CURRICULUM VITAE

William Esco (W. E.) Moerner
Harry S. Mosher Professor and Professor, by courtesy, of Applied Physics
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Education

1975	B.S. Physics (Final Honors) B.S. Electrical Engineering (Final Honors) A.B. Mathematics (summa cum laude)	Washington University St. Louis, Missouri
1978	M.S. (Physics)	Cornell University Ithaca, New York
1982	Ph.D. (Physics)	Cornell University Ithaca, New York

Thesis Topic: Vibrational Relaxation Dynamics of an IR-Laser-Excited Molecular Impurity Mode in Alkali Halide Lattices
Thesis Advisor: Professor A. J. Sievers

Academic Honors

1963-82	Grade Point Average of All A's (4.0)
1971-75	Alexander S. Langsdorf Engineering Fellow, Washington University
1975	Dean's Award for Unusually Exceptional Academic Achievement
1975	Ethan A. H. Shepley Award for Outstanding Achievement (university-wide)
1975-79	National Science Foundation Graduate Fellow

Career Summary

2011-	Chemistry Department Chair
2005-	Professor, by courtesy, of Applied Physics
2002-	Harry S. Mosher Professor of Chemistry
1998-	Professor of Chemistry Department of Chemistry Stanford University

Multidisciplinary education and research program on single-molecule spectroscopy, imaging,

and quantum optics in solids, proteins, and liquids; single-molecule biophysics in cells; nanophotonics of metallic nanoantennas; and photoactive polymer materials with emphasis on photorefractive polymers. Major milestones include: first room-temperature single-molecule source of single photons, antibunching for a single CdSe/ZnSe nanocrystal, observation of nucleotide-dependent orientational flexibility of single kinesin motors bound to microtubules, single-pair FRET for a dual-GFP sensor of calcium ion concentrations, full characterization of the single-copy properties of DsRed fluorescent proteins, first analysis of diffusion of single MHCII transmembrane protein complexes in cells, discovery of a new class of single-molecule fluorophores and development of these for cellular imaging, direct measurement of local electromagnetic field enhancement for bowtie nanoantennas and their use in surface-enhanced Raman scattering and in enhancing single-molecule fluorescence, observation of single GFP fusions in bacteria acting as nanoscale, photoswitchable light sources to show super-resolved cellular structures, invention of a new trap for nanoscale objects and single biomolecules in solution, observation of specific ATP-induced conformational changes for a model substrate interacting with the chaperonin GroEL/ES, determination of ADP number distributions for single multi-subunit enzymes in solution, imaging of huntingtin protein aggregates in cells, and demonstration of 3D superresolution imaging of single photoactivatable molecules, cellular structures, and cellular mRNA particles with a double-helix point-spread function microscope. First method for correction of dipole-induced shifts in single-molecule localization imaging, analysis of the impact of orientation flexibility on this effect. Application of the ABEL trap to the analysis of photosynthetic antenna protein photodynamics, G-protein-coupled receptors, single fluorophores, single electron-transfer enzymes in solution, and direct detection of mobility and diffusion coefficient of single biomolecules.

1995-1998 Distinguished Chair in Physical Chemistry
Department of Chemistry and Biochemistry
University of California San Diego

Multidisciplinary education and research program on single-molecule spectroscopy and quantum optics in solids, proteins, and liquids; single-molecule biophysics, near-field microscopy; and photoactive polymer materials with emphasis on photorefractive polymers. Major milestones include 3-D studies of single molecules diffusing in gels, observation of blinking and switching in single GFP molecules, pumping of single molecules with whispering gallery modes of microspheres, and beam fanning and self-pumped phase conjugation in new extremely high gain photorefractive polymers. Research group included four postdoctoral research associates, three graduate students, and three undergraduates.

1994-95 Research Staff Member and Project Leader
IBM Almaden Research Center
San Jose, California

Multidisciplinary research program on single-molecule spectroscopy, near-field optics, and photorefractive (PR) polymers. Project leader for ARPA contract on PR polymers.

1993-1994 Visiting Guest Professor and IBM Research Staff Member
Laboratory for Physical Chemistry

ETH Zentrum (Swiss Federal Institute of Technology)
Zürich, Switzerland

Research program in single-molecule spectroscopy, spectral hole-burning, and near-field optics. Educated and supervised 4 Ph.D. students and two visiting scientists; lectured on single-molecule laser spectroscopy and photorefractive polymers. Major accomplishments included discovery and imaging of single molecules in Shpol'skii matrices and the first near-field single-molecule spectroscopy. Continued as consultant on IBM project on photorefractive polymer materials research and development.

1989-1993 Research Staff Member and Project Leader
IBM Almaden Research Center
San Jose, California

Multidisciplinary research program in Organic Optoelectronic Materials Department with two main thrust areas: (i) precision fundamental spectroscopy of defect centers in solids including single-molecule detection and spectroscopy, statistical fine structure, and spectral hole-burning, and (ii) optical and physical properties of nonlinear materials, including organic photorefractive polymeric materials.

Novel accomplishments:

Single-Molecule Spectroscopy and Spectral Hole-Burning:

Phase-sensitive, time-resolved study of ballistic phonon propagation in a solid; direct observation of spectral diffusion in a solid using a single-molecule probe; observation of lifetime-limited linewidths, dephasing, and nonlinear saturation for a single molecule; observation of hole-burning and spectral diffusion for a single molecule in a polymer; observation of photoinduced reaction kinetics for a single molecule; observation of photon antibunching for a single molecule in a solid; measurement of vibrationally dispersed fluorescence from a single molecule in a crystal and in a polymer; and magnetic resonance of a single molecular spin.

Organic Nonlinear Materials:

Intracavity second harmonic generation in an organic crystal; observation of photorefractivity in a polymer; demonstration of two-beam coupling in a photorefractive polymer; subsecond photorefractive response in a polymer; sensitization of a photorefractive polymer with C_{60}; development of photorefractive polymers with net gain and efficiency sufficient to surpass some conventional inorganic crystals; and image storage in a photorefractive polymer.

1988-1989 Manager, Laser-Materials Interactions
IBM Almaden Research Center
San Jose, California

Managed Research Staff Members in Laser-Materials Interactions Project which concentrated on laser spectroscopy of solids and quantum optics. Continued research on statistical properties of inhomogeneously broadened lines and on mechanisms of the photorefractive effect in electro-optic crystals. Major accomplishment: first optical detection and spectroscopy of a single impurity molecule in a solid.

1981-1988 Research Staff Member
IBM Almaden Research Center
San Jose, California

Performed individual research on materials and mechanisms for frequency domain optical storage using high resolution, low temperature laser spectroscopy and photochemical and nonphotochemical hole-burning spectroscopy. Developed high sensitivity measurement techniques such as laser frequency modulation, optical normalization, and ultrasonic modulation to measure extremely small changes in optical absorption.

Novel accomplishments:

Photochemical hole burning at GaAs laser wavelengths, observation of high efficiency photochemistry for an infrared color center; observation of two-photon absorption for linear polyenes in crystals using cw lasers; detailed studies of hole-burning bottlenecks for organic and inorganic systems; use of the quantum-limited sensitivity of FM spectroscopy to measure the stimulated Raman gain in deuterium; use of high resolution ultrasonic modulation to detect photochemical holes; observation of photochemical hole production in 100 ns; complete analysis of coupled reading-writing constraints for single-photon hole-burning materials leading to the need for photon-gating; observation of photon-gated hole-burning in an organic system; development of photon-gating via a donor-acceptor electron transfer mechanism, which allowed fast (30 ns) hole formation in small focused laser spots; and observation of statistical fine structure in an inhomogeneously broadened spectral line.

1975-1981 Graduate Research Assistant and NSF Graduate Fellow
Laboratory for Atomic and Solid State Physics,
Cornell University, Ithaca, New York

Performed basic research on the vibrational relaxation dynamics of molecular impurities in alkali halides. Principal techniques included low temperature laser saturation, high resolution spectral hole burning, and coherent transient spectroscopy with CO_2 and PbSnTe diode lasers. Major accomplishments were the first measurements of T_1 and T_2 for ReO_4^- molecules in a variety of alkali halide hosts, and the discovery of persistent nonphotochemical spectral hole burning for a molecular vibrational mode in a crystalline lattice.

1972-1975 Research Assistant
Department of Physics
Washington University, St. Louis, Missouri

Performed experiments, computer simulations, and theory to develop more accurate formulae for the determination of ultrasonic propagation velocity and dispersion in composite resonators. Assisted in ultrasonic studies of the magnetoelastic properties of single crystal Co and Ni.

Honors and Awards

John Gamble Kirkwood Medal for Outstanding Achievement in Science, from Yale University and the New Haven Section of the American Chemical Society, 2013
Engineering Alumni Achievement Award, Washington University, 2013
Peter Debye Award in Physical Chemistry, 2013
Pittsburgh Spectroscopy Award, 2012
Irving Langmuir Prize in Chemical Physics, 2009
Wolf Prize in Chemistry, 2008
Member, National Academy of Sciences, 2007
Fellow, American Association for the Advancement of Science, 2004
Geoffrey Frew Fellow, Australian Academy of Sciences, 2003
Harry Stone Mosher Professor of Chemistry, Stanford University, 2002
Fellow, American Academy of Arts and Sciences, 2001
Earle K. Plyler Prize for Molecular Spectroscopy, American Physical Society, 2001
Robert Burns Woodward Visiting Professor, Department of Chemistry, Harvard University, 1997-1998
First holder of Distinguished Professorship in Physical Chemistry, Department of Chemistry and Biochemistry, University of California, San Diego, 1995-1998.
Visiting Guest Professor of Physical Chemistry, Swiss Federal Institute of Technology (ETH-Zürich), 1993-1994
IBM Outstanding Technical Achievement Award for Single-Molecule Detection and Spectroscopy, November 22, 1992
Fellow, American Physical Society, November 16, 1992
Fellow, Optical Society of America, May 28, 1992
Senior Member, IEEE, June 17, 1988
IBM Outstanding Technical Achievement Award (with R. M. Macfarlane and R. M. Shelby) for Photon-Gated Spectral Hole-Burning, July 11, 1988
National Winner of the Roger I. Wilkinson Outstanding Young Electrical Engineer Award for 1984, from the electrical engineering honorary society, Eta Kappa Nu, April 22, 1985

Lectureships

John Gamble Kirkwood Lecturer, Department of Chemistry, Yale University, September 2013
Walter Kauzmann Lecturer in Biophysical Chemistry, Princeton University, September 2013
E. K. C. Lee Lecturer, Department of Chemistry, University of California, Irvine, May 2013
Samuel Krimm Lecture in Biophysics, University of Michigan, April 2013
Ehrenfest Colloquium Lecturer (repeat), University of Leiden, The Netherlands, June 2012
Pittsburgh Conference Lecturer, Department of Chemistry, University of Pittsburgh, 2011
Leica Scientific Forum United Kingdom Lecturer, June 2011
Willis Flygare Memorial Lecturer, Department of Chemistry, University of Illinois at Urbana-Champaign, 2011
Joe L. Franklin Lecturer, Department of Chemistry, Rice University, 2010
William Lloyd Evans Lecturer, Department of Chemistry, The Ohio State University, 2009
Karl Friedrich Bonhoeffer Lecturer, Max Planck Institute for Biophysical Chemistry, Göttingen, Germany, 2009

Neil Gordon Frontiers in Chemistry Lecturer, Department of Chemistry, Wayne State University, 2009

A. S. Noyes Lecturer, Department of Chemistry and Biochemistry, University of Texas at Austin, 2009

DuPont-Marshall Lecturer, Department of Chemistry, University of Pennsylvania, 2008

Herbert H. King Lecturer, Department of Chemistry, Kansas State University, 2006

Edwin Yunker Lecturer, Department of Physics, Oregon State University, 2006

A. R. Gordon Distinguished Lecturer, Department of Chemistry, University of Toronto, 2006

Lecturer, Summer School on Visualization, Manipulation, and Modeling of Single Biomolecules, ENS Paris, France, 2005

Geoffrey Frew Fellowship Lecturer, Australian Academy of Sciences (University of Queensland, Australian National University, Swinburne Institute of Technology, University of Melbourne), 2003

International Invited Lecturer (Basel, Berne, Lausanne, Geneva): Conference Universitaire de Suisse Occidentale du 3ème Cycle en Chimie, 2003

Moses Gomberg Lecturer, Department of Chemistry, University of Michigan, 2001

William Draper Harkins Lecturer, Department of Chemistry, University of Chicago, 2001

Guest Lecturer in Frontiers in Spectroscopy, Ohio State University, 1999

Arthur D. Little Lecturer, Department of Chemistry, Massachusetts Institute of Technology, 1995

Ehrenfest Colloquium Lecturer, University of Leiden, The Netherlands, March 1994

Samuel M. McElvain Lecturer, Department of Chemistry, University of Wisconsin, 1993

Patents

U. S. Patent 4,614,116: "Phase Sensitive Ultrasonic Modulation Method for the Detection of Strain-Sensitive Spectral Features", September 30, 1986.

U. S. Patent 5,064,264: "Photorefractive Materials", November 12, 1991.

U. S. Patent 5,361,148: "Apparatus for Photorefractive Two-Beam Coupling," November 1, 1994.

U. S. Patent 5,460,907: "Photorefractive Materials", October 24, 1995.

U. S. Patent 5,607,799: “Optical Photorefractive Article,” March 4, 1997.

U. S. Patent 6,046,925: “Photochromic Fluorescent Proteins and Optical Memory Storage Devices Based on Fluorescent Proteins,” April 4, 2000.

U. S. Patent 6,280,884: “Process for Photorefractive Index Grating Formation,” August 28, 2001.

U. S. Patent 7,068,698 “Room-Temperature Source of Single Photons Based on a Single Molecule in a Condensed Matter Host," June 27, 2006.

U. S. Patent 8,057,655: “Sub-Micron Object Control Arrangement and Approach Therefor,” Nov. 15, 2011.

U. S. Patent 8,153,446 B2: “Fluorogenic Compounds Converted to Fluorophores by Photochemical or Chemical Means and Their Use in Biological Systems,” April 10, 2012.

Application: “Three-dimensional Superresolution Optical Imaging,” Provisional filed December 17, 2008; Filed December 17, 2009.

Application: “Firefly Luceferin Analogues, Methods of Making Firefly Luceferin Analogues, and Methods of Imaging,” Provisional filed March 10, 2009.

Application: "Enhancement of Molecular Emission by Bowtie Nanoantennas," Provisional filed October 15, 2010; Filed October 17, 2011.

Application: "Apparatus and Method for Localizing Objects for Distance and/or in Three Dimensions Using a Spiral Point Spread Function," Disclosure filed May 17, 2012, Provisional filed December 13, 2011.

Twelve additional published disclosures in optics, frequency domain optical storage, single-molecule applications, and photorefractive materials.

Professional Societies and Positions

Advisory Editor, *Chemical Physics Letters* 1998-
Advisory Editor, *Single Molecules* 2000-2002
Advisory Editor, *ChemPhysChem* 2004-
Editorial Advisory Board, *Journal of Physical Chemistry* 2013-

American Academy of Arts and Sciences
American Association for the Advancement of Science
American Chemical Society
- Program Committee, Symposium on Optical Properties of Polymers, August 1996
- Single-Molecule Symposium Organizer, Physical Chemistry Division, April 1997
- Co-Editor, Special Issue of *Accounts of Chemical Research* on Single Molecules and Ions, December 1996

American Physical Society
- Chair, Herbert P. Broida Prize Committee 2000
- Member, Earle K. Plyler Prize Committee 2001
- Member, Irving Langmuir Prize Committee 2010
- Symposium Organizer for Laser Science Topical Group, 1992 March Meeting
- Symposium Organizer for Laser Science Topical Group, 1993 March Meeting

Institute of Electrical and Electronic Engineers, Lasers and Electro-Optics Society
- Assistant Treasurer, 1988 Annual Meeting
- Treasurer and Program Committee Member, 1989 Annual Meeting
- Symposium Organizer, LEOS 1989 Annual Meeting on Optical Memory and Storage

Materials Research Society
National Academy of Sciences
Optical Society of America
- Chair, Fundamental and Applied Spectroscopy Technical Group, 1992-1994
- General Chair and Founder, OSA Topical Conference on Persistent Spectral Hole-Burning Science and Applications, 1991
- Co-Editor, 2 Special Issues of J. Opt. Soc. America B on Persistent Spectral Hole-Burning
- Advisory Chair and Program Committee Member, Topical Meeting on Spectral Hole-Burning and Luminescence, 1993-1994
- Assistant Chair, Fundamental and Applied Spectroscopy Technical Group, 1992

Society of Photo-Optical Instrumentation Engineers

Program Co-Chair, Symposium on Organic Photorefractive Materials, 1996, 1997, 1998
Program Committee, 1999-2003

Conference on Quantum Electronics and Laser Science
Program Committee, 1992 and 1993

Conference on Lasers and Electro-Optics
Program Committee, 1999

International Conference on Hole-Burning and Single-Molecule Spectroscopies
Program Committee, 1996, 1999, 2003

Gordon Research Conference on Single-Molecule Approaches to Biology,
Co-Vice Chair, 2008; Co-Chair, 2010.

Task Forces and Major University Committees

Chairman, IBM Task Force on Frequency Domain Optical Storage, 1984.

Physics and Mechanisms Member, IBM Task Force on Holographic Optical Storage, 1986.

Co-Chair, Systems and Applications, IBM Optical Storage Initiative, 1988.

Member, Appointments and Promotions Committee, Division of Humanities and Sciences, Stanford University, 2002-2004.

Member, Nanoinitiative Committee, Stanford University, Winter 2006

Member, NSF Center for Probing the Nanoscale Executive Committee, Fall 2007

Member, Stanford University Committee on Health and Safety, 2007-2008

Chair, Stanford University Committee on Health and Safety, 2008-2009, 2009-2010

Member, Stanford University Emergency Management Steering Committee, 2009-2010

Member, Advisory Board, Center for Biological Imaging at Stanford, 2010-

Study Panels and Governmental Committees

Member, NSF SBIR Study Panel, September, 1996.

Member, NIH Bioengineering Symposium Panel on Imaging at the Molecular and Cellular Levels, February 27-28, 1998.

Co-Chair, Toward Molecular Scale Devices Subgroup, NSF Integrating Themes Workshop for Physical Chemists, September 18-20, 1998, Keystone, Colorado.

Member, NIH Review Panel, November 1999; September 2000.

Member, FAMOS Update Panel, National Research Council, 1999-2002.

Member, NIH-NIGMS Workshop on Single Molecule Detection and Manipulation, 2000

Member, NSF-Intelligence Community Workshop on Approaches to Combat Terrorism, 2002.

Subgroup Chair, NIH-NIDA Workshop on Emerging Technologies: Analysis of Endogeneous Biomaterials and Single-Molecule Studies, 2002.

Member, International Review Committee for the Institute of Atomic and Molecular Sciences (IAMS) of Academia Sinica, Taiwan, 2003-2004

Member, NIH-BST Molecular Imaging Study Section, 2004.

Member, Pacific Northwest National Laboratory DOE-BES Review Panel, 2005.

Member, DOE Workshop on Single-Molecule Research in the New Millenium, 2005.

Member, Advisory Board, Institute of Atomic and Molecular Sciences (IAMS) of Academia Sinica, Taiwan, 2005-

Session Chair: NIH Frontiers in Live Cell Imaging Conference, April 19-21, 2006

Member, NIH-NHGRI Study Section, July, 2006

Member, Board of Scientific Counselors, National Institute of Biomedical Imaging and Bioengineering, 2010-

Member, Corporation Visiting Committee, Department of Chemistry, Massachusetts Institute of Technology, 2014-.

Publications: William Esco (W. E.) Moerner

1. Richard G. Domey and William E. Moerner, "Cooperative Studies of the Kuroshio and Adjacent Regions, Part I: A Factor Analysis," *Indian J. Marine Sciences* **2**, 69 (1973).
2. H. I. Ringermacher, W. E. Moerner, and J. G. Miller, "Improved Transducer Correction for Standing Wave Ultrasonic Velocity Measurements," *J. Appl. Phys.* **45**, 549 (1974).
3. H. I. Ringermacher, W. E. Moerner, and J. G. Miller, "Two Transducer Formula for More Precise Determination of Ultrasonic Phase Velocity from Standing Wave Measurements," Proc. IEEE Ultrasonics Symposium, IEEE Cat. No. PD74CH0896-1SU, 555 (1974).
4. W. E. Moerner and J. G. Miller, "Ultrasonic Dispersion ($\Delta v/v$) Determined from Mechanical Resonance Frequency Shifts," Proc. IEEE Ultrasonics Symposium, IEEE Cat. No. PD74CH0896-1SU, 478 (1974).
5. V. E. Stubblefield, W. E. Moerner, P. A. Fedders, J. G. Miller, and D. I. Bolef, "Ultrasonic Determination of Magnetoelastic and Anisotropy Constants of Single Crystal Ni," Proc. IEEE Ultrasonics Symposium, IEEE Cat. No. PD74CH0896-1SU, 474 (1974).
6. L. H. Greene, R. T. Warner, W. E. Moerner, and A. J. Sievers, "Passive Mode Locking of a TEA CO_2 Laser with Matrix Isolated SF_6," Eleventh International Quantum Electronics Conference Digest of Technical Papers, IEEE Cat. No. PD80CH1561-O, 640 (1980).
7. A. R. Chraplyvy, W. E. Moerner, and A. J. Sievers, "High-Resolution Spectroscopy of Matrix-Isolated ReO_4^- Molecules," *Opt. Lett*. **6**, 254 (1981).
8. A. R. Chraplyvy, W. E. Moerner, and A. J. Sievers, "Infrared Hole Burning Spectroscopy of Matrix-Isolated ReO_4^- Molecules," *Opt. Lett*. **6**, 431 (1981).
9. W. E. Moerner, A. J. Sievers, and A. R. Chraplyvy, "Anharmonic Relaxation Times of Molecular Vibrational Modes in Alkali Halide Crystals," *Phys. Rev. Lett.* **47**, 1082 (1981).
10. W. E. Moerner, A. J. Sievers, R. H. Silsbee, A. R. Chraplyvy, and D. K. Lambert, "Persistent Holes in the Spectra of Localized Vibrational Modes in Crystalline Solids," *Phys. Rev. Lett.* **49**, 398 (1982).
11. W. E. Moerner, F. M. Schellenberg, and G. C. Bjorklund, "Photochemical Hole Burning at GaAs Laser Wavelengths," *Appl. Phys.* **B28**, 263 (1982).
12. M. D. Levenson, W. E. Moerner, and D. E. Horne, "FM Spectroscopy Detection of Stimulated Raman Gain," *Opt. Lett.* **8**, 108 (1983).
13. P. Pokrowsky, W. E. Moerner, F. Chu, and G. C. Bjorklund, "Reading and Writing of Photochemical Holes Using GaAlAs Diode Lasers," *Opt. Lett.* **8**, 280 (1983).
14. W. E. Moerner, A. R. Chraplyvy, A. J. Sievers, and R. H. Silsbee, "Persistent Nonphotochemical Spectral Hole Dynamics for an Infrared Vibrational Mode in Alkali Halide Crystals," *Phys. Rev*. **B28**, 7244 (1983).
15. P. Pokrowsky, W. E. Moerner, F. Chu, and G. C. Bjorklund, "Reading and Writing of Photochemical Holes Using GaAlAs Diode Lasers," *Proc. Soc. Photo-Opt. Instrum. Engineers* **382**, 202 (1983).
16. B. H. Schechtman, G. C. Bjorklund, and W. E. Moerner, "A Horse of a Different Color:

Frequency Domain Optical Storage," IBM Research Report # RJ4128, 1983.

17. W. E. Moerner, "Organic Materials for Frequency Domain Optical Storage," Proc. Lasers '83, R. C. Powell, editor, (STS Press, McLean, Virginia, 1983), p. 489.

18. W. E. Moerner, A. R. Chraplyvy, and A. J. Sievers, "Anharmonic Vibrational Relaxation Dynamics for a Molecular Impurity Mode in Alkali Halide Crystals," *Phys. Rev.* **B29**, 6694 (1984).

19. A. L. Huston and W. E. Moerner, "Detection of Persistent Spectral Holes Using Ultrasonic Modulation," *J. Opt. Soc. Am. B: Opt. Phys.* **1**, 349 (1984).

20. M. Romagnoli, W. E. Moerner, F. M. Schellenberg, M. D. Levenson, and G. C. Bjorklund, "Beyond the Bottleneck: Submicrosecond Hole-Burning in Phthalocyanine," *J. Opt. Soc. Am. B: Opt. Phys.* **1**, 341 (1984).

21. W. E. Moerner, M. Gehrtz, and A. L. Huston, "Measurement of Quantum Efficiencies for Persistent Spectral Hole-Burning," *J. Phys. Chem.* **88**, 6459 (1984).

22. W. E. Moerner, "The Spectroscopic Search for Single-Photon Materials," *Photonics Spectra* **19**, 59 (February 1985).

23. H. W. H. Lee, A. L. Huston, M. Gehrtz, and W. E. Moerner, "Photochemical Hole-Burning in a Protonated Phthalocyanine with GaAlAs Diode Lasers," *Chem. Phys. Lett.* **114**, 491 (1985).

24. W. E. Moerner and M. D. Levenson, "Can Single-Photon Processes Provide Useful Materials for Frequency Domain Optical Storage?" *J. Opt. Soc. Amer. B: Opt. Phys.* **2**, 915 (1985).

25. W. E. Moerner, F. M. Schellenberg, G. C. Bjorklund, P. Kaipa, and F. Lüty, "High Efficiency Photochemical Hole-Burning for an Infrared Color Center," *Phys. Rev.* **B32**, 1270 (1985).

26. M. Gehrtz, W. E. Moerner, and G. C. Bjorklund, "Shot-Noise Limited Detection in FM Spectroscopy by Optical Nulling of Residual Amplitude Modulation," IBM RJ#4678, 1985.

27. H. W. H. Lee, M. Gehrtz, E. Marinero, and W. E. Moerner, "Two-Color, Photon-Gated Spectral Hole-Burning in an Organic Material," *Chem. Phys. Lett.* **118**, 611 (1985).

28. W. E. Moerner, "Laser-Light-Induced Physical Processes in Optical Materials: Persistent Spectral Hole-Burning," *Proc. Soc. Photo-Opt. Instrum. Engr.* **541**, 60 (1985).

29. W. E. Moerner, R. M. Macfarlane, and R. M. Shelby, "Photon-Gated Spectral Hole-Burning," Physics/Optics News in 1985 *Optics News* **11** (12), 9 (1985).

30. W. E. Moerner, "Molecular Electronics for Frequency Domain Optical Storage: Persistent Spectral Hole-Burning - A Review," *J. Molec. Elec.* **1**, 55 (1985).

31. W. E. Moerner, P. Pokrowsky, F. M. Schellenberg, and G. C. Bjorklund, "Persistent Spectral Hole-Burning for R' Color Centers in LiF Crystals: Statics, Dynamics, and External Field Effects," *Phys. Rev.* **B33**, 5702 (1986).

32. W. E. Moerner and A. L. Huston, "Phase-Sensitive Ultrasonic Modulation of Persistent Spectral Holes," *Appl. Phys. Lett.* **48**, 1181 (1986).

33. W. Lenth and W. E. Moerner, "Gated Spectral Hole-Burning for Frequency Domain Optical Recording," *Optics Commun.* **58**, 249 (1986).

34. W. E. Moerner, "Dynamical Hole-Burning Requirements for Frequency Domain Optical Storage," in Unconventional Photoactive Solids, Harvey Scher, editor, (Plenum, New York, 1988), pp. 41-51.

35. W. Lenth, R. M. Macfarlane, W. E. Moerner, F. M. Schellenberg, R. M. Shelby, and G. C. Bjorklund, "High-Density Frequency-Domain Optical Recording," *Proc. Soc. Photo-opt. Instrum. Engr.* **695**, 216 (1986).

36. A. J. Sievers and W. E. Moerner, "Persistent Infrared Spectral Hole-Burning for Impurity Vibrational Modes in Solids," Chapter 6 of Persistent Spectral Hole-Burning: Science and Applications, W. E. Moerner, editor, Topics in Current Physics Vol. 44 (Springer, Berlin, Heidelberg, 1988).

37. W. E. Moerner and A. L. Huston, "Phase-sensitive Detection of Persistent Spectral Holes Using Synchronous Ultrasonic Modulation Spectroscopy," *J. Opt. Soc. Am. B: Opt. Phys.* **3**, P210 (1986).

38. W. E. Moerner, T. P. Carter, and C. Bräuchle, "Fast Burning of Persistent Spectral Holes in Small Laser Spots Using Photon-Gated Materials," *Appl. Phys. Lett.* **50**, 430 (1987).

39. T. P. Carter, C. Bräuchle, V. Y. Lee, M. Manavi, and W. E. Moerner, "Photon-Gated Spectral Hole-Burning Via Donor-Acceptor Electron Transfer," *Opt. Lett.* **12**, 370 (1987).

40. T. P. Carter, C. Bräuchle, V. Y. Lee, M. Manavi, and W. E. Moerner, "Mechanism of Photon-Gated Persistent Spectral Hole-Burning in Metalloporphyrin/Halomethane Systems: Donor-Acceptor Electron Transfer," *J. Phys. Chem.* **91**, 3998 (1987).

41. W. E. Moerner, W. Lenth, and G. C. Bjorklund, "Frequency Domain Optical Storage and Other Applications of Persistent Spectral Hole-Burning," Chapter 7 of Persistent Spectral Hole-Burning: Science and Applications, W. E. Moerner, editor,Topics in Current Physics Vol. 44 (Springer, Berlin, Heidelberg, 1988).

42. W. E. Moerner, "Introduction to Persistent Spectral Hole-Burning: Science and Applications," Chapter 1 of Persistent Spectral Hole-Burning: Science and Applications, W. E. Moerner, editor, Topics in Current Physics Vol. 44 (Springer, Berlin, Heidelberg, 1988).

43. W. E. Moerner and T. P. Carter, "Statistical Fine Structure in Inhomogeneously Broadened Absorption Lines," *Phys. Rev. Lett.*, **59**, 2705 (1987).

44. W. E. Moerner and T. P. Carter, "Statistical Fine Structure in Inhomogeneously Broadened Absorption Lines in Solids," Advances in Laser Science III, AIP Conference Proceedings **172** (AIP, New York, 1988), p. 419.

45. T. P. Carter, M. Manavi, and W. E. Moerner, "Statistical Fine Structure in the Inhomogeneously Broadened Electronic Origin of Pentacene in p-Terphenyl," *J. Chem. Phys.* **89**, 1768 (1988).

46. T. P. Carter, D. E. Horne, and W. E. Moerner, "Pseudo-Stark Effect and FM/Stark Double-Modulation Spectroscopy for the Detection of Statistical Fine Structure in Alexandrite," *Chem. Phys. Lett.* **151**, 102 (1988).

47. L. Kador, T. P. Carter, and W. E. Moerner, "FM-Stark Double-Modulation Spectroscopy for the Detection of Weak Spectral Features in Solids," Proc. IEEE Lasers and Electro-Optics Society Annual Meeting, IEEE Cat. No. 88CH 2683-1, pp. 246-248 (1988).

48. W. E. Moerner and L. Kador, "Optical Detection and Spectroscopy of Single Molecules in a Solid," *Phys. Rev. Lett.* **62**, 2535 (1989).

49. L. Kador, D. E. Horne, and W. E. Moerner, "Optical Detection and Probing of Single Dopant Molecules of Pentacene in a p-Terphenyl Host Crystal by Means of Absorption Spectroscopy," Feature Article in *J. Phys. Chem.* **94**, 1237 (1990).

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Published Conference Abstracts

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Invited Presentations: William Esco (W. E.) Moerner

1. "Conductivity and Optical Properties of Glow-Discharge Deposited Amorphous Silicon - A Promising New Semiconductor," Solid State Seminar, Cornell University Physics Department, November 15, 1977.
2. "Progress in Frequency Domain Optical Memories," Conference on Lasers and Electro-Optics (CLEO '82), Phoenix, Arizona, April 14-16, 1982. With G. C. Bjorklund and F. M. Schellenberg.
3. "Recent Progress in PHB Optical Memories," Symposium on Unconventional Photoactive Solids, Wasserschloss Mitwitz, Mitwitz, West Germany, June 28 - July 1, 1982. With G. C. Bjorklund, F. M. Schellenberg, and P. Pokrowsky.
4. "Persistent Spectral Hole Burning for a Molecular Vibrational Mode in a Crystalline Solid," Universität Bayreuth, Bayreuth, West Germany, July 2, 1982.
5. Progress in Frequency Domain Optical Memories," Chemical Physics Institute, ETH-Zürich, Switzerland, July 8, 1982. With G. C. Bjorklund.
6. "Progress in Frequency Domain Optical Memories," Institute for Inorganic Chemistry, Universität Bern, Switzerland, July 9, 1982. With G. C. Bjorklund.
7. "Progress in Frequency Domain Optical Memories and Hole-Burning at GaAlAs Laser Wavelengths," IBM Zürich Research Laboratory, Rüschlikon, Switzerland, July 12, 1982. With G. C. Bjorklund.
8. "Materials for Frequency Domain Optical Memories," Research Seminar, IBM Thomas J. Watson Research Center, October 13, 1982.
9. "Materials for Frequency Domain Optical Memory Applications: Progress and Remaining Problems," NRL - ONR Photochemistry Conference, Washington, D.C., October 15, 1982. With G. C. Bjorklund.
10. "Materials for Frequency Domain Optical Memory Applications: Progress and Outlook," SRI International, Menlo Park, California, November 3, 1982. With G. C. Bjorklund.
11. "Frequency Domain Optical Memories: An Important Application of Laser Spectroscopy," Physics Colloquium, University of Santa Clara, Santa Clara, California, April 18, 1983.
12. "Photochemical and Photophysical Spectral Hole Dynamics in Organic and Inorganic Systems," Chemical Physics Seminar, Stanford University, Stanford, California, April 21, 1983.
13. "Materials Requirements for Frequency Domain Optical Memories," Quantum Electronics Seminar on Experimental Techniques in Lasers and Optics, Stanford University, Stanford, California, October 24, 1983.
14. "Materials for Frequency Domain Optical Memories," 1983 Office of Naval Research and Naval Research Laboratory Photochemistry Conference, University of California at Los Angeles, Los Angeles, California, November 11, 1983.
15. "Hole-Burning Materials for Frequency Domain Optical Memories," March Meeting of the American Physical Society, Detroit, Michigan, March 28, 1984.

16. "Frequency Domain Optical Storage: The Quest for the Ultimate Material," Solid State Physics Seminar, Cornell University, Ithaca, New York, April 3, 1984.

17. "Frequency Domain Optical Storage: A Potentially Exciting Application of Laser Spectroscopy," Physics Colloquium, San Jose State University, San Jose, California, April 12, 1984.

18. "Organic Photoreactions for Frequency Domain Optical Storage," Gordon Research Conference on Electron Donor Acceptor Interactions, Plymouth, New Hampshire, August 13-17, 1984.

19. "A Challenge for Laser Spectroscopy of Solids: Frequency Domain Optical Storage," Lasers '84, San Francisco, California, November 26, 1984.

20. "Photochemical Hole-Burning," IBM Scientific Advisory Committee Meeting on Optical Storage, Boulder, Colorado, February 14, 1985.

21. "Laser-Light-Induced Physical Processes in Optical Materials: Persistent Spectral Hole-Burning," SPIE Critical Review on Radiation Effects in Optical Materials, Southwest Conference on Optics, Albuquerque, New Mexico, March 6, 1985.

22. "Persistent Spectral Hole-Burning: Dynamical Requirements for Frequency Domain Optical Storage," Gordon Research Conference on Molecular Electronic Spectroscopy, Wolfeboro, New Hampshire, August 12-16, 1985.

23. "Dynamical Hole-Burning Requirements for Frequency Domain Optical Storage," Second International Conference on Unconventional Photoactive Solids, Cleveland, Ohio, September 9-12, 1985.

24. "Materials for Photon-Gated Spectral Hole-Burning," Hewlett-Packard Laboratories, Palo Alto, California, February 11, 1986.

25. "Mechanisms for Photon-Gated Spectral Hole-Burning," Physical Chemistry Seminar, University of California, Santa Cruz, California, February 13, 1986.

26. "Frequency Domain Optical Storage Using Persistent Spectral Hole-Burning: Photon Gating," Society of Photographic Scientists and Engineers Annual Meeting, Minneapolis, Minnesota, May 19, 1986.

27. "Frequency Domain Optical Storage: Photon-Gated Materials," Xerox Palo Alto Research Center ICL Seminar, Palo Alto, California, August 18, 1986.

28. "Spectroscopy of Inhomogeneously Broadened Zero-Phonon Transitions in Solids: Persistent Spectral Hole-Burning and Beyond," Chemistry Department Colloquium, Indiana University, Bloomington, Indiana, September 24, 1987.

29. "Statistical Fine Structure in Inhomogeneously Broadened Absorption Lines in Solids," International Laser Science Conference ILS-III, Atlantic City, New Jersey, November 1-5, 1987. With T. P. Carter.

30. "Spectroscopy of Inhomogeneously Broadened Zero-Phonon Transitions in Solids: Persistent Spectral Hole-Burning and Beyond," Chemistry Colloquium, University of California, Riverside, California, November 11, 1987.

31. "Statistical Fine Structure in Inhomogeneously Broadened Spectral Lines," American Physical Society March Meeting, New Orleans, Lousiana,March 21-25, 1988.

32. "Statistical Fine Structure of Inhomogeneously Broadened Absorption Lines," Condensed Matter Seminar, University of California, Santa Cruz, California, May 8, 1988.

33. "Photon-Gating and High-Density Frequency Domain Optical Storage," IEEE Vail Computer Elements Workshop, Vail, Colorado, June 28, 1988.

34. "Statistical Fine Structure in Inhomogeneously Broadened Spectral Lines," AT&T Bell Laboratories, Murray Hill, New Jersey, July 1, 1988.

35. "New Developments in Laser Spectroscopy of Solids: Statistical Fine Structure," Cornell University Optical Science Seminar, Ithaca, New York, September 19, 1988.

36. "New Developments in Laser Spectroscopy of Solids--Statistical Fine Structure," Physical Chemistry Seminar, Iowa State University, Ames, Iowa, November 18, 1988.

37. "How to Use Inhomogeneous Broadening to Your Advantage: Statistical Fine Structure and Single Molecule Spectroscopy in Solids," American Physical Society March Meeting, St. Louis, Missouri, March 20-24, 1989.

38. "Statistical Properties of Inhomogeneously Broadened Lines in Solids," American Chemical Society Annual Meeting, Dallas, Texas, April 9-14, 1989.

39. "Photon-Gated Persistent Spectral Hole-Burning," International Symposium on Optical Memory, ISOM 89, Kobe, Japan, September 26-28, 1989.

40. "Ultrasensitive Laser Spectroscopy in Solids: Single-Molecule Detection," Fourth International Conference on Unconventional Photoactive Solids, The Almaden Symposium, San Jose, California, October 15-18, 1989.

41. "Fundamental Aspects of Persistent Spectral Hole-Burning: Photon-Gating, Statistical Fine Structure, and Absorption Spectra of Single Dopant Centers in Solids," invited talk presented at:

    (i) The Research Center for Advanced Science and Technology, University of Tokyo, Tokyo, Japan, October 23, 1989;
    (ii) SONY Corporation Central Research Center, Yokohama, Japan, October 24, 1989;
    (iii) Nikon Corporation Research Laboratory, Tokyo, Japan, October 25, 1989;
    (iv) Mitsubishi Central Research Laboratory, Hyogo, Japan, October 26, 1989;
    (v) Toray Industries Electronic and Imaging Materials Research Laboratory, Otsu, Japan, October 27, 1989.

42. "Organic Optoelectronic Materials," IBM 1989 Computer Science Symposium on Novel Computing, Gotemba, Japan, October 29, 1989. With G. C. Bjorklund.

43. "Persistent Spectral Hole-Burning: Photon-Gating and Fundamental Statistical Limits," International Symposium on Polymers for Microelectronics Science and Technology (PME '89), University of Tokyo, Tokyo, Japan, October 29 - November 2, 1989.

44. "Laser Spectroscopy of Solids: From Sqrt(N) to N = 1," U. S. - Japan Exchange Seminar on Dynamics of Excited States, East-West Center, University of Hawaii, Honolulu, Hawaii, November 6-10, 1989.

45. "Laser Spectroscopy of Solids: From Sqrt(N) to N = 1," Stanford Chemical Physics Seminar, Stanford, California, November 30, 1989.

46. "How to Find a Single Molecule in a Haystack: Optical Detection and Spectroscopy of a Single Molecule in a Solid," Chemistry Department Colloquium, Columbia University, New York, New York, December 14, 1989.

47. "Finding a Single Molecule in a Haystack: Single-Absorber Optical Spectroscopy in Molecular Solids," Western Spectroscopy Association Thirty-Seventh Annual Conference, Asilomar, California, January 25, 1990.

48. "New Observations in Laser Spectroscopy of Solids: From Sqrt(N) to N = 1," Washington University Physics Department Colloquium, St. Louis, Missouri, February 7, 1990.

49. "Finding a Needle in a Haystack: Optical Detection and Spectroscopy of Single Absorbers in Molecular Crystals," Physical Chemistry Colloquium, University of California, San Diego, San Diego, California, April 24, 1990.

50. "Finding a Needle in a Haystack: Optical Detection and Spectroscopy of Single Absorbers in Solids," International Quantum Electronics Conference IQEC 90, Anaheim, California, May 22, 1990. With L. Kador.

51. "Finding a Single Molecule in a Haystack: Laser Spectroscopy of Solids from Sqrt(N) to N = 1," University of Oregon, Chemical Physics Institute Retreat, Charleston, Oregon, September 22, 1990.

52. "Finding a Single Molecule in a Haystack: Laser Spectroscopy of Solids from Sqrt(N) to N = 1," University of Utah Physics Department Colloquium, Salt Lake City, Utah, October 18, 1990.

53. "Demonstration of Photorefractivity in Organic Polymers," Postdeadline Paper Optical Society of America Annual Meeting, Boston, Massachusetts, November 5-9, 1990. With S. Ducharme, J. C. Scott, and R. J. Twieg.

54. "Finding a Single Molecule in a Haystack: Laser Spectroscopy of Solids from Sqrt(N) to N = 1," SPIE Conference 1435 on Ultrasensitive Laser Spectroscopy, Los Angeles, California, January 21-23, 1991. With W. P. Ambrose.

55. "Finding a Single Molecule in a Haystack: Laser Spectroscopy of Solids from Sqrt(N) to N = 1," Simon Fraser University Physics Department Colloquium, Vancouver, British Columbia, April 3, 1991. With W. P. Ambrose.

56. "Finding a Single Molecule in a Haystack: Laser Spectroscopy of Solids from Sqrt(N) to N = 1," Physics Department Colloquium, University of British Columbia, Vancouver, British Columbia, April 4, 1991. With W. P. Ambrose.

57. "Observation of the Photorefractive Effect in Doped Nonlinear Polymers," Materials Research Society Spring Meeting, Anaheim, California, April 30 - May 1, 1991. With S. Ducharme, J. C. Scott, and R. J. Twieg.

58. "Observation of the Photorefractive Effect in Doped Nonlinear Polymers," Quantum Electronics and Laser Science QELS 91, Baltimore, Maryland, May 13-17, 1991. With S. Ducharme, J. C. Scott, and R. J. Twieg.

59. "Photorefractivity in Doped Nonlinear Organic Polymers," Soc. Photo-Opt. Instrum. Engr. Conference on Nonlinear Optical Properties of Organic Materials IV, San Diego, California, July 24-26, 1991. With S. Ducharme, J. C. Scott, and R. J. Twieg.

60. "The Photorefractive Effect in Nonlinear Polymers," International Topical Conference on Optical Probes of Conjugated Polymers, Snowbird, Utah, August 19-22, 1991. With J. C. Scott, S. Ducharme, and R. J. Twieg.

61. "The Photorefractive Effect in Nonlinear Polymers," ACS Symposium on Polymeric Materials for Photonic and Optical Applications, New York, New York, August 25-30, 1991. With J. C. Scott, S. Ducharme,and R. J. Twieg.

62. "Single Molecule Spectral Diffusion in a Solid Detected by Fluorescence Spectroscopy," 1991 International Conference on Dynamical Processes in the Excited States of Solids, Leiden, The Netherlands, August 27-30, 1991. With W. P. Ambrose and Th. Basché.

63. "Properties of Photorefractive Polymers," Observatoire Francais des Techniques Avancees Molecular Electronics Group Meeting, Paris, France, September 13, 1991.

64. "Observations of Spectral Diffusion in Solids on the Single Molecule Level," Fourth Congress of the French Chemical Society Colloquium on Perspectives in Molecular Electronics, Strasbourg, France, September 19, 1991.

65. "Optical Spectra of Single Impurity Molecules in a Polymer: Spectral Diffusion and Persistent Spectral Hole-Burning," Postdeadline Paper, First International Topical Meeting on Persistent Spectral Hole-Burning Science and Applications, Monterey, California, September 26-28, 1991. With Th. Basché.

66. "Photorefractivity in Doped Nonlinear Polymers," University of Arizona Optical Sciences Center Colloquium, Tucson, Arizona, October 24, 1991.

67. "Observations of Spectral Diffusion and Hole-Burning for a Single Molecule in a Solid," Physical Chemistry Seminar, University of California, Santa Barbara, California, January 14, 1992.

68. "Optical Spectroscopy of Single Impurity Molecules in Solids," Laser Applications in Chemical Analysis OSA Topical Meeting LACA III, Salt Lake City, Utah, January 27-30, 1992.

69. "A Solid as a Single-Molecule Trap: Observations of Spectral Diffusion and Hole-Burning of a Single Impurity Molecule," American Physical Society March Meeting, Indianapolis, Indiana, March 16-20, 1992.

70. "Characterization of Photorefractive Polymers: Proving Photorefractivity," American Chemical Society Symposium on Organic Optoelectronic Materials, Monterey, California, March 31 - April 3, 1992.

71. "Nonlinear Optical Properties of Organic Photorefractive Polymers," Materials Research Society Symposium V, San Francisco, California, April 27-May 1, 1992. With C. A. Walsh, S. M. Silence, R. J. Twieg, T. J. Matray, J. C. Scott, V. Y. Lee, R. D. Miller, F. Hache, D. M. Burland, and G. C. Bjorklund.

72. "A Solid as a Single-Molecule Trap: Spectral Diffusion, Hole-Burning, and Photon Antibunching," Quantum Electronics and Laser Science QELS 92, Anaheim, California, May 10-15, 1992. With Th. Basché, W. P. Ambrose, and M. Orrit.

73. "Photoconduction and Photorefraction in Molecularly Doped Polymers," European Materials Research Society Meeting, Strasbourg, France, June 8-12, 1992. With J. C. Scott, and L. Th. Pautmeier.

74. "Photorefractivity in Doped Nonlinear Polymers: Shifted Phase Gratings, Higher Speed, and Sensitization," Gordon Research Conference on Electronic Processes in Organic Materials, Andover, New Hampshire, July 27-31, 1992.

75. "Photorefractive Polymers: Visions and Present Status," Institute for Experimental Physics Colloquium, University of Bayreuth, Bayreuth, Germany, September 9, 1992.

76. "Photorefractive Polymers - A New Class of Materials for Optical Processing," Institute for Physical Chemistry Seminar, University of Munich, Munich, Germany, September 11, 1992.

77. **Plenary Lecture**, "A Solid as a Single-Molecule Trap: Optical Spectroscopy of Single Impurity Centers in a Solid," OSA Topical Meeting on Spectral Hole-Burning and Luminescence Line-Narrowing, Ascona, Switzerland, September 14-18, 1992.

78. "Photorefractivity in Nonlinear Organic Polymers," Optical Society of America Annual Meeting, Albuquerque, New Mexico, September 21, 1992. With S. Silence, J. C. Scott, C. A. Walsh, F. Hache, R. J. Twieg, T. Matray, V. Y. Lee, D. M. Burland, and G. C. Bjorklund.

79. "Optical Spectroscopy Using a Solid as a Single-Molecule Trap," Optical Society of America Annual Meeting, Albuquerque, New Mexico, September 21, 1992. With Th. Basché, and M. Orrit.

80. "Probing a Single Molecule Hidden Deep Inside a Solid," DOE Workshop on Advanced Laser Techniques for Chemical Measurements, Santa Fe, New Mexico, October 19-21, 1992.

81. "Physical Studies in Solids at the Single-Molecule Level," CLS-2 Seminar, Los Alamos National Laboratory, Los Alamos, New Mexico, October 21, 1992.

82. "Nonlinear Optical Properties of Photorefractive Polymers," OE-LASE Conference, Los Angeles, California, January 19-21, 1993. With S. M. Silence, F. Hache, M. Donckers, C. A. Walsh, D. M. Burland, G. C. Bjorklund, and R. J. Twieg.

83. **Samuel M. McElvain Lecture**, "Recent Developments in the Optical Spectroscopy of Single Molecular Impurities in Solids," Chemistry Department, University of Wisconsin, Madison, Wisconsin, March 2, 1993.

84. "New Developments in Photorefractive Polymers," American Physical Society March Meeting, Seattle, Washington, March 22-26, 1993.

85. "Optical Spectroscopy of Single Molecules in Solids," American Chemical Society Annual Meeting, Denver, Colorado, March 29 - April 2, 1993.

86. "New Developments in Organic Photorefractive Polymers," Materials Research Society Spring Meeting Symposium on Organic Materials for Nonlinear Optical Applications, San Francisco, California, April 14-16, 1993. With S. M. Silence, M. Donckers, F. Hache, C. A. Walsh, E. Ginsburg, P. K. Jenkner, G. C. Bjorklund, D. M. Burland, R. D. Miller, J. C. Scott, and R. J. Twieg.

87. "Optical Spectroscopy of a Single Impurity Molecule in a Solid: Spectral Diffusion, Photon Antibunching, and Single-Spin Magnetic Resonance," Condensed Matter Seminar, University of California, Berkeley, California, April 21, 1993.

88. "Optical Spectroscopy of a Single Impurity Molecule in a Solid," Physical Chemistry Seminar, University of Pittsburg, Pittsburg, Pennsylvania, April 29, 1993.

89. "Recent Progress in Photorefractive Polymers," Quantum Electronics and Laser Science Conference (QELS 93), Baltimore, Maryland, May 2-7, 1993. With S. M. Silence, M. C. J. M. Donckers, C. A. Walsh, F. Hache, E. J. Ginsburg, P. K. Jenkner, J. C. Scott, R. J. Twieg, R. D. Miller, G. C. Bjorklund, and D. M. Burland.

90. "Single-Molecule Spectral Diffusion in Crystals and Polymers," Ninth International Conference on Dynamical Processes in Excited States of Solids, Cambridge, Massachusetts, August 2-6, 1993.

91. "Overview of Single-Molecule Spectroscopy in Condensed Media," 1993 International Conference on Luminescence and Optical Spectroscopy in Condensed Matter, Storrs, Connecticut, August 9-13, 1993.

92. "Spectral Hole-Burning and Quantum Effects of Single Impurity Molecules in a Solid," 1993 International Conference on Luminescence and Optical Spectroscopy in Condensed Matter, Storrs, Connecticut, August 9-13, 1993. With Th. Basché.

93. "Examining the Components of the Ensemble Average Using Single-Molecule Spectroscopy in Solids: Spectral Diffusion, Phototransformations, and Single-Spin Experiments," Stanford University Physical Chemistry Seminar, Stanford, California, September 30, 1993.

94. "Recent Advances in Photorefractive Polymers: High Efficiency, Improved Speed, and Net Two-Beam Coupling Gain," ACS/OSA Topical Meeting on Organic Thin Films for Photonic Applications, Toronto, Ontario, Canada, October 6-8, 1993. With G. C. Bjorklund, D. M. Burland, P. K. Jenkner, R. D. Miller, J. C. Scott, S. M. Silence, R. J. Twieg, and C. A. Walsh.

95. "Recent Developments in Single-Molecule Spectroscopy in Solids: Spectral Diffusion, Vibrational Spectroscopy, and Magnetic Resonance of a Single Molecular Spin," Physical Chemistry Seminar, University of Munich, Munich, Germany, 10 November 1993.

96. "Recent Developments in Single-Molecule Spectroscopy in Solids: Spectral Diffusion, Vibrational Spectroscopy, and Magnetic Resonance of a Single Molecular Spin," Laser Seminar, Max Planck Institute for Quantum Optics, Garching, Germany, 11 November 1993.

97. "Recent Developments in the Spectroscopy of Single Molecules in Solids," Inorganic Chemistry Seminar, University of Bern, Bern, Switzerland, 18 November 1993.

98. "Recent Developments in Single-Molecule Spectroscopy in Solids: Spectral Diffusion, Vibrational Spectroscopy, and Magnetic Resonance of a Single Molecular Spin," Laser Seminar, IBM Zürich Research Laboratory, Rüschlikon, Switzerland, 6 December 1993.

99. "Recent Developments in Single-Molecule Spectroscopy in Solids: Spectral Diffusion, Vibrational Spectroscopy, and Magnetic Resonance of a Single Molecular Spin," Organic Chemistry Seminar, ETH Zürich, Zürich, Switzerland, 15 December 1993.

100. "Recent Developments in the Spectroscopy of Single Molecules in Solids," Physics Colloquium, University of Ulm, Ulm, Germany, January 21, 1994.

101. "New Frontiers in Single-Molecule Spectroscopy in Solids: Spectral Diffusion, Vibrational Modes, and Magnetic Resonance of a Single Molecular Spin," Laboratory for Physical Chemistry Colloquium, ETH-Zürich, Zürich, Switzerland, February 15, 1994.

102. **Ehrenfest Colloquium**, "Spectroscopy of Individual Molecules in Solids," University of Leiden, Leiden, The Netherlands, March 16, 1994.

103. "Photorefractive Polymers," Philips Research Laboratories, Eindhoven, The Netherlands, March 17, 1994.

104. "Detection and Spectroscopy of Single Molecules in Solids," Conference on Development of Sensors for Environmental Microbes, Logan, Utah, April 11, 1994.

105. "New Frontiers in Solids at the Level of a Single Impurity Molecule," Physics Seminar, University of Utah, Salt Lake City, Utah, April 12, 1994.

106. "Photorefractive Polymers," Laser Seminar, ETH-Hönggerberg, Zürich, Switzerland, April 25, 1994.

107. "Recent Advances in Single-Molecule Spectroscopy in Solids: Vibrational Modes and Near-Field Excitation at Low Temperatures," Optical Spectroscopy and Magnetic Resonance on Single Molecules, WE-Heraeus-Seminar 130, Physikzentrum Bad Honnef, Germany, May 30 – June 1, 1994.

108. "New Frontiers in Single Molecule Spectroscopy in Solids," Gordon Research Conference on Electronic Processes in Organic Materials, Proctor Academy, New Hampshire, July 24-29, 1994.

109. "Spectroscopy of Individual Molecules Trapped in Solids," 14th International Conference on Atomic Physics, Boulder, Colorado, July 31-August 5, 1994.

110. "Photorefractive Polymers **Tutorial**," ACS/OSA Symposium on Polymeric Thin Films for Photonic Applications, Washington, D. C., August 21-24, 1994. With S. M. Silence, G. C. Bjorklund, D. M. Burland, R. D. Miller, J. J. Stankus, and R. J. Twieg.

111. "New Frontiers in Single-Molecule Spectroscopy in Solids: Resonance Frequency Shifts, Vibrational Modes, and Magnetic Resonance of a Single Molecular Spin," American Chemical Society National Meeting, Washington, D. C., August 21-24, 1994.

112. "Science and Applications of Photorefractive Polymers," OSA Topical Meeting on Spectral Hole-Burning and Related Spectroscopies, Tokyo, Japan, August 24-26, 1994. With S. M. Silence, G. C. Bjorklund, D. M. Burland, R. D. Miller, J. J. Stankus, and R. J. Twieg.

113. "Spectroscopy of Individual Molecules in Solids," NRC-CNRC Gerhard Herzberg Honorary Conference on The Future of Spectroscopy, Ste-Adèle, Quebec, September 26-28, 1994.

114. "Photorefractive Polymers and Their Applications," Optical Society of America Annual Meeting - ILS IX, Dallas, Texas, October 2-7, 1994. With G. C. Bjorklund, S. M. Silence, and J. J. Stankus.

115. "New Frontiers in Single-Molecule Spectroscopy in Solids," Chemistry Department Colloquium, University of Chicago, Chicago, Illinois, October 24, 1994.

116. "Probing Nanoenvironments in Solids with Individual Impurity Molecules," Physical Chemistry Seminar, University of California, Berkeley, California, November 1, 1994.

117. "New Frontiers in Single-Molecule Spectroscopy in Solids," Condensed Matter Seminar, University of California, Davis, California, November 10, 1994.

118. "Guacamoles as Probes of Local Environments in Solids," Aspen 1995 Winter Conference on Condensed Matter Physics, Aspen, Colorado, January 15-21, 1995.

119. "New Frontiers in the Spectroscopy of Individual Molecules in Solids," Physical Chemistry Seminar, University of Illinois, Urbana, Illinois, January 25, 1995.

120. "Dynamics and Vibrational Spectra of Individual Molecules in Polymer Glasses," Photonics West Conference on Advanced Optical Methods for Ultrasensitive Detection, San Jose, California, February 6-7, 1995. With Anne B. Myers and P. Tchénio.

121. "Guacamoles, Shpol'skii Matrices, and Subwavelength Optical Spectroscopy," Science Colloquium, IBM Almaden Research Center, San Jose, California, February 10, 1995.

122. **Arthur D. Little Lecture in Physical Chemistry**,"Science and Applications of Photorefractive Polymers," Massachusetts Institute of Technology, Boston, Massachusetts, March 7, 1995.

123. **Arthur D. Little Lecture in Physical Chemistry**, "Probing Nanoenvironments in Solids with Single Impurity Molecules," MIT/Harvard Physical Chemistry Seminar, Massachusetts Institute of Technology, Boston, Massachusetts, March 9, 1995.

124. **Tutorial Lecture**, "Science and Applications of Photorefractive Polymers," March Meeting of the American Physical Society, San Jose, California, March 19, 1995.

125. "Near-Field Optical Spectroscopy of Single Molecules in Solids," Joint U. S.-European Conference on Nanostructures, University of California, Santa Barbara, March 27-28, 1995.

126. **Plenary Lecture**, "Magnetic Resonance Spectroscopy of A Single Molecular Spin," 36th Experimental Nuclear Magnetic Resonance Conference, Boston, Massachusetts, March 26-30, 1995. With J. Köhler, E. J. J. Groenen, and J. Schmidt.

127. "Photorefractivity in Organic Polymeric Materials," SPIE Conference on Xerographic Photoreceptors and Photorefractive Polymers, San Jose, California, July 10-11, 1995. With C. Poga, D. M. Burland, T. Hanemann, C. R. Moylan, S. M. Silence, and R. J. Twieg.

128. "Photon-Gated Spectral Hole-Burning Materials," Conference on Material Requirements for Persistent Spectral Hole Burning and Time-Domain Optical Storage and Processing, Bozeman, Montana, August 3-4, 1995.

129. "Photorefractive Polymer Composites: A New Class of Optical Holographic Materials," Society for Applied Spectroscopy and Golden Gate Polymer Forum, Menlo Park, California, September 7, 1995.

130. "Near-Field Optical Spectroscopy of Single Molecules in Solids," Seventh International Conference on Unconventional Photoactive Systems, Palo Alto, California, September 5-8, 1995. With D. Pohl, and U. P. Wild.

131. "Near-Field Excitation and Stark Effect of Single Molecules in Solids," Optical Society of America Annual Meeting/ILS-XI, Portland, Oregon, September 10-15, 1995. With U. P. Wild, and D. Pohl.

132. "Photorefractive Polymers for Holographic Optical Storage," OSA/ACS Topical Meeting on Organic Thin Films for Photonics Applications, Portland, Oregon, September 11-14, 1995. With C. Poga, Y. Jia, and R. J. Twieg.

133. "Probing Nanoenvironments in Solids with Single Impurity Molecule Spectroscopy," Condensed Matter Physics Seminar, UCSD, La Jolla, California, October 4, 1995.

134. "Probing Nanoenvironments in Solids Using Single Impurity Molecule Spectroscopy," University of Arizona Optical Sciences Center Colloquium, Tucson, Arizona, October 26, 1995.

135. "Probing Nanoenvironments in Solids with Single Impurity Molecules," Todai Institute of Solid State Physics Symposium 1995, Tokyo, Japan, November 8-10, 1995.

136. "Fundamentals of Single-Molecule Spectroscopy," International Workshop on Single Molecule Spectroscopy: New Systems and Methods, Monte Verita, Ascona, Switzerland, March 10-15, 1996.

137. "Mechanisms of Photorefractivity in Polymer Composites," ACS Annual Meeting Symposium on Charge Transfer Interactions in Polymers, New Orleans, Louisiana, March 24-29, 1996. With D. M. Burland, C. R. Moylan, and R. J. Twieg.

138. "High-Resolution Spectroscopy of Single Molecules in Solids," (**Plenary)** 51st Ohio State University International Symposium on Molecular Spectroscopy, Columbus, Ohio, June 10-14, 1996.

139. "Optical Spectroscopy of Individual Molecules in Solids," Gordon Research Conference on Atomic and Molecular Interactions, Colby-Sawyer College, New London, New Hampshire, June 30 - July 5, 1996.

140. "Mechanisms of Photorefractivity in Polymer Composites," SPIE Conference on Organic Photorefractive Materials and Xerographic Photoreceptors, Denver, Colorado, August 7-8, 1996.

141. "High-Density Digital Data Storage in Organic Photorefractive Materials," SPIE Conference on Organic Photorefractive Materials and Xerographic Photoreceptors, Denver, Colorado, August 7-8, 1996. With P. M. Lundquist, C. Poga, R. G. Devoe, R. M. Shelby, and R. J. Twieg.

142. "Fundamentals of Single-Molecule Spectroscopy in Solids," Fifth International Meeting on Hole Burning and Related Spectroscopies, Brainerd, Minnesota, September 13-17, 1996. With D. J. Norris.

143. "Single-Molecule Nanophotonics: Gels and Molecular Motors," Physical Chemistry Seminar, University of California San Diego, La Jolla, California, October 8, 1996.

144. "Single-Molecule Nanophotonics," Sixth NEC Symposium on Fundamental Approaches to New Material Phases: Quantum Optical Phenomena in Spatially Confined Materials, Karuizawa, Japan, October 13-17, 1996.

145. "Single-Molecule Nanophotonics," University of Texas Organic Chemistry Seminar, Austin, Texas, October 25, 1996.

146. "Probing Nanoenvironments in Condensed Media with Single Fluorophores," Chemistry Division Seminar, Argonne National Laboratory, Argonne, Illinois, December 2, 1996.

147. "Mechanisms of Photorefractivity in Polymer Composites," Third International Conference on Organic Nonlinear Optics, Marco Island, Florida, December 16-20, 1996. With A. Grunnet-Jepsen, and C. Thompson.

148. "Observation of Beam Fanning in a Photorefractive Polymer," Materials Research Society 1997 Spring Meeting, San Francisco, California, March 31- April 4, 1997. With A. Grunnet-Jepsen, and C. L. Thompson.

149. "Polyacrylamide Gels for Single-Molecule Biophysics," Symposium on Chemistry of Single Molecules, American Chemical Society Annual Meeting, San Francisco, California, April 13-17, 1997. With R. M. Dickson.

150. "Single-Molecule Nanophotonics," La Jolla Interfaces in Science Conference, April 18, 1997.

151. "Recent Advances in Photorefractive Polymer Materials," SPIE Symposium 3147, Nonlinear Optical Properties of Organic Materials X, San Diego, California, July 30 – August 1, 1997. With A. Grunnet-Jepsen, and C. L. Thompson.

152. "Single-Molecule Spectroscopy in Chemistry and Biophysics: Peeling Back the Ensemble Average," R. B. Woodward Lecture, Department of Chemistry and Chemical Biology, Harvard University, Cambridge, Massachusetts, September 15, 1997.

153. "Mechanisms and Applications of Photorefractivity in New Polymer Composites," R. B. Woodward Lecture, Department of Chemistry and Chemical Biology, Harvard University, Cambridge, Massachusetts, September 18, 1997.

154. "Recent Advances in High Gain Photorefractive Polymers," IEEE Lasers and Electro-Optics Society Annual Meeting, San Francisco, California, November 10-13, 1997. With A. Grunnet-Jepsen.

155. "Optical Probes of Single Molecules and Proteins in Gels," Advances in Cellular Imaging, Cambridge Healthtech Institute, San Diego, California, November 13-14, 1997. With R. M. Dickson and S. Kummer.

156. "Single-Molecule Nanophotonics in Solids, Liquids, and Proteins," Japan-U. S. Information Exchange Seminar on Photophysics and Photoconversion in Small domains by Near-Field Scanning Optical Microscopy," Napa Valley, California, January 10-14, 1998. With R. M. Dickson and S. Kummer.

157. "Understanding Photorefractivity in Polymers: Materials for an Optical Transistor?" Physical Chemistry Colloquium, University of California, Berkeley, Berkeley, California, January 27, 1998.

158. "Photorefractive Polymers: Materials for Optical Processing Applications," Weissberger-Williams Lecture, Eastman Kodak Company, Rochester, New York, February 6, 1998.

159. "Optical Studies of Individual Molecules, One at a Time—What Can We Learn?", Physical Chemistry Seminar, University of California Irvine, Irvine, California, February 17, 1998.

160. "Optical Studies of Single Molecules and Proteins in Biocompatible Gels," Annual Meeting, Biophysical Society, Kansas City, Missouri, February 22-26, 1998. With R. M. Dickson and S. Kummer.

161. "Optical Properties of Single Small Fluorophores and Single Green Fluorescent Protein Molecules in Poly(acrylamide) Gels," March Meeting, American Physical Society, Los Angeles, California, March 16-20, 1998.

162. "Recent Advances in Photorefractive Polymer Composites," Dallas National Meeting, American Chemical Society, Dallas, Texas, March 29 – April 2, 1998. With A. Grunnet-Jepsen, B. Smith, and D. Wright.

163. "Single-Molecule Optical Probes of Local Environments in Gels and Proteins," Dallas National Meeting, American Chemical Society, Dallas, Texas, March 29 – April 2, 1998. With R. M. Dickson and S. Kummer.

164. "Single-Molecule 'Astronomy' in Condensed Media: Peeling Back the Ensemble Average," Chemical Sciences and Technology Laboratory Colloquium, National Institute of Standards and Technology, Gaithersburg, Maryland, April 15, 1998.

165. "Recent Advances in High Gain Photorefractive Polymers," Conference on Lasers and Electro-Optics CLEO '98, San Francisco, California, May 3-8, 1998. With A. Grunnet-Jepsen, D. A. Wright, and B. R. Smith.

166. "High-Speed Photorefractive Polymer Composites," Postdeadline Paper, Conference on Lasers and Electro-Optics CLEO '98, San Francisco, California, May 3-8, 1998. With M. A. Diaz-Garcia, D. Wright, M. DeClue, J. Casperson, B. R. Smith, and R. J. Twieg.

167. "Recent Advances in Single-Molecule Spectroscopy in Chemistry and Biophysics: Peeling Back the Ensemble Average", Gordon Conference on Electronic Processes in Organic Materials, Salve Regina University, Newport, Rhode Island, July 26-31, 1998.

168. "Mechanisms of Photorefractivity in Polymer Composites," Summer School on Molecular Optoelectronics, Cursos de Verano, San Lorenzo de El Escorial, Madrid, Spain, August 3-7, 1998.

169. "Applications of Photorefractive Polymers," Summer School on Molecular Optoelectronics, Cursos de Verano, San Lorenzo de El Escorial, Madrid, Spain, August 3-7, 1998.

170. "Fast and Efficient Photorefractivity in Polymer Composites," American Chemical Society Annual Meeting Symposium on Organic Thin Films for Photonic Applications, Boston, Massachusetts, August 23-27, 1998. With M. A. Diaz-Garcia, A. Grunnet-Jepsen, D. Wright, M. Bratcher, M. DeClue, J.S. Siegel, and R.J. Twieg.

171. "Optical Probes of Single Molecules and Proteins in Aqueous Environments," 4th International Workshop on Single Molecule Detection and Ultrasensitive Analysis in the

Life Sciences, Berlin Adlershof, September 30-October 2, 1998. With R. M. Dickson, S. Kummer, and E. J. Peterman.

172. "Optical Detection of Single Molecules and Individual Proteins in Poly(Acrylamide) Gels," Optical Society of America Annual Meeting, Baltimore, Maryland, October 4-9, 1998. With R. M. Dickson, S. Kummer, E. J. Peterman, J. Deich and J. Frazier.

173. "Mechanisms for High Gain in Photorefractive Polymers," Optical Society of America Annual Meeting, Baltimore, Maryland, October 4-9, 1998. With M. A. Diaz-Garcia, A. Grunnet-Jepsen, and D. Wright.

174. "Optical Spectroscopy of Individual Molecules in Solids and Biological Environments," Physics Research Conference Colloquium, California Institute of Technology, October 15, 1998.

175. "Those Blinking Single Molecules!" Science and Technology Colloquium, IBM Almaden Research Center, October 23, 1998.

176. "Optical Spectroscopy of Individual Molecules in Solids and Biological Environments," Chemical Physics Seminar, California Institute of Technology, November 3, 1998.

177. "Single-Molecule Spectroscopy," Frontiers in Spectroscopy Lectures, Ohio State University, Columbus, Ohio, January 20-22, 1999.

178. "Single-Molecule Optical Probes in Physical Chemistry and Biophysics," Optics and Quantum Electronics Seminar, Stanford University, Stanford, California, February 8, 1999.

179. "Single-Molecule Studies of Fluorescent Proteins and Enzymes," Biophysical Society Annual Meeting, Baltimore, Maryland, February 13-17, 1999. With E. J. Peterman, H. Sosa, S. Brasselet, R. M. Dickson, S. Kummer, R. Sakowicz, and L. S. B. Goldstein.

180. "Single-Molecule Spectroscopy and Detection and Low and Room Temperature," Seventh Japan Science and Technology Corporation International Symposium on Molecular Processes and Biosystems, Tokyo, Japan, February 24-25, 1999. With S. Brasselet, and E. J. Peterman.

181. "New Insights into Trapping and Compensation in Photorefractive Polymers," Material Research Society Spring Meeting Symposium F, San Francisco, California, April 5-9, 1999. With D. Wright, M. Diaz-Garcia, A. Goonesekera, J. Casperson, B. Smith, M. S. DeClue, E. Glazer, J. S. Siegel, and R. J. Twieg.

182. "Understanding Trapping in Photorefractive Polymer Composites for Optical Processing Applications," Conference on Lasers and Electro-Optics CLEO '99, Baltimore, Maryland, May 23-28, 1999. With A. Grunnet-Jepsen, D. Wright, J. Casperson, E. Glazer, M. DeClue, J. S. Siegel, and R. J. Twieg.

183. "Single-Molecule Optical Science in Physical Chemistry and Biophysics," Nobel Conference on Single-Molecule Spectroscopy in Physics, Chemistry, and Biology, Lindigo, Sweden, June 5-9, 1999.

184. "Understanding Photorefractivity in High-Performance Polymer Composites," Seventh Topical Meeting on Photorefractive Materials, Effects, and Devices, PR'99, Elsinore, Denmark, June 27-30, 1999. With A. Grunnet-Jepsen, D. Wright, M. S. DeClue, J. S. Siegel, and R. J. Twieg.

185. P**lenary Lecture**, "Single-Molecule Optical Imaging and Spectroscopy Can Probe Hidden Complexity," International Conference on Photochemistry ICP'99, Duke University, Durham, North Carolina, August 2-6, 1999.

186. **Critical Review**, "Single Molecules Under an Optical Spotlight," Interdisciplinary Laser Science Conference ILS-XV, Santa Clara, California, September 26-October 1, 1999.

187. "Trap Dynamics in Photorefractive Polymer Composites," Materials Research Society Fall Meeting, Boston, Massachusetts, November 29 - December 3, 1999. With D. Wright, A. Goonesekera, M. A. Diaz-Garcia, and R. J. Twieg.

188. "Shedding Light on Single Biomolecules," *Frontiers in Biosciences Series*, Stanford University, Stanford, California, January 13, 2000.

189. "Single Molecules Under an Optical Spotlight," Special Seminar, Laboratoire de Photonique Quantique et Moléculaire, Ecole Normale Supérieure de Cachan, France, January 28, 2000.

190. "Single-Molecule Optical Spectroscopy in Condensed Matter," 6th French-Israeli Symposium on Nonlinear Quantum Optics, FRISNO6, Ecole de Physique, Les Houches, France, January 30 – February 4, 2000.

191. "Single Molecules Under an Optical Spotlight," Third Flory Conference on Physical and Macromolecular Chemistry, Stanford University, Stanford, CA, February 11-12, 2000.

192. "Single Photons on Demand from Individual Molecules," Quantum Entanglement Symposium, Stanford University, Stanford, CA, March 20-22, 2000. With B. Lounis.

193. "Optical Studies of Single Biomolecules in Aqueous Environments," American Chemical Society Annual Meeting, Washington, DC, August 20-24, 2000. With S. Brasselet, B. Lounis, E. J. G. Peterman, H. Sosa, and L. S. B. Goldstein.

194. "Single-Molecule Studies of Fluorescent Proteins and Molecular Motors," Third European Biophysics Congress, Munich, Germany, September 9-13, 2000.

195. "Advanced Microscopy for Protein Localization in Caulobacter," DARPA Biofutures Meeting, Hilton Washington Dulles, November 1-2, 2000. With M. Paige, S. Nishimura, E. Judd, and L. Shapiro.

196. "Mechanisms of Photorefractivity in Polymer Composites," Northwestern University Organic Materials Symposium, Evanston, Illinois, November 17, 2000.

197. "Trap Dynamics in Photorefractive Polymers: Mechanisms and Applications," Symposium on Field-Responsive Polymers, American Chemical Society POLY Millenial 2000, Waikoloa, Hawaii, December 9-13, 2000. With D. Wright, A. Goonesekera, M. DeClue, J. S. Siegel, and R. J. Twieg.

198. "Recent Progress in Photorefractive Polymers: Mechanisms and Applications," International Congress of Pacific Basin Societies, Pacifichem 2000, Honolulu, Oahu, Hawaii, December 14-19, 2000. With D. Wright, U. Gubler, A. Goonesekera, M. DeClue, J. S. Siegel, M. He, and R. J. Twieg.

199. "Single-Molecule Spectroscopy, from Quantum Optics to Molecular Motors," Aspen Winter Workshop on Single Molecule Biophysics, Aspen, Colorado, January 14-20, 2001.

200. **Public Lecture**, "Visualizing Single Molecules with Lasers," Aspen Center for Physics

Winter Conference 2001, Aspen, Colorado, January 17, 2001.

201. "Single-Molecule Spectroscopy: From Biophysics to Quantum Optics," Physical Chemistry Seminar, University of California, Berkeley, California, January 23, 2001.

202. "Single-Molecule Spectroscopy to Explore Fluorescent Proteins and Molecular Motors," Chemistry Department Seminar, Boston College, Boston, Massachusetts, February 22, 2001.

203. "Single-Molecule Spectroscopy, from Molecular Motors to Quantum Optics," Physics Department Colloquium, University of Chicago, Chicago, Illinois, March 1, 2001.

204. **William Draper Harkins Lecture**, "Pushing Back Ensemble Averaging with Single-Molecule Spectroscopy," Chemistry Department, University of Chicago, Chicago, Illinois, March 5, 2001.

205. "Single-Molecule Spectroscopy and Imaging: History, Fundamentals, and Recent Examples," Tutorial Lecture, T6: Single Molecule Imaging in Condensed Matter and Biology, American Physical Society March Meeting, Seattle, Washington, March 11, 2001.

206. **Earle K. Plyler Prize Lecture**, "Single-Molecule Spectroscopy: From 2K, to Molecular Motors, to Quantum Optics," American Physical Society March Meeting, Seattle, Washington, March 12-16, 2001.

207. "Single-Molecule Spectroscopy: From Quantum Optics to Molecular Motors," American Chemical Society Annual Meeting, April 1-5, 2001. With B. Lounis, H. Sosa, E. J. G. Peterman, and L. S. B. Goldstein.

208. "Photorefractive Polymers: What They Are and What You Can Do With Them," Quantum Electronics Seminar, Department of Applied Physics, Stanford University, Stanford, California, April 16, 2001.

209. "Photorefractive Polymer Design Strategies," Society of Photo-Optical Instrumentation Engineers Annual Meeting, San Diego, California, July 29 - August 3, 2001. With D. Wright, U. Gubler, M. He, R. J. Twieg, M. DeClue, and J. S. Siegel.

210. "Single-Biomolecule Optical Detection and Spectroscopy, from Molecular Motors to MHCII in Live Cells," Fourth International Conference on Biological Physics, ICBP 2001, Kyoto, Japan, July 30 - August 3, 2001. With M. Vrljic, S. Nishimura, H. M. McConnell, H. Sosa, E. Peterman, and Larry Goldstein.

211. **Moses Gomberg Lecture**, "Single-Molecule Spectroscopy, from Quantum Optics to Molecular Motors," Department of Chemistry, University of Michigan, September 6, 2001.

212. "Optical Spectroscopy of Single Biomolecules," Optical Society of America Annual Meeting / Interdisciplinary Laser Science XVII, Long Beach, California, October 14-18, 2001. With M. Vrjlic, S. Nishimura, and H. McConnell.

213. "Single-Molecule Spectroscopy: From Low-Temperature Physical Chemistry to Biophysics," Nobel Jubilee Centennial Symposium: "Frontiers in Molecular Science," Friiberghs Herdegaard, Stockholm, Sweden, December 4-7, 2001.

214. "Recent Advances in the Understanding and Development of Photorefractive Polymers and Glasses," Sixth International Conference on Organic Nonlinear Optics, ICONO'6, Tucson, Arizona, December 16-20, 2001. With D. Wright, U. Gubler, O. Ostroverkhova, M. He,

A. Sastre-Santos, and R. J. Twieg.

215. "Single-Molecule Spectroscopy, from Quantum Optics to Molecular Motors," Chemistry Colloquium, Department of Chemistry, Cornell University, Ithaca, New York, February 14, 2002.

216. "Single-Molecule Spectroscopy: From Molecular Motors to Quantum Optics," Physical Chemistry Seminar, Colorado State University, Ft. Collins, Colorado, March 21, 2002.

217. "Single-Molecule Spectroscopy, from Biophysics to Quantum Optics," Chemical Physics Seminar, Department of Chemistry and Biochemistry, University of Colorado and JILA, Boulder, Colorado, March 22, 2002.

218. "High-Performance Photorefractive Organic Glasses: Understanding Mechanisms and Limitations," Society of Photo-Optical Instrumentation Engineers Annual Meeting, Seattle, Washington, July 7-11, 2002. With O. Ostroverkhova, U. Gubler, D. Wright, M. He, and R. J. Twieg.

219. "Emerging Frontiers in Single-Molecule Spectroscopy," Volkswagen Stiftung Third International Symposium on Physics, Chemistry, and Biology with Single Molecules, Tutzing, Germany, September 22-25, 2002.

220. "Emerging Frontiers in Single-Molecule Spectroscopy," Eighth International Workshop on Single Molecule Detection and Ultrasensitive Analysis in Life Sciences," Berlin-Adlershof, Germany, September 25-27, 2002.

221. "Emerging Frontiers in Single-Molecule Spectroscopy," Physics Colloquium, University of Illinois at Urbana-Champaign, Urbana, IL, October 10, 2002.

222. "Single-Molecule Biophysics," Biophysics Seminar, University of Illinois at Urbana-Champaign, Urbana, IL, October 11, 2002.

223. "Optical Measurements of Single Molecules in Cells," NIH-NIDA Workshop on Emerging Technologies: Analysis of Endogeneous Biomaterials and Single-Molecule Studies, Rockville, MD, December 4-5, 2002.

224. "New Fluorophores and Analyses for Single-Molecule Spectroscopy and Enzymology," Second Aspen Conference on Single-Molecule Biophysics, Aspen, CO, January 5-11, 2003.

225. "High Performance Photorefractive Polymers and Glasses: Mechanisms and Applications," IBM Almaden Science and Technology Colloquium, San Jose, CA, February 7, 2003.

226. "Single Molecules as Nanophotonic Probes and Sources," March Meeting of the American Physical Society, Austin, TX, March 3-7, 2003.

227. "Single Molecules as Local Nanoscopic Probes," Nanoscience and Technology Conference, Groningen, The Netherlands, May 18-21, 2003.

228. "Optically Sensing the State of a Single Molecule," Quantum Electronics and Laser Science Conference, Baltimore, MD, June 1-6, 2003. With K. A. Willets and O. Ostroverkhova.

229. "Lighting the Way with Single Molecules," DC to Daylight: A Symposium Honoring Prof. A. J. Sievers, Cornell University, Ithaca, NY, June 14, 2003.

230. "Single Molecules as Local Nanophotonic Probes and Sources", a series of lectures presented in the Conference Universitaire de Suisse Occidentale du 3ème Cycle en Chimie:

    (a) "Single-Molecule Spectroscopy as a Local Nanoscopic Probe," University of Basel, June 18, 2003

    (b) "Optical Spectroscopy of Single Molecules in Condensed Phases," University of Bern, June 19, 2003

    (c) "Biophysical Studies Using Single-Molecule Local Probes," EPFL Lausanne, June 20, 2003

    (d) "Fundamentals of Single-Molecule Spectroscopy and Nanophotonics," University of Geneva, June 23, 2003

    (e) "Applications of Single Molecules as Nanophotonic Probes and Sources," University of Geneva, June 24, 2003

229. "Observing Single Molecules in Cells, and a New Class of Single-Molecule Fluorophores," Gordon Research Conference on Electronic Spectroscopy and Dynamics, Bates College, Lewiston, ME, July 6-11, 2003.

230. "Single Molecules as Local Nanoscopic Probes," Eighth International Meeting on Hole Burning, Single Molecule, and Related Spectroscopies: Science and Applications, Bozeman, MT, July 27-31, 2003.

231. "Emerging Frontiers in Single-Molecule Fluorescence Imaging," American Chemical Society Annual Meeting, New York, NY, September 7-11, 2003.

232. "A Single Molecule as a Nanoscale Probe," Nanoscale Science and Technology Workshop 2003, University of Washington Center for Nanotechnology, Seattle, WA, September 22-23, 2003. With S. Y. Nishimura.

233. "Optical Probing of Single Molecules: Examples from Physics, Chemistry, and Biophysics," Physics Department, University of Queensland, Brisbane, Queensland, Australia, November 25, 2003.

234. "Single Molecules March to Different Drummers: Jellyfish, Cholesterol, and Quantum Communication," Toyota Lecture, Australian National University, Canberra, Australian Capital Territory, Australia, November 26, 2003.

235. "Optical Probing of Single Molecules: Examples from Physics, Chemistry, and Biophysics," Swinburne Institute of Technology, Melbourne, Victoria, Australia, November 27, 2003.

236. "Single Molecules as Nanophotonic Probes and Sources," Geoffrey Frew Fellowship Lecture, Australian Conference on Optics, Lasers, and Spectroscopy ACOLS03, University of Melbourne, Melbourne, Victoria, Australia, December 1, 2003.

237. "Single Molecules and Defect Centers in Solids as Nanophotonic Probes and Sources," Stanford-ENS Quantum Entanglement Symposium, Stanford University, Stanford, California, December 15-18, 2003.

238. "Single Molecules as Nanophotonic Probes and Sources," Chemistry Department Colloquium, University of California, Davis, California, February 4, 2004.

239. "Single Molecules as Local Nanoscopic Probes," Department of Chemistry and Biochemistry Seminar, Arizona State University, Tempe, Arizona, March 12, 2004.

240. "Single-Molecule Fluorescence Imaging of Biomolecular Dynamics," Minerva-Gentner Symposium on Optical Spectroscopy of Biomolecular Dynamics, Kloster Banz, Germany, March 21-25, 2004.

241. "Single-Molecule Fluorophores from Nonlinear Optical Chromophores," Materials Research Society Spring Meeting, San Francisco, California, April 12-16, 2004. With K. A. Willets, P. Callis, and R. J. Twieg.

242. "Single Molecules as Nanophotonic Probes and Sources," Gordon Research Conference on Electronic Processes in Organic Materials, Mount Holyoke College, South Hadley, Massachusetts, July 25-30, 2004.

243. "Optical Explorations of Single Molecules, *in vitro* and *in vivo*," 5th International Conference on Biological Physics ICBP2004, Gothenburg, Sweden, August 23-27, 2004.

244. "Visualizing Single-Molecule Dynamics in Cells," Symposium on Biophysical Chemistry and Novel Imaging of Single Molecules and Single Cells, American Chemical Society Annual Meeting, Philadelphia, Pennsylvania, August 22-26, 2004.

245. "Nanophotonics with Single Molecules and Small Metallic Nanostructures," FACSS 31st Annual Meeting, Nanomaterials for Photonics Symposium, Portland, Oregon, October 3-7, 2004. With D. P. Fromm, A. Sundaramurthy, P. J. Schuck, K. Willets, and G. Kino.

246. "Single Photon Sources Based on Single Molecules and Nanocrystals," Optical Society of America Annual Meeting, Frontiers in Optics 2004 / Laser Science XX, Rochester, New York, October 10-14, 2004.

247. "Nanophotonics with Single Molecules and Small Metallic Nanostructures," First MIT-ENS Cachan Workshop on Molecular Photonics and Biophotonics at the Micro and Nano-scale," Boston, Massachusetts, October 12-13, 2004. With D. P. Fromm, A. Sundaramurthy, P. J. Schuck, K. Willets, and G. Kino.

248. "Single-molecule emitters as nanoscale probes and sources," NIST Quantum Information Program Distinguished Lectureship, National Institute of Standards and Technology, Gaithersburg, Maryland, November 4, 2004.

249. "Single Molecules as Nanoscale Reporters, in vitro and in vivo," Plenary Lecture, Western Spectroscopy Association Annual Meeting, Asilomar, California, January 26-28, 2005.

250. "Single-Molecule Biophysics and Nanophotonics," Nanotechnology Symposium, American Association for the Advancement of Science Annual Meeting, Washington, DC, February 17-21, 2005.

251. "Single-Molecule Biophysics, Nanophotonics, and Trapping," Chemistry Colloquium, University of Washington, Seattle, Washington, April 6, 2005.

252. "Single-Molecule Biophysics, Nanophotonics, and Trapping," DOE Workshop on Single-Molecule Research in the New Millenium," Rockville, Maryland, April 10-12, 2005.

253. "Single-Molecule Biophysics, Nanophotonics, and Trapping," Molecular Science Institute Seminar, Berkeley, California, April 28, 2005.

254. "Single-Molecule Biophysics, Nanophotonics, and Trapping," Applied Physics Department, Stanford University, Stanford, California, May 16, 2005.

255. "Single-Molecule Biophysics, Nanophotonics, and Trapping," Institute for Atomic and Molecular Sciences, Academia Sinica, Taipei, Taiwan, June 17, 2005.

256. "Single-Molecule Imaging: Challenges in Living Cells," Bio-Image Summer School, Ecole Normale Supérieure, Paris, France, July 19, 2005.

257. "Novel Approaches to Single-Molecule Detection and Trapping," Bio-Image Summer School, Ecole Normale Supérieure, Paris, France, July 12, 2005

258. "Recent Progress in Single-Molecule Spectroscopy and Imaging," Telluride Workshop on Single-Molecule Measurements: Theory and Experiment, Telluride, Colorado, August 9-12, 2005. With Stefanie Nishimura, Jaesuk Hwang, SoYeon Kim, Sam Lord, and Kallie Willets.

259. "Single-Molecule Biophysics, Nanophotonics, and Trapping," American Chemical Society Annual Meeting, Washington, DC, August 28 – September 1, 2005. With Adam Cohen, David Fromm, So Yeon Kim, Stefanie Nishimura, P. James Schuck, and Harden McConnell.

260. "Nanophotonics and Single Molecules," Optical Society Annual Meeting, Frontiers in Optics 2005 - Laser Science XXI, Tucson, Arizona, October 16-20, 2005.

261. Single-Molecule Biophysics, Nanophotonics, and Trapping," Physics Department Colloquium, Washington University, St. Louis, Missouri, November 16, 2005.

262. "Measuring, Trapping, and Controlling Single Molecules and Nanoparticles," Pacifichem International Conference 2005, Honolulu, Hawaii, December 15-20, 2005. With Adam Cohen, David Fromm, Hanshin Hwang, Soyeon Kim, Stefanie Nishimura, Samuel Lord, P. James Schuck, Arvind Sundaramurthy, Katherine A. Willets, Harden McConnell, Gordon Kino, and Robert J. Twieg.

263. "Single-Molecule Spectroscopy at High Resolution and Low Temperature: The Early Years," A. R. Gordon Lecture, Department of Chemistry, University of Toronto, January 4, 2006.

264. "Single-Molecule Biophysics: From Proteins to Cells," A. R. Gordon Lecture, Department of Chemistry, University of Toronto, January 5, 2006.

265. **A. R. Gordon Lecture**, "Novel Approaches to Single-Molecule Studies: Local Reporters, Nanoantennas, and Trapping," Department of Chemistry, University of Toronto, January 6, 2006.

266. "Pumping, Probing, Grabbing, and Manipulating Single Molecules," University of California, Berkeley, Workshop on Advanced Imaging Methods, Berkeley, California, January 19-20, 2006.

267. "Single-Molecule Biophysics, Nanophotonics, and Trapping," Chemistry Department Colloquium, Northwestern University, Evanston, Illinois, February 17, 2006.

268. "Probing, Imaging, and Trapping Single Biomolecules," Imaging Focus Group Seminar Series, University of Texas Southwestern Medical School, Dallas, Texas, February 27, 2006.

269. "Single Molecules as Nanoscale Reporters in Biophysics, Chemistry, and Materials Science," IUPAC XXI International Symposium on Photochemistry, Kyoto Japan, April 2-7, 2006.

270. "Single-Molecule Emitters as Reporters of Dynamics and Function in Living Cells," NIH Frontiers in Live Cell Imaging Conference, Bethesda, Maryland, April 19-21, 2006.

271. "Optical Observations of Single Biomolecules," Gordon Research Conference on Single-Molecule Approaches to Biology, Colby-Sawyer College, New London, New Hampshire, June 18-23, 2006.

272. Single-molecule fluorescence tracking probes membrane dynamics," American Chemical Society Annual Meeting, Surface Chemistry Symposium in honor of Gabor Somorjai, San Francisco, California, September 10-14, 2006. With Hanshin Hwang, So Yeon Kim, Anika Kinkhabwala, and Stefanie Nishimura.

273. "Single-molecule fluorescence imaging reports on biomolecular dynamics," American Chemical Society Annual Meeting, Symposium on Frontiers in Single-Molecule Biophysical Chemistry and Imaging, San Francisco, California, September 10-14, 2006. With Adam Cohen, Nicholas R. Conley, So Yeon Kim, Anika Kinkhabwala, Marcelle Koenig, Andrea H. Kurtz, Samuel J. Lord, Zhikuan Lu, Hui Wang, and Robert J. Twieg.

274. "Single-Molecule Biophysics, Nanophotonics, and Trapping," Herbert H. King Lecture, Department of Chemistry, Kansas State University, Manhattan, Kansas, October 26, 2006.

275. "Visualizing Single Molecules with Lasers," Yunker Lecture, Department of Physics, Oregon State University, Corvallis, Oregon, November 6, 2006.

276. "Single-Molecule Fluorescence Imaging Reports on Biomolecular Dynamics," Workshop on Single-Molecule Fluorescence, PicoQuant GMBH and the Center for Biophotonics, UC Davis, Sacramento, California, January 18-19, 2007

277. "Fluorescence and Single-Molecule Studies of Chaperonin Nanomachines: Overview," Nanomedicine Center for Protein Folding Machinery Nanomedicine Lecture, Webex, February 22, 2007.

278. "Observing Dynamics of Individual Biomolecules with Single-Molecule Microscopy," Symposium on Nanomachines and Nanotechnologies, Biophysical Society Annual Meeting, Baltimore, Maryland, March 3-7, 2007.

279. "Refining Single-Molecule Fluorescence Imaging for Chaperonin Studies," 21st Annual Symposium of the Protein Society, Boston, Massachusetts, July 21-25, 2007.

280. "Recent Progress in Single-Biomolecule Fluorescence Imaging," Symposium on Single-Molecule Spectroscopy, Imaging, and Manipulation of Biomolecular Systems," American Chemical Society Annual Meeting, Boston, Massachusetts, August 19-23, 2007.

281. **Invited Tutorial,** "Single-Molecule Biophysical Imaging, Superresolution, and Trapping," Optical Society of America Annual Meeting, Frontiers in Optics/Laser Science, San Jose, California, September 16-20, 2007.

282. "Single-Molecule Superresolution Imaging and Trapping," BIOS 2008 Hot Topics Plenary Event, San Jose, California, January 19, 2008

283. **Keynote Lecture**, "Recent Progress in Single-Biomolecule Fluorescence Imaging," BIOS 2008 Conference 6862 on Single Molecule Spectroscopy and Imaging, San Jose, California, January 19-24, 2008

294. "Recent Progress in Single-Biomolecule Fluorescence Imaging, In and Out of Cells," PULSE Seminar, Stanford Linear Accelerator Center, April 10, 2008.

295. **Wolf Prize Lecture,** "Single-Molecule Optical Spectroscopy and Imaging: Early Steps to Recent Advances," Tel-Aviv Symposium in Chemical Physics on Single-Molecule Spectroscopy in Chemistry, Physics, and Biology, Tel-Aviv University, Tel-Aviv, Israel, May 27, 2008.

296. **Wolf Prize Lecture and Pathway Seminar,** "Single-Molecule Optical Spectroscopy and Imaging: Early Steps to Recent Advances," Hebrew University of Jerusalem, Jerusalem, Israel, May 28, 2008.

297. "Single-Molecule Optical Spectroscopy and Imaging: Early Steps to Recent Advances," Wolf Prize Mini-Symposium, Weizmann Institute of Science, Rehovot, Israel, May 29, 2008.

298. "Single-Molecule Spectroscopy and Imaging: Early Steps to Recent Advances," Nobel Symposium on Single-Molecule Spectroscopy in Chemistry, Physics, and Biology, Sanga-Saby, Sweden, June 1-6, 2008.

299. "Single-Molecule Biophysical Imaging, Superresolution, and Trapping," Hitachi Global Storage Technology Resarch Colloquium, San Jose, California, July 2, 2008.

300. **DuPont-Marshall Lecture,** "Single-Molecule Optical Spectroscopy and Imaging: From Early Steps to Recent Advances," Department of Chemistry, University of Pennsylvania, Philadelphia, Pennsylvania, October 7, 2008.

301. "Single-Molecule Optical Spectroscopy and Imaging: Early Steps to Recent Advances," Science Colloquium, IBM Almaden Research Center, San Jose, California, January 16, 2009.

302. **Arthur S. Noyes Lecture,** "Single-Molecule Optical Spectroscopy and Imaging: From Early Steps to Recent Advances," Department of Chemistry and Biochemistry, University of Texas at Austin, Austin, Texas, February 5, 2009.

303. **Neil Gordon Frontiers in Chemistry Lecture,** "Single-Molecule Optical Spectroscopy and Imaging: From Early Steps to Recent Advances," Department of Chemistry, Wayne State University, Detroit, Michigan, March 9, 2009

304. **Langmuir Prize Lecture**, "Single-Molecule Fluorescence Imaging: Nanoscale Emitters with Photoinduced Switching Enable Superresolution," American Physical Society March Meeting, Pittsburgh, Pennsylvania, March 17, 2009.

305. "Imaging Beyond the Diffraction Limit in Cells Using Single-Molecule Active Control," American Chemical Society Annual Meeting, Salt Lake City, Utah, March 22, 2009.

306. "Single-Molecule Optical Spectroscopy and Imaging: Early Steps to Recent Advances," Kavli Nanoscience Colloquium, California Institute of Technology, Pasadena, California, April 14, 2009.

307. "Single-Molecule Optical Spectroscopy and Imaging: Early Steps to Recent Advances," Physical Chemistry Seminar, University of California, Berkeley, Berkeley, California, April 21, 2009.

308. "Imaging and Trapping Single Biomolecules, In and Out of Cells," TSRI Distinguished Lecture, The Scripps Research Institute, La Jolla, California, May 10, 2009.

309. "Single-Molecule Biophysical Imaging, Superresolution, and Trapping," Leica Scientific Forum Lecture, Heidelberg, Germany, May 25, 2009.

310. **Karl Friedrich Bonhoeffer Lecture**, "Single-Molecule Biophysical Imaging, Superresolution, and Trapping," Max Planck Institute for Biophysical Chemistry, Göttingen, Germany, May 27, 2009.

311. "Nanoscale Single-Molecule Emitters with Photoinduced Switching Enable Superresolution in Three Dimensions (and other topics)," 10th International Conference on Hole-Burning, Single-Molecule, and Related Spectroscopies (HBSM 2009), Palm Cove, Queensland, Australia, June 22-27, 2009.

312. "Single-Molecule Optical Spectroscopy and Imaging: From Early Steps to Superresolution Imaging in Living Cells," Single-Molecule Imaging, Spectroscopy, and Manipulation of Biological Systems, Fragrant Hill Science Conference, Beijing, China, July 8-10, 2009.

313. "Single-Molecule Biophysical Imaging, Superresolution, and Trapping," Kavli Institute of Theoretical Physics Lecture, Beijing, China, July 13, 2009.

314. "Molecules and Methods for Superresolution Imaging by Single-Molecule Photoswitching (and other topics)," 15th International Workshop on Single-Molecule Spectroscopy and Ultrasensitive Analysis in Life Sciences, SMD15, Berlin-Adlershof, Germany, September 15-18, 2009.

315. "Lighting Up Single Molecules to Probe Complex Environments, From Crystals to Cells," Evans Award Public Lecture, The Ohio State University, Columbus, Ohio, October 8, 2009.

316. "Single-Molecule Superresolution Imaging and Trapping," **The Evans Award Lecture**, The Ohio State University, Columbus, Ohio, October 9, 2009.

317. "Three-Dimensional Superresolution Using Single-Molecule Photoswitches and a Double-Helix PSF," 2009 Computational Optical Sensing and Imaging (COSI) Conference, San Jose, California, October 13-15, 2009. With Michael Thompson, Matthew Lew, Majid Badieirostami, Samuel J. Lord, Nicholas R. Conley, Hsiao-lu D. Lee, Sri Rama Prasanna Pavani, and Rafael Piestun.

318. "Single-Molecule Biophysical Imaging, Superresolution, and Trapping," 2009 Frontiers in Optics (FiO)/Laser Science XXV (LS) Conference, San Jose, California, October 11-15, 2009.

319. **Keynote Lecture**, "Single-Molecule Approaches to Biomolecular Dynamics and Imaging of Cellular Superstructures," Keystone Symposium on Structural Biology/Structural Genomics, Breckenridge, Colorado, January 8-13, 2010.

320. "Lighting Up Single Molecules to Probe Complex Environments, from Crystals to Cells," BioMedSci 231 Fluorescence Guest Lecture, University of California San Diego, La Jolla, California, January 21, 2010.

321. "Recent Progress in Single-Molecule Biophysical Imaging, Superresolution, and Trapping," Pharmacology Department Seminar, University of California San Diego, La Jolla, California, January 21, 2010.

322. "Single-Molecule Biophysical Imaging, Superresolution, and Trapping," Physics Colloquium, Washington University, St. Louis, Missouri, February 3, 2010.

323. "Superresolution Imaging and Trapping Single Biomolecules, In and Out of Cells," Biophysics and Chemistry/Chemical Biology Seminar, University of California, San Francisco, California, February 25, 2010.

324. **Joe L. Franklin Lecture**, "Three Single-Molecule Stories: 3D Superresolution, Trapping, and Nanophotonic Enhancement," Department of Chemistry, Rice University, Houston, Texas, March 10, 2010.

325. "Two Single-Molecule Stories: 3D Superresolution Imaging and Nanophotonic Enhancements," Stanford University Photonics Retreat, Napa, California, April 10, 2010.

326. "Single-Molecule Biophysical Imaging, Superresolution, and Trapping," Physical Chemistry Seminar, University of California, Irvine, California, May 4, 2010.

327. **Tutorial Lecture**, "Single-Molecule Approaches for Superresolution Imaging, Trapping, and Nanophotonics," Conference on Lasers and Electro-Optics (CLEO) 2010, San Jose, California, May 16-21, 2010.

328. "Molecules and Methods for Superresolution Imaging in Living Cells", American Chemical Society Annual Meeting, Boston, Massachusetts, August 22-26, 2010.

329. "Single Molecules as Nanoscopic Probes of 3D Structure and Metallic Nanoantennas," American Chemical Society Annual Meeting, Boston, Massachusetts, August 22-26, 2010.

330. "Single-molecule and super-resolution microscopy of cells, nanoantennas, and biomolecules in solution," Aarhus University iNANO Summer School N7 on Nanooptics, Fuglsoecentret, Aarhus, Denmark, September 3-7, 2010.

331. "Molecules and Methods for Super-Resolution Optical Imaging in Living Cells," Recent Advances and Future Prospects for Visualizing Macromolecular Complexes and Cellular Structures Conference, National Institute of Health, Bethesda, Maryland, October 12-13, 2010.

332. "Extracting Superresolution and 3D Information from Cells with Single Fluorescent Molecules," MIT/Harvard Physical Chemistry Seminar, Cambridge, Massachusetts, October 14, 2010.

333. "Examples, Molecules, and Methods for Superresolution Imaging in Cells," Advanced Imaging Methods Workshop, University of California, Berkeley, January 19-21, 2011.

334. "Optical Localization and Super-Resolution Studies of Biological Systems with Single Molecules," Computational Optical Science and Imaging Seminar, Department of Electrical Engineering, University of Colorado, Boulder, Colorado, February 14, 2011.

335. "Three-Dimensional Tracking of Single mRNA Particles in S. cerevisiae Using a Double-Helix Point Spread Function," Biophysical Society Annual Meeting New and Notable, March 5-9, 2011.

336. **Willis H. Flygare Memorial Lecture**, "New Insights from Single Molecules as Nanoscale Points of Light," Department of Chemistry, University of Illinois at Urbana-Champaign, Urbana, Illinois, March 14, 2011.

337. "Single Fluorescent Molecules as Nano-Illuminators for Biological Structure and Function," American Physical Society March Meeting, Dallas, Texas, March 21-24, 2011.

338. "Examples, Molecules, and Methods for Super-Resolution Imaging in Cells with Single Molecules," a series of lectures presented in the **Leica Scientific Forum** at:

    (a) Institute of Integrated Biology, University of Liverpool, June 27, 2011

    (b) Department of Pharmacology, University of Oxford, June 28, 2011

    (c) Department of Chemistry, University of Cambridge, June 29, 2011

    (d) Department of Physics, Imperial College London, June 30, 2011

339. "Super-Resolution Imaging in Cells with Single Molecules: Examples and Methods," Single Molecule Spectroscopy: Current Status and Perspectives, W.E. Hereaus Symposium 488, Chemnitz, Germany, July 12-15, 2011.

340. "Single Fluorescent Molecules as Nano-Illuminators for Biological Structure and Function," American Chemical Society Annual Meeting, Denver, Colorado, August 29, 2011.

341. "Single-Molecule Studies of Biomolecular Dynamics in Solution and Fluorescence Enhancements by Metallic Nanoantennas," Paul Barbara Memorial Symposium on Forces Driving Contemporary Themes in Physical Chemistry, American Chemical Society Annual Meeting, Denver, Colorado, September 1, 2011.

342. "Super-Resolved Optical Microscopy: A New View of Bacterial Protein Superstructures," Society for General Microbiology Autumn Meeting, The University of York, York, UK, September 6, 2011.

343. "New Insights from Single Molecules: From 3D Super-Resolution in Cells to Biomolecular Diversity in Solution," Student-Hosted Colloquium Kickoff Lecture, Department of Chemistry, Stanford University, Stanford, California, October 6, 2011.

344. "Optical Explorations of Single Biomolecules and Enzymes in Solution with an Anti-Brownian Electrokinetic Trap," Frontiers in Optics/Laser Science Conference, San Jose, California, October 18, 2011.

345. "Single fluorescent molecules as nano-illuminators for biological structure and function in cells," Single Molecules Meet Systems Biology Symposium, HHMI Janelia Farm Research Campus, Ashburn, Virginia, October 26, 2011.

346. "Single fluorescent molecules as nano-illuminators for biological structure and function in cells," **Pittsburgh Conference Lecture**, Department of Chemistry, University of Pittsburgh, Pittsburgh, Pennsylvania, October 27, 2011.

347. "Single-molecule studies of biomolecular dynamics in solution and fluorescence

enhancements by metallic nanoantennas," **Pittsburgh Conference Lecture**, Department of Chemistry, University of Pittsburgh, Pittsburgh, Pennsylvania, October 28, 2011.

348. "Photodynamics of Single Antenna Proteins and Redox Enzymes in Solution by Suppression of Brownian Motion," DOE-BES Photosynthetic Systems Research Meeting, Baltimore, Maryland, November 8, 2011.

349. "Single-Molecule Active-Control Microscopy for Nanoscale 3D Cell Images," Nano/Biophotonics **Plenary Lecture**, BiOS/Photonics West, San Francisco, California, January 24, 2012.

350. "Single-Molecule Studies of Trapped Biomolecules in Solution with the ABEL Trap," Nanoscience Subgroup, Biophysical Society Annual Meeting, San Diego, California, February 25, 2012.

351. "Single Molecules as Light Sources for Super-Resolution Imaging and Probes for Single Biomolecules in Solution," Pittsburgh Spectroscopy Award Lecture, Pittcon 2012, Orlando, Florida, March 13, 2012.

352. "Watching Dynamical Processes for Single Biomolecules in Solution with the ABEL Trap," American Chemical Society Spring National Meeting, San Diego, California, March 25, 2012.

353. "Breaking the Optical Diffraction Limit in Cells with Single Molecules and STED Microscopy," Stanford Symposium on Biomedical Imaging, Center for Biomedical Imaging at Stanford (CBIS), Stanford, California, April 6, 2012.

354. "Single Molecules as Light Sources for 3D Super-Resolution Imaging and Probes for Single Biomolecules in Solution," Biomedical Plenary Lecture, ICFO (Institute of Photonic Sciences), Barcelona, Spain, May 3, 2012.

355. "Single-Molecule Active-Control Microscopy Illuminates Cells Beyond the Diffraction Limit," Special Focus Lecture, International Symposium on Biomedical Imaging (ISBI) 2012, Barcelona, Spain, May 4, 2012.

356. "Single Molecules as Light Sources for 3D Super-Resolution Imaging and Probes for Single Biomolecules in Solution," Ehrenfest Colloquium, Leiden University, Leiden, The Netherlands, June 20, 2012.

357. "Super-Resolution Imaging of Protein and DNA Localization Patterns in Bacteria," Biology and Physics of Bacterial Chromosome Organization, Leiden, The Netherlands, June 21, 2012.

358. "What's New With Single Molecules: From Light Sources for 3D Super-Resolution Imaging in Cells to Biomolecular Photodynamics in Solution," Center for Nanoscale Science Special Seminar Honoring Prof. Dr. Chris Bräuchle, Ludwig Maximilian Universität München, Germany, July 6, 2012.

359. "Exploring Protein Superstructures in Bacteria Using Two- and Three-Dimensional Super-Resolution Imaging," CECAM Conference: Toward *in silico* bacterial cells, EPFL, Lausanne, Switzerland, July 9, 2012.

360. "Single-Molecule Active Control Microscopy for Optical 3D Cell Images to Sub-40 nm Resolution," International Conference on X-Ray Microscopy XRM 2012, Shanghai,

China, August 9, 2012.

361. "Watching dynamical processes for single molecules in solution," (Keynote), Eleventh International Conference on Hole-Burning, Single-Molecule, and Related Spectroscopies: Science and Applications, University of Tübingen, Germany, August 27-30, 2012.

362. "Single Molecules as Light Sources for Super-Resolution Imaging and Probes for Single Biomolecules in Solution," (Keynote), Swiss Single-Molecule Localization Microscopy Symposium, EPFL, Lausanne, Switzerland, August 29-31, 2012.

363. "Single Molecules as Light Sources for Super-Resolution Imaging and Probes for Single Biomolecules in Solution," Symposium on Atomic, Molecular, and Optical Sciences, Institute for Atomic and Molecular Science, Academia Sinica, Taipei, Taiwan, November 12, 2012.

364. "Single Molecules as Light Sources for Super-Resolution Imaging and Probes for Single Biomolecules in Solution," 16th Future of Light Symposium, Boston University Photonics Center, Boston, Massachusetts, November 29, 2012.

365. "Recent Progress in Wide-Field 3D Super-Resolution Cellular Imaging Using Single Molecules," Symposium on Understanding Cell Behavior Through Single Cell and Single Molecule Biology, University of New Mexico, Albuquerque, New Mexico, January 10-12, 2013.

366. "Recent Progress in 3D Super-Resolution Imaging in Cells Using Single Molecules," Advanced Imaging Methods Workshop, University of California, Berkeley, California, January 30 – February 1, 2013.

367. "Biophysical Variables Which Are (Now) Available from Single-Molecule Optical Studies," American Physical Society March Meeting, Industrial Physics Forum, Baltimore, Maryland, March 19, 2013.

368. "Exploring Protein Superstructures in Bacterial and Mammalian Cells using Single-Molecule Active-Control Microscopy," Pittcon 2013 Conference, Philadelphia, Pennsylvania, March 21, 2013.

369. "Single-Molecule Spectroscopy and Imaging: 3D Nanoscopy and Biomolecular Dynamics," **Samuel Krimm Lecture** in Biophysics, University of Michigan, Ann Arbor, Michigan, April 5, 2013.

370. "Single-Molecule Spectroscopy and Imaging: 3D Nanoscopy and Biomolecular Dynamics," **Peter Debye Award Lecture**, American Chemical Society Annual Meeting, New Orleans, Louisiana, April 9, 2013.

371. "Lighting Up Nature with Single Molecules," Department of Electrical Engineering Seminar, Washington University, St. Louis, Missouri, April 18, 2013.

372. "Single-Molecule Spectroscopy and Imaging: 3D Nanoscopy and Biomolecular Dynamics," **E. K. C. Lee Lecture**, Chemistry Department, University of California at Irvine, Irvine, California, May 30, 2013.

373. "Applications of Single-Molecule Fluorophores to Observe Cellular Structures and Processes on the Nanoscale," American Association for the Advancement of Science Webinar, June 12, 2013.

374. "Actively-Controlled Single-Molecule Emitters Enable 3D Super-Resolution Imaging in Cells," Plenary, International Conference on Photochemistry, Leuven, Belgium, July 24, 2013.

375. "Challenges and opportunities for 3D single-molecule localization microscopy in cells," Cold Spring Harbor – Asia Conference on New Advances in Optical Imaging of Live Cells and Organisms, Suzhou Dushu Lake Conference Center, August 22, 2013.

376. "Single-Molecule Spectroscopy and Imaging: 3D Nanoscopy and Biomolecular Dynamics," Molecular Foundry Seminar, Lawrence Berkeley National Laboratory, Berkeley, California, August 27, 2013.

377. "Quantitative Aspects of 3D Super-Resolution Imaging in Cells," Frontiers in Single-Cell Analysis Conference, Stanford University, Stanford, California, September 5, 2013.

378. "Recent Progress in 3D Super-Resolution Imaging in Cells Using Single Molecules (plus Observing Single-Molecule Photodynamics in Solution with the ABEL Trap)," Methods and Applications of Fluorescence 13, Genoa, Italy, September 10, 2013.

379. "Single-Molecule Spectroscopy and Imaging: 3D Nanoscopy and Biomolecular Dynamics," 2013 **Walter Kauzmann Lecture** in Biophysical Chemistry, Department of Chemistry, Princeton University, Princeton, New Jersey, September 25, 2013.

380. "Single-Molecule Spectroscopy and Imaging: 3D Nanoscopy and Biomolecular Dynamics," 2013 **John Gamble Kirkwood Award Lecture**, Department of Chemistry, Yale University, New Haven, Connecticut, September 27, 2013.

381. "Photodynamics of Single Photosynthetic Antenna Proteins in Solution," 23rd Western Photosynthesis Conference, Asilomar Conference Center, Pacific Grove, California, January 2-5, 2014.

382. "Single-Molecule Spectroscopy and Imaging: 3D Nanoscopy and Biomolecular Dynamics," Russell Berrie Nanotechnology Institute – Technion – Israel Institute of Technology Winter School, HaGoshrim Hotel, Israel, February 9-13, 2014.

383. "Single-Molecule Spectroscopy and Imaging: 3D Nanoscopy and Biomolecular Dynamics," Chemistry Department Seminar, University of Santa Clara, February 28, 2014.

384. "Single-Molecule Spectroscopy," Dreyfus Presidential Symposium on Chemical Instrumentation, American Chemical Society Spring National Meeting, Dallas, Texas, March 18, 2014.

385. "Single-Molecule Spectroscopy and Imaging: 3D Nanoscopy and Biomolecular Dynamics," Physical Chemistry Seminar, University of California, Berkeley, California, April 1, 2014.

386. "Single-Molecule Spectroscopy and Imaging: 3D Nanoscopy and Biomolecular Dynamics," Biological Sciences Seminar, University of Southern California, Los Angeles, California, April 25, 2014.