, "Direct Estimation of the Vocal Tract Shape by Inverse Filtering of Acoustic Speech Waveforms," *IEEE Trans. Audio Electroacoust.*, **AU-21**, 417 (1973).
- [798] B. S. Atal and S. Hanauer, "Speech Analysis and Synthesis by Linear Prediction of the Speech Wave," *J. Acoust. Soc. Am.*, **50**, 637 (1971).
- [799] E. A. Robinson and S. Treitel, "Digital Signal Processing in Geophysics," in *Applications of Digital Signal Processing*, A. V. Oppenheim, ed., Prentice Hall, Upper Saddle River, NJ, 1978.
- [800] E. A. Robinson and S. Treitel, *Geophysical Signal Analysis*, Prentice Hall, Upper Saddle River, NJ, 1980.
- [801] J. F. Claerbout, *Fundamentals of Geophysical Data Processing*, McGraw-Hill, New York, 1976.
- [802] J. F. Claerbout, "Synthesis of a Layered Medium from its Acoustic Transmission Response," *Geophysics*, **33**, 264 (1968).
- [803] F. Koehler and M. T. Taner, "Direct and Inverse Problems Relating Reflection Coefficients and Reflection Response for Horizontally Layered Media," *Geophysics*, **42**, 1199 (1977).
- [804] J. M. Mendel and F. Habibi-Ashrafi, "A Survey of Approaches to Solving Inverse Problems for Lossless Layered Media Systems," *IEEE Trans. Geosci. Electron.*, **GE-18**, 320 (1980).
- [805] E. A. Robinson, "A Historical Perspective of Spectrum Estimation," *Proc. IEEE*, **70**, 885 (1982).
- [806] E. A. Robinson, "A Spectral Approach to Geophysical Inversion by Lorentz, Fourier, and Radon Transforms," *Proc. IEEE*, **70**, 1039 (1982).
- [807] K. P. Bube and R. Burridge, "The One-Dimensional Problem of Reflection Seismology," *SIAM Rev.*, **25**, 497 (1983).
- [808] J. G. Berryman and R. R. Green, "Discrete Inverse Methods for Elastic Waves in Layered Media," *Geophysics*, **45**, 213 (1980).
- [809] K. M. Case, "Inverse Scattering, Orthogonal Polynomials, and Linear Estimation," in *Topics in Functional Analysis, Advances in Mathematics Supplementary Studies*, vol.3, I. C. Gohberg and M. Kac, eds., Academic Press, New York, 1978.
- [810] F. J. Dyson, "Old and New Approaches to the Inverse Scattering Problem," in *Studies in Mathematical Physics*, E. H. Lieb, B. Simon, and A. S. Wightman, eds., Princeton University Press, Princeton, NJ, 1976.
- [811] R. G. Newton, "Inversion of Reflection Data for Layered Media: A Review of Exact Methods," *Geophys. J. R. Astron. Soc.*, **65**, 191 (1981).
- [812] O. Brune, "Synthesis of a Finite Two-Terminal Network whose Driving-Point Impedance is a Prescribed Function of Frequency," *J. Math. and Phys.*, **10**, 191 (1931).
- [813] P. I. Richards, "A Special Class of Functions With Positive Real Part in a Half Plane," *Duke Math. J.*, **14**, 777 (1947).
- [814] H. W. Bode, *Network Analysis and Feedback Amplifier Design*, Van Nostrand, New York (1945).
- [815] M. E. Van Valkenburg, *Introduction to Modern Network Synthesis*, Wiley, New York, 1960.
- [816] H. J. Carlin and A. B. Giordano, *Network Theory, An Introduction to Reciprocal and Nonreciprocal Circuits*, Prentice Hall, Upper Saddle River, NJ, (1964).
- [817] R. M. Fano, "Theoretical Limitations on the Broadband Matching of Arbitrary Impedances," *J. Franklin Inst.*, **249**, 57 and 139 (1950).
- [818] W-K. Chen, *Broadband Matching*, World Scientific, Singapore, 1988.
- [819] I. Schur, "On Power Series which are Bounded in the Interior of the Unit Circle, I and II," in *I. Schur Methods in Operator Theory and Signal Processing, Operator Theory: Advances and Applications*, vol.18, I. Gohberg, ed., Birkhäuser, Boston, 1986.
- [820] T. Kailath, "A Theorem of I. Schur and its Impact on Modern Signal Processing," *ibid*.
- [821] T. Kailath, A. M. Bruckstein, and D. Morgan, "Fast Matrix Factorization via Discrete Transmission Lines," *Lin. Alg. Appl.*, **75**, 1 (1985).
- [822] A. Yagle and B. C. Levy, "The Schur Algorithm and its Applications," *Acta Applic. Math.*, **3**, 255 (1985).

- [823] P. P. Vaidyanathan and S. K. Mitra, "Discrete Version of Richard's Theorem and Applications to Cascaded Lattice Realization of Digital Filter Transfer Functions," *IEEE Trans. Circ. Syst., CAS-33*, 26 (1986).
- [824] R. J. Duffin, "Algorithms for Classical Stability Problems," *SIAM Rev.*, **11**, 196 (1969).
- [825] A. J. Berkhouit, "Stability and Least-Squares Estimation," *Automatica*, **11**, 637 (1975).
- [826] P. P. Vaidyanathan and S. K. Mitra, "A Unified Structural Interpretation of Some Well-Known Stability-Test Procedures for Linear Systems," *Proc. IEEE*, **75**, 478 (1987).

### Geometrical Optics and Ray Tracing

- [827] S. Cornbleet, "Geometrical Optics Reviewed: A New Light on an Old Subject," *Proc. IEEE*, **71**, 471 (1983).
- [828] S. Cornbleet, *Microwave and Geometrical Optics*, Academic Press, London, 1994.
- [829] G. W. Forbes, "On Variational Problems in Parametric Form," *Am. J. Phys.*, **59**, 1130 (1991).
- [830] E. G. Rawson, D. R. Herriott, and J. McKenna, "Analysis of Refractive Index Distributions in Cylindrical, Graded-Index Glass Rods (GRIN Rods) Used as Image Relays," *Appl. Opt.*, **9**, 753 (1970).
- [831] E. W. Marchand, "Ray Tracing in Gradient-Index Media," *J. Opt. Soc. Am.*, **60**, 1 (1970).
- [832] W. Streifer and K. B. Paxton, "Analytic Solution of Ray Equations in Cylindrically Inhomogeneous Guiding Media. 1: Meridional Rays," *Appl. Opt.*, **10**, 769 (1971).
- [833] K. B. Paxton and W. Streifer, "Analytic Solution of Ray Equations in Cylindrically Inhomogeneous Guiding Media. Part 2: Skew Rays," *Appl. Opt.*, **10**, 1164 (1971).
- [834] E. W. Marchand, "Ray Tracing in Cylindrical Gradient-Index Media," *Appl. Opt.*, **11**, 1104 (1972).
- [835] R. Guenther, *Modern Optics*, Wiley, New York, 1990.
- [836] ITU Recommendation **ITU-R P.453-6**, (1997), "The Radio Refractive Index: Its Formula and Refractivity Data." Available from [1315].
- [837] ITU Recommendation **ITU-R P.834-2**, (1997), "Effects of Tropospheric Refraction on Radiowave Propagation." Available from [1315].

### Waveguides and Transmission Lines

- [838] N. Marcuvitz, ed., *Waveguide Handbook*, Dover Publications, New York, 1965.
- [839] T. Saad, *Microwave Engineer's Handbook*, vols.I and II, Artech House, Dedham, MA, 1971.
- [840] J. A. Staniforth, *Microwave Transmission*, Wiley, New York, 1972.
- [841] K. Chang, ed., *Handbook of Microwave and Optical Components*, vol.1, Wiley, New York, 1989.
- [842] R. E. Collin, *Field Theory of Guided Waves*, 2nd ed., IEEE Press, Piscataway, NJ, 1991.
- [843] A. W. Lines, G. R. Nicoll, and A. M. Woodward, "Some Properties of Waveguides with Periodic Structure," *Proc. IEE*, **97**, Pt.III, 263 (1950).
- [844] A. F. Harvey, "Periodic and Guiding Structures at Microwave Frequencies," *IEEE Trans. Microwave Theory Tech.*, **MTT-8**, 30 (1960).
- [845] A. F. Harvey, *Microwave Engineering*, Academic Press, London, 1963.
- [846] R. E. Collin, *Foundations of Microwave Engineering*, McGraw-Hill, New York, 1966.
- [847] R. S. Elliott, *An Introduction to Guided Waves and Microwave Circuits*, Prentice Hall, Upper Saddle River, NJ, 1993.
- [848] D. Marcuse, *Light Transmission Optics*, 2nd ed., Van Nostrand Reinhold, New York, 1982.
- [849] A. Yariv, *Optical Electronics*, 3d ed., Holt, Rinehart, and Winston, Inc., New York, 1985.
- [850] G. P. Agrawal, *Nonlinear Fiber Optics*, 3/e, Academic, New York, 2001.
- [851] A. Hasegawa, *Optical Solitons in Fibers*, Springer-Verlag, Berlin, 1989.
- [852] P. Diament, *Wave Transmission and Fiber Optics*, Macmillan, New York, 1990.
- [853] H. A. Haus, *Waves and Fields in Optoelectronics*, Prentice Hall, Upper Saddle River, NJ, 1984.
- [854] D. L. Lee, *Electromagnetic Principles of Integrated Optics*, Wiley, New York, 1986.

- [855] C. S. Lee, S. W. Lee, and S. L. Chuang, "Plot of Modal Field Distribution in Rectangular and Circular Waveguides," *IEEE Trans. Microwave Theory Tech.*, **MTT-33**, 271 (1985).
- [856] D. J. White, "Adding Plane Waves to Find the Complete TM and TE Wave Solutions for Metallic Rectangular Waveguides," *Am. J. Phys.*, **51**, 1115 (1983).
- [857] J. F. Lotspeich, "Explicit General Eigenvalue Solutions for Dielectric Slab Waveguides," *Appl. Opt.*, **14**, 327 (1975).
- [858] S. Rosenstark, *Transmission Lines in Computer Engineering*, McGraw-Hill, New York, 1994.
- [859] R. E. Matick, *Transmission Lines for Digital and Communication Networks*, IEEE Press, New York, 1995.
- [860] J. C. Freeman, *Fundamentals of Microwave Transmission Lines*, Wiley, New York, 1996.
- [861] "The Bergeron Method," Texas Instruments Application Report, SDYA014, October 1996, available online from [www.ti.com/sc/docs/pshets/abstract/apps/sdy014.htm](http://www.ti.com/sc/docs/pshets/abstract/apps/sdy014.htm).
- [862] E. O. Hammerstad and O. Jensen, "Accurate Models for Microstrip Computer-Aided Design," *IEEE MTT-S Digest International Microwave Symposium*, p.408, 1980, reprinted in Ref. [866].
- [863] H. Wheeler, "Transmission Line Properties of Parallel Strips Separated by a Dielectric Sheet," *IEEE Trans. Microwave Theory Tech.*, **MTT-13**, 172 (1965).
- [864] I. J. Bahl and D. K. Trivedi, "A Designer's Guide to Microstrip Line," *Microwaves*, **16**, May 1977, p. 174.
- [865] I. J. Bahl and R. Garg, "A Designer's Guide to stripline Circuits," *Microwaves*, **17**, January 1978, p. 90.
- [866] T. Itoh, Ed., *Planar Transmission Line Structures*, IEEE Press, New York, 1987.
- [867] E. H. Fooks and R. A. Zakarevicius, *Microwave Engineering Using Microstrip Circuits*, Prentice Hall, Upper Saddle River, NJ, 1989.
- [868] F. Gardiol, *Microstrip Circuits*, Wiley, New York, 1994.
- [869] H. M. Barlow and A. L. Cullen, "Surface Waves," *Proc. IEE*, Pt.III, **100**, 329 (1953).
- [870] S. A. Schelkunoff, "Anatomy of Surface Waves," *IRE Trans. Antennas Propagat.*, **AP-7**, 133 (1959).
- [871] T. Tamir and A. A. Oliner, "Guided Complex Waves, Part 1" *Proc. IEE*, **110**, 310 (1963), and "Part 2," *ibid*, p. 325.
- [872] A. Hessel, "General Characteristics of Traveling-Wave Antennas," in Ref. [9], vol.2, p. 151.
- [873] T. Tamir, "Leaky-Wave Antennas," in Ref. [9], vol.2, p. 259.
- [874] F. J. Zucker, "Surface-Wave Antennas," in Ref. [9], vol.2, p. 298.
- [875] T. Tamir and F. Y. Koo, "Varieties of Leaky Waves and Their Excitation Along Multilayer Structures," *IEEE J. Quant. Electr.*, **QE-22**, 544 (1986).
- [876] J. Zenneck, "Über die Fortpflanzung ebener elektromagnetische Wellen längs einer ebenen Leiterfläche und ihre Beziehung zur drahtlosen Telegraphie," *Annalen der Physik*, **23**, 846 (1907).
- [877] J. Fan, A. Dogariu, and L. J. Wang, "Amplified Total Internal Reflection," *Opt. Express*, **11**, 299 (2003).
- [878] A. E. Siegman, "Evanescence Gain: Does It really Exist?," Stanford University, EE Department Preprint, unpublished, 2003.
- [879] P. K. Tien, "Integrated Optics and New Wave Phenomena in Optical Waveguides," *Rev. Mod. Phys.*, **49**, 361 (1977).

### Coupled Transmission Lines and Crosstalk

- [880] S. A. Schelkunoff and T. M. Odarenko, "Crosstalk Between Coaxial Transmission Lines," *Bell Syst. Tech. J.*, **16**, 144 (1937).
- [881] S. O. Rice, "Steady-State Solutions of Transmission Line Equations," *Bell Syst. Tech. J.*, **20**, 131 (1941).
- [882] D. B. Jarvis, "The Effects of Interconnections on High-Speed Logic Circuits," *IEEE Trans. Electron. Comput.*, **EC-12**, 476 (1963).
- [883] H. Amemiya, "Time-Domain Analysis of Multiple Parallel Transmission Lines," *RCA Rev.*, **28**, 241 (1967).
- [884] J. A. DeFalco, "Reflection and Crosstalk in Logic Circuit Interconnections," *IEEE Spectrum*, **7**, July 1977, p.44.

- [885] J. C. Isaacs and N. A. Strakhov, "Crosstalk in Uniformly Coupled Lossy Transmission Lines," *Bell Syst. Tech. J.*, **52**, 101 (1973).
- [886] A. Deutsch, et al., "High-Speed Signal Propagation on Lossy Transmission Lines," *IBM J. Res. Dev.*, **34**, 601 (1990).
- [887] C. R. Paul, "Literal Solutions for Time-Domain Crosstalk on Lossless Transmission Lines," *IEEE Trans. Electromagn. Compat.*, **EMC-34**, 433 (1992).
- [888] H. W. Johnson and M. Graham, *High-Speed Digital design*, Prentice Hall, Upper Saddle River, NJ, 1993.
- [889] J. A. Brandão Faria, *Multiconductor Transmission-Line Structures*, Wiley, New York, 1993.
- [890] C. R. Paul, *Analysis of Multiconductor Transmission Lines*, Wiley, New York, 1994.
- [891] C. R. Paul, "Decoupling the Multiconductor Transmission Line Equations," *IEEE Trans. Microwave Theory Tech.*, **MTT-44**, 1429 (1996).
- [892] J.-F. Mao, O. Wing, and F.-Y. Chang, "Synthesis of Coupled Transmission Lines," *IEEE Trans. Circ. Syst., I*, **44**, 327 (1997).
- [893] A. Deutsch, et al., "When are Transmission-Line Effects Important for On-Chip Interconnections?," *IEEE Trans. Microwave Theory Tech.*, **MTT-45**, 1836 (1997).
- [894] A. Deutsch, "Electrical Characteristics of Interconnections for High-Performance Systems," *Proc. IEEE*, **86**, 315 (1998).
- [895] T. C. Edwards and M. B. Steer, *Foundations of Interconnect and Microstrip Design*, Wiley, New York, 2000.
- [896] J. A. Davis, et al., "Interconnect Limits on Gigascale Integration (GSI) in the 21st Century," *Proc. IEEE*, **89**, 305 (2001).
- [897] C. R. Paul, "Solution of the Transmission-Line Equations Under the Weak-Coupling Assumption," *IEEE Trans. Electromagn. Compat.*, **EMC-44**, 413 (2002).

### Coupled-Mode Theory

- [898] J. R. Pierce, "Coupling of Modes of Propagation," *J. Appl. Phys.*, **25**, 179 (1954).
- [899] S. E. Miller, "Coupled Wave Theory and Waveguide Applications," *Bell Syst. Tech. J.*, **33**, 661 (1954).
- [900] J. S. Cook, "Tapered Velocity Couplers," *Bell Syst. Tech. J.*, **34**, 807 (1955).
- [901] W. H. Louisell, "Analysis of the Single Tapered Mode Coupler," *Bell Syst. Tech. J.*, **34**, 853 (1955).
- [902] W. H. Louisell, *Coupled Mode and Parametric Electronics*, Wiley, New York, 1960.
- [903] C. W. Barnes, "Conservative Coupling Between Modes of Propagation—A Tabular Summary," *Proc. IEEE*, **52**, 64 (1964).
- [904] H. Kogelnik, "Coupled Wave Theory for Thick Hologram Gratings," *Bell Syst. Tech. J.*, **48**, 2909 (1969).
- [905] D. Marcuse, "The Coupling of Degenerate Modes in Two Parallel Dielectric Waveguides," *Bell Syst. Tech. J.*, **50**, 1791 (1971).
- [906] A. W. Snyder, "Coupled-Mode Theory for Optical Fibers," *J. Opt. Soc. Am.*, **62**, 1267 (1972).
- [907] A. Yariv, "Coupled-Mode Theory for Guided-Wave Optics," *IEEEJ. Quant. Electron.*, **QE-9**, 919 (1973).
- [908] H. F. Taylor and A. Yariv, "Guided Wave Optics," *Proc. IEEE*, **62**, 1044 (1974).
- [909] H. Kogelnik, "Theory of Dielectric Waveguides," in *Integrated Optics*, T. Tamir, ed., Springer-Verlag, New York, 1975.
- [910] E. Marom, O. G. Ramer, and S. Ruschin, "Relation Between Normal-Mode and Coupled-Mode Analyses of Parallel Waveguides," *IEEEJ. Quant. Electron.*, **QE-20**, 1311 (1984).
- [911] A. Hardy and W. Streifer, "Coupled Mode Solutions of Multiwaveguide Systems," *IEEEJ. Quant. Electron.*, **QE-22**, 528 (1986).
- [912] A. W. Snyder, Y. Chen, and A. Ankiewicz, "Coupled Waves on Optical Fibers by Power Conservation," *J. Lightwave Technol.*, **7**, 1400 (1989).
- [913] H. A. Haus and W.-P. Huang, "Coupled-Mode Theory," *Proc. IEEE*, **79**, 1505 (1991).
- [914] W.-P. Huang, "Coupled-Mode Theory for Optical Waveguides: An Overview," *J. Opt. Soc. Am., A-11*, 963 (1994).

- [915] W.-P. Yuen, "On the Different Formulations of the Coupled-Mode Theory for Parallel Dielectric Waveguides," *J. Lightwave Technol.*, **12**, 82 (1994).
- [916] R. März, *Integrated Optics*, Artech House, Boston, 1995.
- [917] B. Little, "Filter Synthesis for Coupled Waveguides," *IEEEJ. Quant. Electron.*, **QE-15**, 1149 (1997).
- [918] N. Matuschek, G. Steinmeyer, and U. Keller, "Relation Between Coupled-Mode Theory and Equivalent Layers for Multilayer Interference Coatings," *Appl. Opt.*, **39**, 1626 (2000).
- [919] M. McCall, "On the Application of Coupled Mode Theory for Modeling Fiber Bragg Gratings," *J. Lightwave Technol.*, **18**, 236 (2000).

### Diffuse Reflection and Transmission

- [920] A. Schuster, "Radiation Through a Foggy Atmosphere," *Astroph. J.*, **21**, 1 (1905). Reprinted in [922] and [923].
- [921] F. Kottler, "The Elements of Radiative Transfer," *Progress in Optics*, E. Wolf, ed., vol. III, North-Holland Publishing Co., Amsterdam, 1964.
- [922] D. H. Menzel, ed., *Selected Papers on the Transfer of Radiation*, Dover Publications, New York, 1966.
- [923] C. F. Bohren, ed., *Selected Papers on Scattering in the Atmosphere*, SPIE Milestone Series, vol. MS-7, SPIE Press, Bellingham, WA, 1989.
- [924] C. F. Bohren, "Multiple Scattering of Light and Some of its Observable Consequences," *Am. J. Phys.*, **55**, 524 (1987).
- [925] P. Kubelka and F. Munk, "Ein Beitrag zur Optik der Farbanstriche," *Zeit. Tech. Physik*, **12**, 593 (1931). Translated by S. Westin in [www.graphics.cornell.edu/~westin/pubs/kubelka.pdf](http://www.graphics.cornell.edu/~westin/pubs/kubelka.pdf).
- [926] P. Kubelka, "New Contributions to the Optics of Intensely Light-Scattering Materials, Part I," *J. Opt. Soc. Am.*, **38**, 448 (1948).
- [927] P. Kubelka, "New Contributions to the Optics of Intensely Light-Scattering Materials, Part II: Nonhomogeneous Layers," *J. Opt. Soc. Am.*, **44**, 330 (1954).
- [928] D. B. Judd, *Color in Business, Science, and Industry*, 2nd ed., Wiley, New York, 1963.
- [929] W. W. Wedlandt and H. G. Hecht, *Reflectance Spectroscopy*, Interscience, Wiley, New York, 1966.
- [930] G. Kortum, *Reflectance Spectroscopy*, Springer Verlag, New York, 1969.
- [931] W. G. Egan and T. W. Hilgeman, *Optical Properties of Inhomogeneous Materials*, Academic Press, New York, 1979.
- [932] S. Wan, R. R. Anderson, and J. A. Parish, "Analytical Modeling for the Optical Properties of the Skin with In Vitro and In Vivo Applications," *Photochem. Photobiol.*, **34**, 493 (1981).
- [933] B. Chaudhuri and S. C. Som, "Experimental Verification of the Matrix Formulation of the Schuster-Kubelka-Munk Theory of Diffusing Layers," *J. Optics*, **12**, 245 (1981).
- [934] R. Molenaar, J. J. ten Bosch, and J. R. Zijp, "Determination of Kubelka-Munk Scattering and Absorption Coefficients by Diffuse Illumination," *Appl. Opt.*, **38**, 2068 (1999).
- [935] V. I. Haltrin, "Diffuse Reflection Coefficient of a Stratified Sea," *Appl. Opt.*, **38**, 932 (1999).
- [936] A. Ishimaru, *Wave Propagation and Scattering in Random Media*, IEEE Press, Piscataway, NJ, 1997.

### Impedance Matching

- [937] N. Balabanian, "Impedance Matching," *IEEE Trans. Microwave Theory Tech.*, **MTT-3**, 53 (1955).
- [938] M. A. Hamid and M. M. Yunik, "On the Design of Stepped Transmission-Line Transformers," *IEEE Trans. Microwave Theory Tech.*, **MTT-15**, 528 (1967).
- [939] G. N. French and E. H. Fooks, "The Design of Stepped Transmission-Line Transformers," *IEEE Trans. Microwave Theory Tech.*, **MTT-16**, 885 (1968).
- [940] R. M. Arnold, "Transmission Line Impedance Matching Using the Smith Chart," *IEEE Trans. Microwave Theory Tech.*, **MTT-21**, 977 (1974).
- [941] J. H. Lepoff, "Matching: When Are Two Lines Better Than One?," *Microwaves*, March 1981, p.74.
- [942] G. N. French and E. H. Fooks, "Double Section Matching Transformers," *IEEE Trans. Microwave Theory Tech.*, **MTT-17**, 719 (1969).

- [943] F. Regier, "Series-Section Transmission Line Impedance Matching", *QST*, July 1978, p.14.
- [944] M. W. Maxwell, "Another Look at Reflections," Parts 1-4, *QST*, April 1973 p.35, June, p.20, August, p.36, October, p.22.
- [945] F. Witt, "Match Bandwidth of Resonant Antenna Systems," *QST*, October 1991, p.21. See also, A. S. Griffith, "Match Bandwidth Revisited," *QST*, June 1992, p.71.
- [946] D. K. Belcher, "RF Matching Techniques, Design and Example," *QST*, October 1972, p. .
- [947] T. Dorbuck, "Matching-Network Design," *QST*, March 1979, p.24.
- [948] J. S. Chakmanian, "Control VSWR Bandwidth in T-Section Networks," *Microwaves*, July 1981, p.87.
- [949] E. Wingfield, "New and Improved Formulas for the Design of Pi and Pi-L Networks," *QST*, August 1983, p.23, and *QST*, January 1984, p.49.
- [950] W. N. Caron, *Antenna Impedance Matching*, America Radio Relay League, Newington, CT, 1999.
- [951] Hewlett Packard, "Interactive Impedance Matching Model," available from the web site [1323].
- [952] Y. L. Chow and K. L. Wan, "A Transformer of One-Third Wavelength in Two Sections - For a Frequency and Its First Harmonic," *IEEE Microwave Wireless Compon. Lett.*, **12**, 22 (2002).
- [953] C. Monzon, "Analytical Derivation of a Two-Section Impedance Transformer for a Frequency and Its First Harmonic," *IEEE Microwave Wireless Compon. Lett.*, **12**, 381 (2002).
- [954] C. Monzon, "A Small Dual-Frequency Transformer in Two Sections," *IEEE Trans. Microwave Theory Tech.*, **51**, 1157 (2003).
- [955] S. J. Orfanidis, "A Two-Section Dual-Band Chebyshev Impedance Transformer," *IEEE Microwave Wireless Compon. Lett.*, **13**, 382 (2003).

### S-Parameters

- [956] H. Carlin, "The Scattering Matrix in Network Theory," *IEEE Trans. Circ. Th.*, **CT-3**, 88 (1956).
- [957] V. Belevitch, "Elementary Applications of the Scattering Formalism in Network Design," *IEEE Trans. Circ. Th.*, **CT-3**, 97 (1956).
- [958] D. C. Youla, "On Scattering Matrices Normalized to Complex Port Numbers," *Proc. IRE*, **49**, 1221 (1961).
- [959] D. C. Youla and P. M. Paterno, "Realizable Limits of Error for Dissipationless Attenuators in Mismatched Systems," *IEEE Trans. Microwave Theory Tech.*, **MTT-12**, 289 (1964).
- [960] K. Kurokawa, "Power Waves and the Scattering Matrix," *IEEE Trans. Microwave Theory Tech.*, **MTT-13**, 194 (1965).
- [961] R. F. Bauer and P. Penfield, Jr., "De-Embedding and Unterminating," *IEEE Trans. Microwave Theory Tech.*, **MTT-22**, 282 (1974).
- [962] G. E. Bodway, "Two-Port Power Flow Analysis Using Generalized Scattering Parameters," *Microwave J.*, **10**, 61, May 1967.
- [963] J. K. Hunton, "Analysis of Microwave Measurement Techniques by Means of Signal Flow Graphs," *IEEE Trans. Microwave Theory Tech.*, **MTT-8**, 206 (1960).
- [964] N. Kuhn, "Simplified Signal Flow Graph Analysis," *Microwave J.*, Nov. 1963, p.61.
- [965] F. Weinert, "Scattering Parameters Speed Design of High-Frequency Transistor Circuits," *Electronics*, September 5, 1966, p.78.
- [966] W. H. Froehner, "Quick Amplifier Design with Scattering Parameters," *Electronics*, **40**, no.21, p.100, October 16, 1967.
- [967] J. M. Rollett, "Stability and Power-Gain Invariants of Linear Twoports," *IRE Trans. Circuit Theory*, **CT-9**, 29 (1962).
- [968] D. Woods, "Reappraisal of the Unconditional Stability Criteria for Active 2-Port Networks in terms of S Parameters," *IEEE Trans. Circ. Syst.*, **CAS-23**, 73 (1976).
- [969] R. P. Meys, "Review and Discussion of Stability Criteria for Linear 2-Ports," *IEEE Trans. Circ. Syst.*, **CS-37**, 1450 (1990).
- [970] M. L. Edwards and J. H. Sinsky, "A New Criterion for Linear 2-Port Stability Using a Single Geometrically Derived Parameter," *IEEE Trans. Microwave Theory Tech.*, **MTT-40**, 2303 (1992).

- [971] R. W. Anderson, "S-Parameter Design for Faster, More Accurate Network Design," Hewlett Packard, Test & Measurement Application Note 95-1, available from the web site [1323].
- [972] Hewlett Packard Application Note 1287-1, "Understanding the Fundamental Principles of Vector Network Analysis," available from the web site [1323].
- [973] H. Rothe and W. Dahlke, "Theory of Noisy Fourpoles," *Proc. IRE*, **44**, 811 (1956). Reprinted in [983].
- [974] R. W. Beatty, "Insertion Loss Concepts," *Proc. IEEE*, **52**, 663 (1964).
- [975] D. M. Kerns, "Definitions of  $V$ ,  $I$ ,  $Z$ ,  $Y$ ,  $a$ ,  $b$ ,  $G_{app}$ , and  $S$ ," *Proc. IEEE*, **55**, 892 (1967).
- [976] P. Penfield, Jr., "Wave Representation of Amplifier Noise," *IRE Trans. Circuit Theory*, **CT-9**, 84 (1962). Reprinted in [983].
- [977] I. A. Harris, "Dependence of Receiver Noise-Temperature Measurement on Source Impedance," *Electr. Lett.*, **2**, 130 (1966).
- [978] H. Fukui, "Available Power Gain, Noise Figure, and Noise Measure of Two-Ports and their Graphical Representations," *IEEE Trans. Circuit Theory*, **CT-13**, 137 (1966).
- [979] R. S. Tucker, "Low-Noise Design of Microwave Transistor Amplifiers," *IEEE Trans. Microwave Theory Tech.*, **MTT-23**, 697 (1975).
- [980] R. P. Meys, "A Wave Approach to the Noise Properties of Linear Microwave Devices," *IEEE Trans. Microwave Theory Tech.*, **MTT-26**, 34 (1978).
- [981] S. Withington, "Scattered Noise Waves in Microwave and mm-Wave Networks," *Microwave J.*, **32**, 169, June 1989.
- [982] C. Bowick, *RF Circuit Design*, Newness, Boston, 1980.
- [983] H. Fukui, ed., *Low-Noise Microwave Transistors & Amplifiers*, IEEE Press, Piscataway, NJ 1981.
- [984] T. T. Ha, *Solid-State Microwave Amplifier Design*, Wiley, New York, 1981.
- [985] P. L. Abrie, *The Design of Impedance-Matching Networks for Radio-Frequency and Microwave Amplifiers*, Artech House, Dedham, MA, 1985.
- [986] S. Y. Liao, *Microwave Circuit Analysis and Amplifier Design*, Prentice Hall, Upper Saddle River, NJ, 1987.
- [987] G. D. Vendelin, A. M. Pavio, and U. L. Rohde, *Microwave Circuit Design Using Linear and Nonlinear Techniques*, Wiley, New York, 1990.
- [988] M. W. Medley, *Microwaves and RF Circuits*, Artech House, Norwood, MA, 1992.
- [989] G. Gonzalez, *Microwave Transistor Amplifiers*, 2nd ed., Prentice Hall, Upper Saddle River, NJ, 1997.
- [990] D. M. Pozar, *Microwave Engineering*, 2nd ed., Wiley, New York, 1998.
- [991] "High-Frequency Transistor Primer," Parts I-IV, in Ref. [1325].
- [992] "Maximizing Accuracy in Noise Figure Measurements," Hewlett-Packard Product Note 85719A-1, (1992).
- [993] D. Vondran, "Noise Figure Measurement: Corrections Related to Match and Gain," *Microwave J.*, **42**, 22, March 1999.
- [994] D. Boyd, "Calculate the Uncertainty of NF Measurements," *Microwave J.*, **42**, 93, October 1999.
- [995] "Noise Figure Measurement Accuracy—The Y-Factor Method," Agilent Technologies, Appl. Note 57-2, (2001).

### Transmitting, Receiving, and Scattering Properties of Antennas

- [996] G. Sinclair, "The Transmission and Reception of Elliptically Polarized Waves," *Proc. IRE*, **38**, 148 (1950).
- [997] C. T. Tai, "On the Definition of the Effective Aperture of Antennas," *IEEE Trans. Antennas Propagat.*, **AP-9**, 224 (1961).
- [998] H. T. Friis, "A Note on a Simple Transmission Formula," *Proc. IRE*, **34**, 254 (1946).
- [999] H. T. Friis, "Introduction to Radio and Radio Antennas," *IEEE Spectrum*, **8**, 55, April 1971.
- [1000] R. T. Bush, "The Antenna Formula: An Application of Single-Slit Diffraction Theory," *Am. J. Phys.*, **55**, 350 (1987).
- [1001] D. C. Hogg, "Fun with Friis Free-Space Transmission Formula," *IEEE Antennas and Propagation Mag.*, **35**, 33, August 1993.

- [1002] R. E. Collin, "The Receiving Antenna," in Ref. [9], part 1.
- [1003] M. R. Andrews, P. P. Mitra, and R. deCarvalho, "Tripling the Capacity of Wireless Communications Using Electromagnetic Polarization," *Nature*, **409**, 316 (2001). See also, H. L. Bertoni, "Talk Is Cheap in the City," *Nature*, **409**, 291 (2001).
- [1004] C. G. Montgomery, R. H. Dicke, and E. M. Purcell, eds., *Principles of Microwave Circuits*, McGraw-Hill, New York, 1947.
- [1005] A. F. Stevenson, "Relations Between the Transmitting and Receiving Properties of Antennas," *Quart. Appl. Math.*, **5**, 369 (1948).
- [1006] S. H. Dike and D. D. King, "The Absorption Gain and Back-Scattering Cross Section of the Cylindrical Antenna," *Proc. IRE*, **40**, 853 (1952).
- [1007] Y-Y. Hu, "Back-Scattering Cross Section of a Center-Loaded Cylindrical Antenna," *IRE Trans. Antennas Propagat.*, **AP-6**, 140 (1958).
- [1008] J. Brown, "A Generalized Form of the Aerial Reciprocity Theorem," *Proc. IEE*, **103C**, 472 (1958).
- [1009] D. M. Kerns and E. S. Dayhoff, "Theory of Diffraction in Microwave Interferometry," *J. Res. Nat. Bur. Stand.*, **64B**, 1 (1960).
- [1010] D. Midgley, "A Theory of Receiving Aerials Applied to the Reradiation of an Electromagnetic Horn," *Proc. IEE*, **108B**, 645 (1961).
- [1011] R. F. Harrington, "Theory of Loaded Scatterers," *Proc. IEE*, **111**, 617 (1964).
- [1012] R. J. Garbacz, "Modal Expansions for Resonance Scattering Phenomena," *Proc. IEEE*, **53**, 856 (1965).
- [1013] J. K. Schindler, R. B. Mack, and P. Blacksmith, Jr., "The Control of Electromagnetic Scattering by Impedance Loading," *Proc. IEEE*, **53**, 993 (1965).
- [1014] W. H. Kahn and H. Kurss, "Minimum Scattering Antennas," *IEEE Trans. Antennas Propagat.*, **AP-13**, 671 (1965).
- [1015] R. B. Green, "Scattering from Conjugate-Matched Antennas," *IEEE Trans. Antennas Propagat.*, **AP-14**, 17 (1968).
- [1016] A. T. De Hoop, "A Reciprocity Relation Between the Transmitting and the Receiving Properties of an Antenna," *Appl. Sci. Res.*, **19**, 90 (1968).
- [1017] A. C. Gately, D. J. R. Stock, and B. R-S Cheo, "A Network Description for Antenna Problems," *Proc. IEEE*, **56**, 1181 (1968).
- [1018] W. Wasylkiwsky and W. H. Kahn, "Theory of Mutual Coupling Among Minimum-Scattering Antennas," *IEEE Trans. Antennas Propagat.*, **AP-18**, 204 (1970).
- [1019] W. Wasylkiwsky and W. H. Kahn, "Scattering Properties and Mutual Coupling of Antennas with Prescribed Radiation Pattern," *IEEE Trans. Antennas Propagat.*, **AP-18**, 741 (1970).
- [1020] A. T. De Hoop and G. De Jong, "Power Reciprocity in Antenna Theory," *Proc. IEE*, **121**, 1051 (1974).
- [1021] A. T. De Hoop, "The N-Port Receiving Antenna and its Equivalent Electrical Network," *Philips Res. Reports*, **30**, 302 (1975).
- [1022] D. M. Kerns, *Plane-Wave Scattering Matrix Theory of Antennas and Antenna-Antenna Interactions*, Nat. Bur. Stand. Monograph 162, Washington 1981. See also, *J. Res. Nat. Bur. Stand.*, **80B**, 5 (1975).
- [1023] P. G. Rogers, "Application of the Minimum Scattering Antenna Theory to Mismatched Antennas," *IEEE Trans. Antennas Propagat.*, **AP-34**, 1223 (1986).
- [1024] R. M. Bevensee, "A Lower Bound to the Broad-Band Power Scattered from an Electrically Linear Antenna with a General Lumped Load," *IEEE Trans. Antennas Propagat.*, **AP-37**, 555 (1989).
- [1025] R. C. Hansen, "Relationships Between Antennas as Scatterers and as Radiators," *Proc. IEEE*, **77**, 659 (1989).
- [1026] J. Van Bladel, "On the Equivalent Circuit of a Receiving Antenna," *IEEE Antennas and Propagation Mag.*, **44**, no.1, p.164, February 2002.
- [1027] A. W. Love, "Comment: On the Equivalent Circuit of Receiving Antenna," *IEEE Antennas and Propagation Mag.*, **44**, no.5, p.124, October 2002.
- [1028] R. C. Johnson, "Absorption of Energy Incident Upon a Receiving Antenna," *Microwave J.*, **15**, no.12, p.35 December 1972.
- [1029] R. E. Collin, "Limitations of The Thévenin and Norton Equivalent Circuits for a Receiving Antenna," *IEEE Antennas and Propagation Mag.*, **45**, no.2, p.119, April 2003. See also, *ibid.*, no.4, p.99, August 2003.

- [1030] A. W. Love, "Comment on 'Limitations of The Thévenin and Norton Equivalent Circuits for a Receiving Antenna,'" *IEEE Antennas and Propagation Mag.*, **45**, no.4, p.98, August 2003.
- [1031] J. Bach Andersen and R. G. Vaughan, "Transmitting, Receiving, and Scattering Properties of Antennas," *IEEE Antennas and Propagation Mag.*, **45**, no.4, p.93, August 2003.

## Noise Temperature

- [1032] J. B. Johnson, "Thermal Agitation of Electricity in Conductors," *Phys. Rev.*, **32**, 97 (1928).
- [1033] H. Nyquist, "Thermal Agitation of Electric Charge in Conductors," *Phys. Rev.*, **32**, 110 (1928).
- [1034] W. R. Bennett, *Electrical Noise*, McGraw-Hill, New York, 1960.
- [1035] B. M. Oliver, "Thermal and Quantum Noise," *Proc. IEEE*, **53**, 436 (1965).
- [1036] J. B. Johnson, "Electronic Noise: The First Two Decades," *IEEE Spectrum*, **8**, 42, Feb. 1971.
- [1037] H. T. Friis, "Noise Figures of Radio Receivers," *Proc. IRE*, **32**, 419 (1944). Reprinted in [983].
- [1038] J. R. Pierce, "Physical Sources of Noise," *Proc. IRE*, **44**, 601 (1956).
- [1039] A. E. Siegman, "Thermal Noise in Microwave Systems, Part 1," *Microwave J.*, **4**, p.81, March 1961, see also, "Part 2," *ibid.*, p.66, April 1961, and "Part 3," *ibid.*, p.93, May 1961.
- [1040] J. S. Wells, W. C. Daywitt, and C. K. S. Miller, "Measurement of Effective Temperature of Microwave Noise Sources," *IEEE Trans. Instr. Meas.*, **IM-13**, 17 (1964).
- [1041] B. L. Seidel and C. T. Stelzried, "A Radiometric Method for Measuring the Insertion Loss of Radome Materials," *IEEE Trans. Microwave Theory Tech.*, **MTT-16**, 625 (1968).
- [1042] R. Pettai, *Noise in Receiving Systems*, Wiley, New York, 1984.
- [1043] J. R. Lewis, "Factors Involved in Determining the Performance of Digital Satellite Links," *Radio and Electronic Engineer*, **54**, 192 (1984).
- [1044] E. Fthenakis, *Manual of Satellite Communications*, McGraw-Hill, New York, 1984.
- [1045] M. Richaria, *Satellite Communications Systems*, McGraw-Hill, New York, 1995.
- [1046] T. Pratt and C. W. Bostian, *Satellite Communications*, Wiley, New York, 1986.
- [1047] L. W. Couch, *Digital and Analog Communication Systems*, 4/e, Macmillan, New York, 1993.
- [1048] K. Rohlfs, *Tools of Radio Astronomy*, Springer Verlag, New York, 1986.
- [1049] S. C. Bundy, "Noise Figure, Antenna Temperature and Sensitivity Level for Wireless Communication Receivers," *Microwave J.*, March 1998, p.108.
- [1050] S. C. Bundy, "Sensitivity Improvements and Associated Benefits of Tower-Top Amplifiers," *Microwave J.*, April 1998, p.88.

## Beamwidth, Directivity, and Superdirective

- [1051] R. S. Elliott, "Beamwidth and Directivity of Large Scanning Arrays," *Microwave J.*, Dec. 1963, p.53, and Jan. 1964, p.74.
- [1052] R. J. Stegen, "The Gain-Beamwidth Product of an Antenna," *IEEE Trans. Antennas Propagat.*, **AP-12**, 505 (1964).
- [1053] W. W. Hansen and J. R. Woodyard, "A New Principle in Directional Antenna Design," *Proc. IRE*, **26**, 333 (1938).
- [1054] R. C. Hansen, "Fundamental Limitations in Antennas," *Proc. IEEE*, **69**, 170 (1981), and "Some New Calculations on Antenna Superdirective," *ibid.*, p.1365.
- [1055] R. C. Hansen, "Superconducting Antennas," *IEEE Trans. Aerosp. Electr. Syst.*, **AES-26**, 345 (1990).
- [1056] R. P. Haviland, "Supergain Antennas: Possibilities and Problems," *IEEE Antennas and Propagation Mag.*, **37**, no.4, 13, August 1995.
- [1057] R. L. Pritchard, "Maximum Directivity Index of a Linear Point Array," *J. Acoust. Soc. Am.*, **26**, 1034 (1954).
- [1058] C. T. Tai, "The Optimum Directivity of Uniformly Spaced Broadside Arrays of Dipoles," *IEEE Trans. Antennas Propagat.*, **AP-12**, 447 (1964).
- [1059] Y. T. Lo, S. W. Lee, and Q. H. Lee, "Optimization of Directivity and Signal-to-Noise Ratio of an Arbitrary Antenna Array," *Proc. IEEE*, **54**, 1033 (1966).

- [1060] N. Yaru, "A Note on Super-Gain Antenna Arrays," *Proc. IRE*, **39**, 1081 (1951).
- [1061] D. R. Rhodes, "The Optimum Line Source for the Best Mean-Square Approximation to a Given Radiation Pattern," *IEEE Trans. Antennas Propagat.*, **AP-11**, 440 (1963).
- [1062] D. R. Rhodes, "On an Optimum Line Source for Maximum Directivity," *IEEE Trans. Antennas Propagat.*, **AP-19**, 485 (1971).
- [1063] D. K. Cheng, "Optimization Techniques for Antenna Arrays," *Proc. IEEE*, **59**, 1664 (1971).
- [1064] W. L. Stutzman, "Estimating Directivity and Gain of Antennas," *IEEE Antennas and Propagation Mag.*, **40**, no.4, 7, August 1998.

### Array Design Methods

- [1065] H. Bach and J. E. Hansen, "Uniformly Spaced Arrays," in Ref. [9], part 1.
- [1066] A. C. Schell and A. Ishimaru, "Antenna Pattern Synthesis," in Ref. [9], part 1.
- [1067] S. A. Schelkunoff, "A Mathematical Theory of Linear Arrays," *Bell Syst. Tech. J.*, **22**, 80 (1943).
- [1068] C. L. Dolph, "A Current Distribution for Broadside Arrays Which Optimizes the Relationship Between Beam Width and Side-Lobe Level," *Proc. IRE*, **34**, 335 (1946).
- [1069] H. J. Riblet, Discussion of Dolph's paper, *Proc. IRE*, **35**, 489 (1947).
- [1070] R. L. Pritchard, "Optimum Directivity Patterns for Linear Point Arrays," *J. Acoust. Soc. Am.*, **25**, 879 (1953).
- [1071] R. H. DuHamel, "Optimum Patterns for Endfire Arrays," *Proc. IRE*, **41**, 652 (1953).
- [1072] D. Barbiere, "A Method for Calculating the Current Distribution of Tschebyscheff Arrays," *Proc. IRE*, **40**, 78 (1952).
- [1073] R. J. Stegen, "Excitation Coefficients and Beamwidths of Tschebyscheff Arrays," *Proc. IRE*, **41**, 1671 (1953).
- [1074] C. J. Van der Maas, "A simplified Calculation for Dolph-Tchebyscheff Arrays," *J. Appl. Phys.*, **25**, 121 (1954).
- [1075] A. D. Bresler, "A New Algorithm for Calculating the Current Distributions of Dolph-Chebyshev Arrays," *IEEE Trans. Antennas Propagat.*, **AP-28**, 951 (1980).
- [1076] A. Zielinski, "Matrix Formulation of Dolph-Chebyshev Beamforming," *Pro. IEEE*, **74**, 1799 (1986), and *ibid.*, **77**, 934 (1989).
- [1077] P. Simon, Private Communication, 2003. I would like thank Dr. Simon for permitting me to include his function `chebaray` in this book's MATLAB toolbox.
- [1078] C. J. Drane, "Dolph-Chebyshev Excitation Coefficient Approximation," *IEEE Trans. Antennas Propagat.*, **AP-12**, 781 (1964).
- [1079] H. D. Helms, "Nonrecursive Digital Filters: Design Methods for Achieving Specifications on Frequency Response," *IEEE Trans. Audio Electroacoust.*, **AU-16**, 336 (1968).
- [1080] H. D. Helms, "Digital Filters with Equiripple or Minimax Response," *IEEE Trans. Audio Electroacoust.*, **AU-19**, 87 (1971).
- [1081] M. A. Burns, S. R. Laxpati, and J. P. Shelton, Jr., "A Comparative Study of Linear Array Synthesis Using a Personal Computer," *IEEE Trans. Antennas Propagat.*, **AP-32**, 884 (1984).
- [1082] F. J. Harris, "On the Use of Windows for Harmonic Analysis with the Discrete Fourier Transform," *Proc. IEEE*, **66**, 51 (1978).
- [1083] N. C. Ceckinli and D. Yavuz, "Some Novel Windows and a Concise Tutorial Comparison of Window Families," *IEEE Trans. Acoust., Speech, Signal Process.*, **ASSP-26**, 501 (1978).
- [1084] A. H. Nuttal, "Some Windows with Very Good Sidelobe Behavior," *IEEE Trans. Acoust., Speech, Signal Process.*, **ASSP-29**, 84 (1981).
- [1085] T. T. Taylor, "One Parameter Family of Line Sources Producing  $\sin \pi u / \pi u$  Patterns," Technical Memorandum no.324, Hughes Aircraft Company, Sept. 1953.
- [1086] T. T. Taylor, "Design of Line-Source Antennas for Narrow Beamwidth and Low Side Lobes," *IRE Trans. Antennas Propagat.*, **AP-3**, 16 (1955).
- [1087] R. W. Bickmore and R. J. Spellmire, "A Two-Parameter Family of Line Sources," Technical Memorandum no.595, Hughes Aircraft Company, Oct. 1956.

- [1088] R. S. Elliott, "Beamwidth and Directivity of Large Scanning Arrays," *Microwave J.*, **6**, 53, December 1963; and *ibid.*, **7**, 74, January 1964.
- [1089] J. F. Kaiser, "Nonrecursive Digital Filter Design Using the  $I_0$ -Sinh Window Function," *Proc. 1974 IEEE Int. Symp. on Circuits and Systems*, p.20, (1974), and reprinted in *Selected Papers in Digital Signal Processing, II*, edited by the Digital Signal Processing Committee and IEEE ASSP, IEEE Press, New York, 1976, p.123.
- [1090] J. F. Kaiser and R. W. Schafer, "On the Use of the  $I_0$ -Sinh Window for Spectrum Analysis," *IEEE Trans. Acoust., Speech, Signal Process.*, **ASSP-28**, 105 (1980).
- [1091] D. R. Rhodes, "The Optimum Line Source for the Best Mean-Square Approximation to a Given Radiation Pattern," *IEEE Trans. Antennas Propagat.*, **AP-11**, 440 (1963).
- [1092] A. Papoulis and M. S. Bertram, "Digital Filtering and Prolate Functions," *IEEE Trans. Circuit Th.*, **CT-19**, 674 (1972).
- [1093] D. Slepian, "Prolate Spheroidal Wave Functions, Fourier Analysis and Uncertainty—V: The Discrete Case," *Bell Syst. Tech. J.*, **57**, 1371 (1978).
- [1094] S. Prasad, "On an Index for Array Optimization and the Discrete Prolate Spheroidal Functions," *IEEE Trans. Antennas Propagat.*, **AP-30**, 1021 (1982).
- [1095] D. Slepian, "Some Comments on Fourier Analysis, Uncertainty and Modeling," *SIAM Rev.*, **25**, 379 (1983).
- [1096] J. D. Mathews, J. K. Breakall, and G. K. Karawas, "The Discrete Prolate Spheroidal Filter as a Digital Signal Processing Tool," *IEEE Trans. Acoust., Speech, Signal Process.*, **ASSP-33**, 1471 (1985).
- [1097] A. T. Walden, "Accurate Approximation of a 0th Order Discrete Prolate Spheroidal Sequence for Filtering and Data Tapering," *Sig. Process.*, **18**, 341 (1989).
- [1098] J. W. Adams, "A New Optimal Window," *IEEE Trans. Acoust., Speech, Signal Process.*, **39**, 1753 (1991).
- [1099] J. M. Varah, "The Prolate Matrix," *Lin. Alg. Appl.*, **187**, 269 (1993).
- [1100] D. B. Percival and A. T. Walden, *Spectral Analysis for Physical Applications*, Cambridge Univ. Press., Cambridge, 1993.
- [1101] T. Verma, S. Bilbao, and T. H. Y. Meng, "The Digital Prolate Spheroidal Window," *IEEE Int. Conf. Acoust., Speech, Signal Process.*, **ICASSP-96**, 1351 (1996).
- [1102] A. T. Villeneuve, "Taylor Patterns for Discrete Arrays," *IEEE Trans. Antennas Propagat.*, **AP-32**, 1089 (1984).
- [1103] J. Butler, "Multiple Beam Antennas," Internal Memo RF-3849, Jan. 1960, Sanders Associates, Nashua, N. H.
- [1104] J. P. Shelton and K. S. Kelleher, "Multiple Beams from Linear Arrays," *IEEE Trans. Antennas Propagat.*, **AP-9**, 154 (1961).
- [1105] J. L. Allen, "A Theoretical Limitation on the Formation of Lossless Multiple Beams in Linear Arrays," *IEEE Trans. Antennas Propagat.*, **AP-9**, 350 (1961).
- [1106] H. J. Moody, "The Systematic Design of the Butler Matrix," *IEEE Trans. Antennas Propagat.*, **AP-12**, 786 (1964).
- [1107] J. P. Shelton, "Fast Fourier Transform and Butler Matrices," *Proc. IEEE*, **56**, 350 (1968).
- [1108] W. H. Nester, "The Fast Fourier Transform and the Butler Matrix," *IEEE Trans. Antennas Propagat.*, **AP-16**, 360 (1968).
- [1109] R. J. Mailloux and H. L. Southall, "The Analogy Between the Butler Matrix and the Neural-Network Direction-Finding Array," *IEEE Antennas Propagat. Magazine*, **39**, no.6, 27 (1997).

### Diffraction Theory and Apertures

- [1110] Lord Rayleigh, "On the Passage of Waves through Apertures in Plane Screens and Allied Topics," *Phil. Mag.*, **43**, 259 (1897), and *Theory of Sound*, vol. 2, Dover Publ., New York, 1945.
- [1111] A. Sommerfeld, *Optics*, Academic Press, New York, 1954.
- [1112] S. A. Schelkunoff, "Some Equivalent Theorems of Electromagnetics and their Application to radiation Problems," *Bell Sys. Tech. J.*, **15**, 92 (1936).
- [1113] J. A. Stratton and L. J. Chu, "Diffraction Theory of Electromagnetic Waves," *Phys. Rev.*, **56**, 99 (1939).

- [1114] S. A. Schelkunoff, "On Diffraction and Radiation of Electromagnetic Waves," *Phys. rev.*, **56**, 308 (1939).
- [1115] K-M. Chen, "A Mathematical Formulation of the Equivalence Principle," *IEEE Trans. Antennas Propagat.*, **AP-37**, 1576 (1989).
- [1116] J. A. Stratton, *Electromagnetic Theory*, McGraw-Hill, New York, 1941.
- [1117] S. Silver, "Microwave Aperture Antennas and Diffraction Theory," *J. Opt. Soc. Am.*, **52**, 131 (1962).
- [1118] S. Silver, "Radiation from Current Distributions," "Wavefronts and Rays," "Scattering and Diffraction," in Ref. [21].
- [1119] F. Kottler, "Electromagnetische Theorie der Beugung an schwarzen Schirmen," *Ann. der Physik*, **71**, 457 (1923).
- [1120] F. Kottler, "Diffraction at a Black Screen," in E. Wolf, ed., *Progress in Optics*, vol. VI, North-Holland Publishing Co., Amsterdam, 1971.
- [1121] W. Franz, "Zur Formulierung des Huygenschen Prinzips," *Zeit. Naturforschung*, **3a**, 500 (1948).
- [1122] J. S. Avestas, "Diffraction by a Black Screen," *J. Opt. Soc. Am.*, **65**, 155 (1975).
- [1123] C. T. Tai, "Kirchhoff Theory: Scalar, Vector, or Dyadic?," *IEEE Trans. Antennas Propagat.*, **20**, 114 (1972).
- [1124] A. Ishimaru, *Electromagnetic Wave Propagation, Radiation, and Scattering*, Prentice Hall, Upper Saddle River, NJ, 1991.
- [1125] B. B. Baker and E. T. Copson, *The Mathematical Theory of Huygens' Principle*, 2nd ed., Clarendon Press, Oxford, 1950.
- [1126] C. J. Bouwkamp, "Diffraction Theory," *Repts. Progr. Phys.*, **17**, 35 (1954).
- [1127] H. G. Kraus, "Huygens-Fresnel-Kirchhoff Wave-Front Diffraction Formulation," *J. Opt. Soc. Am.*, **A-6**, 1196 (1989) and **A-7**, 47 (1990) and **A-9**, 1132 (1992).
- [1128] S. Ganci, "An Experiment on the Physical reality of Edge-Diffracted Waves," *Am. J. Phys.*, **57**, 370 (1989).
- [1129] T. W. Mayes and B. F. Melton, "Fraunhofer Diffraction of Visible Light by a Narrow Slit," *Am. J. Phys.*, **62**, 397 (1994).
- [1130] J. Durnin, "Exact Solutions for Nondiffracting Beams. I. The Scalar Theory," *J. Opt. Soc. Am.*, **A-4**, 651 (1987).
- [1131] J. Durnin, "Diffraction-Free Beams," *Phys. rev. Lett.*, **58**, 1499 (1987).
- [1132] J. Boersma, "Computation of Fresnel Integrals," *Math. Comp.*, **14**, 380 (1960).
- [1133] ITU Recommendation, "Propagation by Diffraction," ITU-R P.526-5, (1997). Available from [1315].

### Geometrical Theory of Diffraction

- [1134] J. B. Keller, "Diffraction by an Aperture," *J. Appl. Phys.*, **28**, 426 (1957).
- [1135] J. B. Keller, R. M> Lewis, and B. D. Seckler, "Diffraction by an Aperture. II," *J. Appl. Phys.*, **28**, 570 (1957).
- [1136] J. B. Keller, "Geometrical Theory of Diffraction," *J. Opt. Soc. Am.*, **52**, 116 (1962).
- [1137] R. G. Kouyoumjian and P. H. Pathak, "A Uniform Geometrical Theory of Diffraction for an Edge in a Perfectly Conducting Surface," *Proc. IEEE*, **62**, 1448 (1974).
- [1138] R. G. Kouyoumjian, "The Geometrical Theory of Diffraction and Its Application," in Ref. [1224].
- [1139] G. L. James, *Geometrical Theory of Diffraction for Electromagnetic Waves*, P. Peregrinus, Ltd., England, 1976.
- [1140] V. A. Borovikov and B. Y. Kinber, *Geometrical Theory of Diffraction*, IEE Press, London, 1994.
- [1141] J. Deygout, "Multiple Knife-Edge Diffraction of Microwaves," *IEEE Trans. Antennas Propagat.*, **AP-14**, 480 (1966).
- [1142] K. Furutsu, "A Systematic Theory of Wave Propagation Over Irregular Terrain," *Radio Sci.*, **17**, 1037 (1982).
- [1143] L. E. Vogler, "An Attenuation Function for Multiple Knife-Edge Diffraction," *Radio Sci.*, **17**, 1541 (1982).

- [1144] R. J. Luebbers, "Finite Conductivity Uniform GTD Versus Knife-Edge Diffraction in Prediction of Propagation Path Loss," *IEEE Trans. Antennas Propagat.*, **AP-32**, 70 (1984).
- [1145] C. L. Giovanelli, "An Analysis of Simplified Solutions for Multiple Knife-Edge Diffraction," *IEEE Trans. Antennas Propagat.*, **AP-32**, 297 (1984).
- [1146] J. Walfisch and H. L. Bertoni, "A Theoretical Model of UHF Propagation in Urban Environments," *IEEE Trans. Antennas Propagat.*, **AP-36**, 1788 (1988).
- [1147] L. R. Maciel, H. L. Bertoni, and H. H. Xia, "Unified Approach to Prediction of Propagation Over Buildings for All Ranges of Base Station Antenna Height," *IEEE Trans. Vehic. Tech.*, **VT-42**, 41 (1993).

### Plane-Wave Spectrum and Fourier Optics

- [1148] D. S. Jones, *The Theory of Electromagnetism*, Macmillan, New York, 1964.
- [1149] P. Clemmow, *The Plane Wave Spectrum Representation of Electromagnetic Fields*, Pergamon Press, Oxford, 1966.
- [1150] A. Papoulis, *Systems and Trasnforms with Applications in Optics*, McGraw-Hill, New York, 1968.
- [1151] B. E. A. Saleh and M. C. Teich, *Fundamentals of Photonics*, Wiley, New York, 1991.
- [1152] C. Scott, *Introduction to Optics and Optical Imaging*, IEEE Press, New York, 1998.
- [1153] T. B. Hansen and A. D. Yaghjian, *Plane-Wave Theory of Time-Domain Fields*, IEEE Press, New York, 1999.
- [1154] H. M. Ozaktas, Z. Zalevsky, and M. A. Kutay, *The Fractional Fourier Transform*, Wiley, New York, 2001.
- [1155] M. Mansuripur, *Classical Optics and Its Applications*, Cambridge Univ. Press, Cambridge, UK, 2002.
- [1156] J. W. Goodman, *Introduction to Fourier Optics*, 3d ed., Roberts & Co., Englewood, CO, 2005.
- [1157] H. G. Booker and P. C. Clemmow, "The Concept of an Angular Spectrum of Plane Waves and its Relation to that of Polar Diagram and Aperture Distribution," *Proc. IEEE*, **97**, 11 (1950).
- [1158] A. Papoulis, "Ambiguity Function in Fourier Optics," *J. Opt. Soc. Am.*, **64**, 779 (1974).
- [1159] P. P. Banerjee, "On a Simple Derivation of the Fresnel Diffraction Formula and a Transfer Function Approach to Wave Propagation," *Am. J. Phys.*, **58**, 576 (1990).
- [1160] A. Papoulis, "Pulse Compression, Fiber Communications, and Diffraction: A Unified Approach," *J. Opt. Soc. Am.*, **A-11**, 3 (1994).
- [1161] M. Mansuripur, "Fourier Optics, Part 1," *Opt. & Photon. News*, **11**, p.53, May 2000, and "Fourier Optics, Part 2," *ibid.*, p.44, June 2000.

### Reflector Antennas and Feeds

- [1162] L. J. Chu, "Calculation of the Radiation Properties of Hollow Pipes and Horns," *J. Appl. Phys.*, **11**, 603 (1940).
- [1163] J. R. Risser, "Waveguide and Horn Feeds," in Ref. [21].
- [1164] A. W. Love, ed., *Electromagnetic Horn Antennas*, IEEE Press, New York, 1976.
- [1165] P. J. B. Clarricoats and A. D. Olver, *Corrugated Horns for Microwave Antennas*, IEE Electromagnetic Waves Series 18, P. Peregrinus, Ltd., London, 1984.
- [1166] S. Silver, "Aperture Illumination and Antenna Patterns," "Pencil-Beam and Simple Fanned-Beam Antennas," in Ref. [21].
- [1167] R. E. Collin, "Radiation from Apertures," in Ref. [9], part 1.
- [1168] A. D. Yaghjian, "Equivalence of Surface Current and Aperture Field Integrations for Reflector Antennas," *IEEE Trans. Antennas Propagat.*, **AP-23**, 1355 (1984).
- [1169] W. V. T. Rusch and P. D. Potter, *Analysis of Reflector Antennas*, Academic Press, New York, 1970.
- [1170] A. W. Love, ed., *Reflector Antennas*, IEEE Press, New York, 1978.
- [1171] P. J. Wood, *Reflector Antenna Analysis and Design*, Peter Peregrinus Ltd., London, 1986.
- [1172] P. J. B. Clarricoats and G. T. Poulton, "High-Efficiency Microwave Reflector Antennas—A Review," *Proc. IEEE*, **65**, 1470 (1977).

- [1173] W. V. T. Rusch, "Current State of the Reflector Antenna Art—Entering the 1990's," *Proc. IEEE*, **80**, 113 (1992).
- [1174] R. C. Johnson, *Designer Notes for Microwave Antennas*, Artech House, Norwood, MA, 1991.
- [1175] M. K. Komen, "Use Simple Equations to Calculate Beamwidth," *Microwaves*, Dec. 1981, p. 61.
- [1176] A. W. Love, "Some Highlights in Reflector Antenna Development," *Radio Sci.*, **11**, 671 (1976). Reprinted in Ref. [1170].
- [1177] C. C. Cutler, "Parabolic-Antenna Design for Microwaves," *Proc. IRE*, **35**, 1284 (1947).
- [1178] E. M. T. Jones, "Paraboloid Reflector and Hyperboloid Lens Antennas," *IEEE Trans. Antennas Propagat.*, **AP-2**, 119 (1954).
- [1179] J. F. Kauffman, W. F. Croswell, and L. J. Jowers, "Analysis of the Radiation Patterns of Reflector Antennas," *IEEE Trans. Antennas Propagat.*, **AP-24**, 53 (1976).
- [1180] A. C. Ludwig, "The Definition of Cross Polarization," *IEEE Trans. Antennas Propagat.*, **AP-21**, 116 (1973). Reprinted in Ref. [1170].
- [1181] P. W. Hannan, "Microwave Antennas Derived from the Cassegrain Telescope," *IEEE Trans. Antennas Propagat.*, **AP-9**, 136 (1961). Reprinted in Ref. [1170]

### Microstrip Antennas

- [1182] K. R. Carver and J. W. Mink, "Microstrip Antenna Technology," *IEEE Trans. Antennas Propagat.*, **AP-29**, 2 (1981).
- [1183] A. G. Derneryd, "Linearly Polarized Microstrip Antennas," *IEEE Trans. Antennas Propagat.*, **AP-24**, 846 (1976).
- [1184] P. Hammer, D. Van Bouchaute, D. Verschraeven, and A. Van de Capelle, "A Model for Calculating the Radiation Field of Microstrip Antennas," *IEEE Trans. Antennas Propagat.*, **AP-27**, 267 (1979).
- [1185] Y. T. Lo, D. Solomon, and W. F. Richards, "Theory and Experiment on Microstrip Antennas," *IEEE Trans. Antennas Propagat.*, **AP-27**, 137 (1979).
- [1186] S. L. Chuang, L. Tsang, J. A. Kong, and W. C. Chew, "The Equivalence of the Electric and Magnetic Surface Current Approaches in Microstrip Antenna Studies," *IEEE Trans. Antennas Propagat.*, **AP-28**, 1980.
- [1187] I. J. Bahl and P. Bhartia, *Microstrip Antennas*, Artech House, Dedham, MA 1980.
- [1188] D. M. Pozar, "Microstrip Antennas," *Proc. IEEE*, **80**, 79 (1992).
- [1189] J. F. Zurcher and F. Gardiol, *Broadband Patch Antennas*, Artech House, Dedham, MA, 1995.

### Propagation Effects

- [1190] S. R. Saunders, *Antennas and Propagation for Wireless Communication Systems*, Wiley, Chichester, England, 1999.
- [1191] J. R. Wait, "The Ancient and Modern History of EM Ground-Wave Propagation," *IEEE Antennas and Propagation Mag.*, **40**, no. 5, 7, Oct. 1998.
- [1192] J. D. Parsons, *The Mobile Radio Propagation Channel*, Halsted Press, Wiley, New York, 1991.
- [1193] T. Maclean and Z. Wu, *Radiowave Propagation Over Ground*, Chapman & Hall, London, 1993.
- [1194] K. Siwiak, *Radiowave Propagation and Antennas for Personal Communications*, 2nd ed., Artech House, Norwood, MA, 1998.
- [1195] G. Collins, "Wireless Wave Propagation," *Microwave J.*, July 1998, p.78.
- [1196] H. T. Friis, A. B. Crawford, and D. C. Hogg, "A Reflection Theory for Propagation Beyond the Horizon," *Bell Syst. Tech. J.*, **36**, 627 (1957).
- [1197] J. V. Evans, "Satellite Systems for Personal Communications," *IEEE Antennas Propagat. Magazine*, **39**, no.3, 7, (1997).
- [1198] G. Feldhake, "Estimating the Attenuation Due to Combined Atmospheric Effects on Modern Earth-Space Paths," *IEEE Antennas Propagat. Magazine*, **39**, no.4, 26, (1997).
- [1199] T. S. Rappaport and S. Sandhu, "Radio-Wave Propagation for Emerging Wireless Personal Communication Systems," *IEEE Antennas Propagat. Magazine*, **36**, no.5, 14, (1994).

- [1200] R. K. Crane, "Fundamental Limitations Caused by RF Propagation," *Proc. IEEE*, **69**, 196 (1981).
- [1201] K. Bullington, "Radio Propagation for Vehicular Communications," *IEEE Trans. Vehic. Tech.*, **VT-26**, 295 (1977).
- [1202] K. Bullington, "Radio Propagation Fundamentals," *Bell Syst. Tech. J.*, **36**, 593 (1957).
- [1203] K. Bullington, "Radio Propagation at Frequencies Above 30 Megacycles," *Proc. I.R.E.*, **35**, 1122 (1947).
- [1204] K. A. Norton, "The Calculation of Ground-Wave Field Intensity Over a Finitely Conducting Spherical Earth," *Proc. I.R.E.*, **29**, 623 (1941).
- [1205] K. A. Norton, "The Propagation of Radio Waves Over the Surface of the Earth and in the Upper Atmosphere," part I, *Proc. I.R.E.*, **24**, 1367 (1936), and part II, *ibid*, **25**, 1203 (1937).
- [1206] K. A. Norton, "The Physical Reality of Space and Surface Waves in the Radiation Field of Radio Antennas," *Proc. I.R.E.*, **25**, 1192 (1937).

### Numerical Methods

- [1207] H. C. Pocklington, "Electrical Oscillations in Wires," *Cambridge Phil. Soc. Proc.*, **9**, 324 (1897).
- [1208] E. Hallén, "Theoretical Investigations into Transmitting and Receiving Qualities of Antennas," *Nova Acta Regiae Soc. Sci. Upsaliensis*, p.1, January 1938.
- [1209] K. K. Mei, "On the Integral Equations of Thin Wire Antennas," *IEEE Trans. Antennas Propagat.*, **AP-13**, 374 (1965).
- [1210] R.W.P. King and T.T. Wu, "Currents, Charges and Near Fields of Cylindrical Antennas," *Radio Sci. J. Res. NBS/USNC-USRI*, **69D**, 429 (1965).
- [1211] Y. S. Yeh and K. K. Mei, "Theory of Conical Equiangular-Spiral Antennas Part I-Numerical Technique," *IEEE Trans. Antennas Propagat.*, **AP-15**, 634 (1967).
- [1212] J. H. Richmond, "Digital Computer Solutions of the Rigorous Equations for Scattering Problems," *Proc. IEEE*, **53**, 796 (1965).
- [1213] R. F. Harrington, "Matrix Methods for Field Problems," *Proc. IEEE*, **55**, 136 (1967).
- [1214] R. F. Harrington, *Field Computation by Moment Methods*, Macmillan, New York, 1968.
- [1215] L. L. Tsai and C. E. Smith, "Moment Methods in Electromagnetics for Undergraduates," *IEEE Trans. Education*, **E-21**, 14 (1978).
- [1216] M. M. Ney, "Method of Moments as Applied to Electromagnetic Problems," *IEEE Trans. Microwave Theory Tech.*, **MTT-33**, 972 (1985).
- [1217] E. H. Newman, "Simple Examples of the Method of Moments in Electromagnetics," *IEEE Trans. Educ.*, **31**, 193 (1988).
- [1218] W. P. Wheless and L. T. Wurtz, "Introducing Undergraduates to the Moment Method," *IEEE Trans. Educ.*, **38**, 385 (1995).
- [1219] R. F. Harrington, "Origin and Development of the Method of Moments for Field Computation," *IEEE Antennas and Propagation Mag.*, **32**, 31, June 1990.
- [1220] L. L. Tsai, "A Numerical Solution for the Near and Far Fields of an Annular Ring of Magnetic Current," *IEEE Trans. Antennas Propagat.*, **AP-20**, 569 (1972).
- [1221] L. W. Pearson, "A separation of the logarithmic singularity in the exact kernel of the cylindrical antenna integral equation," *IEEE Trans. Antennas Propagat.*, **AP-23**, 256 (1975).
- [1222] C. M. Butler, "Evaluation of potential integral at singularity of exact kernel in thin-wire calculations," *IEEE Trans. Antennas Propagat.*, **AP-23**, 293 (1975).
- [1223] C. M. Butler and D. R. Wilton, "Analysis of Various Numerical Techniques Applied to Thin-Wire Scatterers," *IEEE Trans. Antennas Propagat.*, **AP-23**, 534 (1975).
- [1224] R. Mittra, Ed., *Numerical and Asymptotic Techniques in Electromagnetics*, Springer-Verlag, New York, 1975.
- [1225] E. K. Miller and F. J. Deadrick, "Some Computational Aspects of Thin-Wire Modeling," in Ref. [1224].
- [1226] D. R. Wilton and C. M. Butler, "Efficient Numerical Techniques for Solving Pocklington's Equation and their Relationships to Other Methods," *IEEE Trans. Antennas Propagat.*, **AP-24**, 83 (1976).
- [1227] G. J. Burke and A. J. Poggio, "Numerical Electromagnetics Code (NEC) — Part II: Program Description - Code," Lawrence Livermore Laboratory Report, UCID-18834, January 1981.

- [1228] G. A. Thiele, "Wire Antennas," in *Computer Techniques for Electromagnetics*, R. Mittra, Ed., Hemisphere Publishing Corp., Washington, 1987.
- [1229] H-M. Shen and T. T. Wu, "The universal current distribution near the end of a tubular antenna," *J. Math. Phys.*, **30**, 2721 (1989).
- [1230] R. W. P. King, "Electric Fields and Vector Potentials of Thin Cylindrical Antennas," *IEEE Trans. Antennas Propagat.*, **38**, 1456 (1990).
- [1231] D. H. Werner, P. L. Werner, and J. K. Breakall, "Some Computational Aspects of Pocklington's Electric Field Integral Equation for Thin Wires," *IEEE Trans. Antennas Propagat.*, **42**, 561 (1994).
- [1232] D. H. Werner, J. A. Huffman, and P. L. Werner, "Techniques for evaluating the uniform current vector potential at the isolated singularity of the cylindrical wire kernel," *IEEE Trans. Antennas Propagat.*, **42**, 1549 (1994).
- [1233] W. A. Davies, "Numerical Methods for Wire Structures," Tech. Report, EE Dept., Virginia Tech, 1995.
- [1234] J. A. Crow, "Quadrature of Integrands with a Logarithmic Singularity," *Math. Comp.*, **60**, 297 (1993).
- [1235] J. Ma, V. Rokhlin, and S. Wandzura, "Generalized gaussian quadrature rules for systems of arbitrary functions," *Siam J. Numer. Anal.*, **33**, 971 (1996).
- [1236] D. H. Werner, "A method of moments approach for the efficient and accurate modeling of moderately thick cylindrical wire antennas," *IEEE Trans. Antennas Propagat.*, **46**, 373 (1998).
- [1237] W. X. Wang, "The Exact Kernel for Cylindrical Antenna," *IEEE Trans. Antennas Propagat.*, **39**, 434 (1991).
- [1238] S-O. Park and C. A. Balanis, "Efficient Kernel Calculation of Cylindrical Antennas," *IEEE Trans. Antennas Propagat.*, **43**, 1328 (1995).
- [1239] R. R. DeLyser, "Using Mathcad in Electromagnetics Education," *IEEE Trans. Education*, **36**, 198 (1996).
- [1240] L. F. Canino, et al., "Numerical solution of the Helmholtz equation in 2D and 3D using a high-order Nyström discretization," *J. Comp. Phys.*, **146**, 627 (1998).
- [1241] G. Liu and S. Gedney, "High-order Nyström solution of the Volume-EFIE for TE-wave scattering," *Electromagnetics*, **21**, 1 (2001).
- [1242] A. F. Peterson, "Application of the Locally Corrected Nyström Method to the EFIE for the Linear Dipole Antenna," *IEEE Trans. Antennas Propagat.*, **52**, 603 (2004).
- [1243] A. F. Peterson and M. M. Bibby, "High-Order Numerical Solutions of the MFIE for the Linear Dipole," *IEEE Trans. Antennas Propagat.*, **52**, 2684 (2004).
- [1244] S. A. Schelkunoff, *Advanced Antenna Theory*, Wiley, New York, 1952.
- [1245] T. T. Wu and R. W. P. King, "Driving Point and Input Admittance of Linear Antennas," *J. Appl. Phys.*, **30**, 74 (1959).
- [1246] T. T. Wu, "Introduction to linear antennas," in [9], Part I.
- [1247] R. H. Duncan and F. A. Hinckley, "Cylindrical Antenna Theory," *J. Res. NBS, Radio Propagation*, **64D**, 569 (1960).
- [1248] D. S. Jones, "Note on the integral equation for a straight wire antenna," *IEE Proc.*, pt. H, **128**, 114 (1981).
- [1249] T. K. Sarkar, "A study of various methods for computing electromagnetic field utilizing thin wire integral equations," *Radio Sci.*, **18**, 29 (1983).
- [1250] N. Kalyanasundaram, "On the Distribution of Current on a Straight Wire Antenna," *IEE Proc.*, Pt. H, **132**, 407 (1985).
- [1251] B. P. Rynne, "The well-posedness of the integral equations for thin wire antennas," *IMA J. Appl. Math.*, **49**, 35 (1992).
- [1252] B. P. Rynne, "Convergence of Galerkin Method Solutions of the Integral Equation for Thin Wire Antennas," *Adv. Comput. Math.*, **12**, 251 (2000).
- [1253] G. Fikioris and T. T. Wu, "On the Application of Numerical Methods to Hallén's Equation," *IEEE Trans. Antennas Propagat.*, **49**, 383 (2001).
- [1254] R. W. P. King, G. J. Fikioris, and R. B. Mack, *Cylindrical Antennas and Arrays*, 2/e, Cambridge University Press, Cambridge, 2002.
- [1255] G. Fikioris, "The approximate integral equation for a cylindrical scatterer has no solution," *J. Electromagn. Waves Appl.*, **15**, 1153 (2001).

- [1256] G. Fikioris, J. Lionas, and C. G. Lioutas, "The Use of the Frill Generator in Thin-Wire Integral Equations," *IEEE Trans. Antennas Propagat.*, **51**, 1847 (2003).
- [1257] P. J. Papakanellos and C. N. Capsalis, "On the combination of the method of auxiliary sources with reaction matching for the analysis of thin cylindrical antennas," *Int. J. Numer. Model.: Electronoc Netw.*, **17**, 433 (2004).
- [1258] A. Heldring and J. M. Rius, "Efficient Full-Kernel Evaluation for Thin Wire Antennas," *Microwave Opt. Technol. Lett.*, **44**, 477 (2005).
- [1259] F. D. Quesada Pereira, et al., "Analysis of Thick-Wire Antennas Using an Novel and Simple Kernel Treatment," *Microwave Opt. Technol. Lett.*, **46**, 410 (2005).
- [1260] D. R. Wilton and N. J. Champagne, "Evaluation and Integration of the Thin Wire Kernel," *IEEE Trans. Antennas Propagat.*, **54**, 1200 (2006).
- [1261] A. Mohan and D. S. Weile, "Accurate Modeling of the Cylindrical Wire Kernel," *Microwave Opt. Technol. Lett.*, **48**, 740 (2006).
- [1262] M. C. van Beurden and A. G. Tijhuis, "Analysis and Regularization of the Thin-Wire Integral Equation with Reduced Kernel," *IEEE Trans. Antennas Propagat.*, **55**, 120 (2007).
- [1263] K. McDonald, "Currents in a Center-Fed Linear Dipole Antenna," available from: [www.hep.princeton.edu/~mcdonald/examples/transmitter.pdf](http://www.hep.princeton.edu/~mcdonald/examples/transmitter.pdf).
- [1264] A. F. Peterson, S. L. Ray, and R. Mittra, *Computational Methods for Electromagnetics*, IEEE Press, New York, 1998.
- [1265] D. B. Davidson, *Computational Electromagnetics for RF and Microwave Engineering*, Cambridge University Press, Cambridge, 2005.
- [1266] A. Bondeson, T. Rylander, and P. Ingelström, *Computational Electromagnetics*, Springer, New York, 2005.

### Elliptic Function Computations

- [1267] M. Abramowitz and I. A. Stegun, *Handbook of Mathematical Functions*, Dover Publications, New York, 1965.
- [1268] I. S. Gradshteyn and I. M. Ryzhik, *Table of Integrals, Series and Products*, 4/e, Academic Press, New York, 1965.
- [1269] D. F. Lawden, *Elliptic Functions and Applications*, Springer-Verlag, New York, 1989.
- [1270] P. F. Byrd and M. D. Friedman, *Handbook of Elliptic Integrals for Engineers and Scientists*, Springer-Verlag, New York, 1971.
- [1271] H. J. Orchard and A. N. Willson, "Elliptic Functions for Filter Design," *IEEE Trans. Circuits Syst., I*, **44**, 273 (1997).
- [1272] S. J. Orfanidis, "High-Order Digital Parametric Equalizer Design", *J. Audio Eng. Soc.*, **53**, 1026 (2005). MATLAB toolbox available from, <http://www.ece.rutgers.edu/~orfanidi/hpeq/>.
- [1273] <http://www.ece.rutgers.edu/~orfanidi/ece521/notes.pdf>, contains a short review of elliptic functions.
- [1274] <http://www.ece.rutgers.edu/~orfanidi/ece521/jacobi.pdf>, contains excerpts from Jacobi's original treatise, C. G. J. Jacobi, "Fundamenta Nova Theoriae Functionum Ellipticarum," reprinted in *C. G. J. Jacobi's Gesammelte Werke*, vol.1, C. W. Borchardt, ed., Verlag von G. Reimer, Berlin, 1881.
- [1275] <http://home.arcor.de/dfcgen/wpapers/elliptic/elliptic.html>, contains a comprehensive discussion of elliptic functions.

### Coupled Antennas, Mutual and Self Impedance

- [1276] L. Brillonin, "Origin of Radiation Resistance," *Radioélectricité*, **3** 147 (1922).
- [1277] A. A. Pistolkors, "Radiation Resistance of Beam Antennae," *Proc. IRE*, **17**, 562 (1929).
- [1278] R. Bechmann, "Calculation of Electric and Magnetic Field Strengths of any Oscillating Straight Conductors," *Proc. IRE*, **19**, 461 (1931).

- [1279] R. Bechmann, "On the Calculation of Radiation Resistance of Antennas and Antenna Combinations," *Proc. IRE*, **19**, 1471 (1931).
- [1280] P. S. Carter, "Circuit Relations in Radiating Systems and Applications to Antenna Problems," *Proc. IRE*, **20**, 1004 (1932).
- [1281] A. W. Nagy, "An Experimental Study of Parasitic Wire Reflectors on 2.5 Meters," *Proc. IRE*, **24**, 233 (1936).
- [1282] G. H. Brown, "Directional Antennas," *Proc. IRE*, **25**, 78 (1937).
- [1283] C. T. Tai, "Coupled Antennas," *Proc. IRE*, **36**, 487 (1948).
- [1284] H. E. King, "Mutual Impedance of Unequal Length Antennas in Echelon," *IEEE Trans. Antennas Propagat.*, **AP-5**, 306 (1957).
- [1285] H. C. Baker and A. H. LaGrone, "Digital Computation of the Mutual Impedance Between Thin Dipoles," *IEEE Trans. Antennas Propagat.*, **AP-10**, 172 (1962).
- [1286] J. H. Richmond and N. H. Geary, "Mutual Impedance Between Coplanar-Skew Dipoles," *IEEE Trans. Antennas Propagat.*, **AP-18**, 414 (1970).
- [1287] R. Hansen, "Formulation of Echelon Dipole Mutual Impedance for Computer," *IEEE Trans. Antennas Propagat.*, **AP-20**, 780 (1972).
- [1288] J. H. Richmond and N. H. Geary, "Mutual Impedance of Nonplanar-Skew Sinusoidal Dipoles," *IEEE Trans. Antennas Propagat.*, **AP-23**, 412 (1975).
- [1289] C. W. Chuang, et al., "New Expressions for Mutual Impedance of Nonplanar-Skew Sinusoidal Monopoles," *IEEE Trans. Antennas Propagat.*, **AP-38**, 275 (1990).
- [1290] J. D. Kraus, "The Corner-Reflector Antenna," *Proc. IRE*, **28**, 513 (1940).
- [1291] H. Yagi, "Beam Transmission of Ultra Short Waves," *Proc. IRE*, **16**, 715 (1928).
- [1292] W. Walkinshaw, "Theoretical Treatment of Short Yagi Aerials," *J. IEE*, **93**, Pt.IIIA, 598 (1946).
- [1293] R. M. Fishenden and E. R. Wiblin, "Design of Yagi Aerials," *Proc. IEE*, **96**, Pt.III, 5 (1949).
- [1294] G. A. Thiele, "Analysis of Yagi-Uda-Type Antennas," *IEEE Trans. Antennas Propagat.*, **AP-17**, 24 (1968).
- [1295] D. K. Cheng and C. A. Chen, "Optimum Element Spacings for Yagi-Uda Arrays," *IEEE Trans. Antennas Propagat.*, **AP-21**, 615 (1973).
- [1296] C. A. Chen and D. K. Cheng, "Optimum Element Lengths for Yagi-Uda Arrays," *IEEE Trans. Antennas Propagat.*, **AP-23**, 8 (1975).
- [1297] G. Sato, "A Secret Story About the Yagi Antenna," *IEEE Antennas and Propagation Mag.*, **33**, 7, June 1991.
- [1298] D. H. Preiss, "A Comparison of Methods to Evaluate Potential Integrals," *IEEE Trans. Antennas Propagat.*, **AP-24**, 223 (1976).

### Web Sites

- [1299] [www.codata.org](http://www.codata.org), Committee on Data for Science and Technology (CODATA). Contains most recent values of physical constants, published in Ref. [89].
- [1300] [www.ieee.org/organizations/history\\_center/general\\_info/lines\\_menu.html](http://www.ieee.org/organizations/history_center/general_info/lines_menu.html), R. D. Friedel, *Lines and Waves, An Exhibit by the IEEE History Center*.
- [1301] [www.ece.umd.edu/~taylor/frame1.htm](http://www.ece.umd.edu/~taylor/frame1.htm), Gallery of Electromagnetic Personalities.
- [1302] [www.ece.umd.edu/~taylor/optics.htm](http://www.ece.umd.edu/~taylor/optics.htm), L. S. Taylor, Optics Highlights.
- [1303] [mintaka.sdsu.edu/GF](http://mintaka.sdsu.edu/GF), A. T. Young, "An Introduction to Green Flashes," with extensive bibliography.
- [1304] [www.ee.surrey.ac.uk/Personal/D.Jefferies/antennas.html](http://www.ee.surrey.ac.uk/Personal/D.Jefferies/antennas.html), Notes on Antennas.
- [1305] [www.arrl.org](http://www.arrl.org), American Radio Relay League.
- [1306] [www.qth.com/antenna](http://www.qth.com/antenna), The Elmer HAMlet.
- [1307] [www.northcountryradio.com](http://www.northcountryradio.com), North Country Radio.
- [1308] [www.tapr.org](http://www.tapr.org), Tuscon Amateur Packet Radio.
- [1309] [aces.ee.olemiss.edu/](http://aces.ee.olemiss.edu/), Applied Computational Electromagnetics Society,
- [1310] [emlib.jpl.nasa.gov](http://emlib.jpl.nasa.gov), EMLIB Software Library (with many EM links.)

- [1311] [www.qsl.net/wb6tpu/swindex.html](http://www.qsl.net/wb6tpu/swindex.html), Numerical Electromagnetics Code (NEC) Archives.
- [1312] [dutettq.et.tudelft.nl/~koen/Nec/neclinks.html](http://dutettq.et.tudelft.nl/~koen/Nec/neclinks.html), NEC links.
- [1313] [www-laagc.atdiv.lanl.gov/electromag.html](http://www-laagc.atdiv.lanl.gov/electromag.html), Los Alamos Accelerator Code Group (LAAGC), Electromagnetic Modeling Software.
- [1314] [soli.inav.net/~rlcross/asap/index.html](http://soli.inav.net/~rlcross/asap/index.html), ASAP-Antenna Scatterers Analysis Program.
- [1315] [www.itu.org](http://www.itu.org), International Telecommunication Union(formerly CCIR.)
- [1316] [www.fcc.gov](http://www.fcc.gov), Federal Communications Commission.
- [1317] [sss-mag.com/smith.html](http://sss-mag.com/smith.html), The Smith Chart Page (with links.)
- [1318] [www.wirelessdesignonline.com](http://www.wirelessdesignonline.com), Wireless Design Online.
- [1319] [www.csdmag.com](http://www.csdmag.com), Communication Systems Design Magazine.
- [1320] [home.earthlink.net/~jpdowning/pbgbib.html](http://home.earthlink.net/~jpdowning/pbgbib.html), J. P. Dowling, H. Everett, and E. Yablonovitz, Photonic and Acoustic Band-Gap Bibliography.
- [1321] [www.sspectra.com/index.html](http://www.sspectra.com/index.html), Software Spectra, Inc. Contains thin-film design examples.
- [1322] [www.therfc.com/attenrat.htm](http://www.therfc.com/attenrat.htm), Coaxial Cable Attenuation Ratings.
- [1323] [www.tm.agilent.com/data/static/eng/tmo/Notes/interactive/](http://www.tm.agilent.com/data/static/eng/tmo/Notes/interactive/), Agilent, Application Notes Library.
- [1324] [www.semiconductor.agilent.com](http://www.semiconductor.agilent.com), Agilent RF & Microwave Products.
- [1325] [www.semiconductor.agilent.com](http://www.semiconductor.agilent.com), Agilent Wireless Library.
- [1326] [www.sss-mag.com/spara.html](http://www.sss-mag.com/spara.html), S-Parameter Archive (with links.)
- [1327] [www.ise.pw.edu.pl/~mschmidt/literature/](http://www.ise.pw.edu.pl/~mschmidt/literature/), M. Schmidt-Szalowski, Literature on Selected Microwave Topics.
- [1328] [www.mathworks.com](http://www.mathworks.com), MATLAB resources at Mathworks, Inc.
- [1329] [www.3m.com/about3M/technologies/lightmgmt](http://www.3m.com/about3M/technologies/lightmgmt), Giant Birefringent Optics, 3M, Inc.
- [1330] [wwwppd.nrl.navy.mil/nrlformulary/nrlformulary.html](http://wwwppd.nrl.navy.mil/nrlformulary/nrlformulary.html), NRL Plasma Formulary.
- [1331] [voyager.jpl.nasa.gov](http://voyager.jpl.nasa.gov), Voyager web site.
- [1332] [deepspace.jpl.nasa.gov/dsn](http://deepspace.jpl.nasa.gov/dsn), NASA's Deep-Space Network.
- [1333] [www.hep.princeton.edu/~mcdonald/examples](http://www.hep.princeton.edu/~mcdonald/examples), K. McDonald, "Physics Examples and other Pedagogic Diversions".