

Mansoor Sheik-Bahae

Distinguished Professor

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Educational History:

Ph.D. Electrical Engineering (Electro-Physics), 1987
State University of New York (SUNY) at Buffalo

M.S. Electrical Engineering, 1982
Catholic University of America, Washington D.C.

B.S. Electrical Engineering, 1980, *Summa Cum Laude*
Catholic University of America, Washington D.C.

Employment History:

- | | |
|-------------|---|
| 8/14- now | Distinguished Professor, Department of Physics and Astronomy,
University of New Mexico, Albuquerque, NM |
| 6/05- 8/14 | Professor, Department of Physics and Astronomy,
and Department of Electrical and Computer Engineering
University of New Mexico, Albuquerque, NM |
| 8/94- 5/05 | Assistant and Associate Professor, Department of Physics and Astronomy,
University of New Mexico, Albuquerque, NM |
| 9/90 - 8/94 | Associate Research Professor, Center for Research and Education in Optics and
Lasers (CREOL), University of Central Florida, Orlando, Florida |

Awards:

- ◆ UNM Distinguished Professor (2014)
- ◆ OSA's **R. W. Wood Prize** (shared with Eric van Stryland) – March 2012
- ◆ Recognized for “Most cited paper in the history of IEEE-JQE”, LEOS 2007
- ◆ *OSA Fellow* (2000)
- ◆ 1996 *NSF-CAREER award*
- ◆ 1990 *Engineer of the Year Award*, IEEE/LEOS (Orlando, Florida)

Professional Service:

- General Chair of *Optical Science and Engineering Program (OSE)*, University of New Mexico (03-09)
- Director of Consortium for Laser Cooling in Solids ([CLCS](#)), 2004-now
- Member, Board of Directors of UNM's Science and Technology Transfer Corporation [STC.UNM](#)
- Topical Editor, Journal of Optical Society of America (B). 2010-2013
- Member of the Executive Organizing Committee (SPIE- Photonics West- LASE): 07,08,09,10
- Conference co-chair (Laser Cooling in Solids, SPIE- Photonics West) 07,08,09,10,11,12
- Chair and member of program subcommittee *Applications of Nonlinear Optics* for CLEO 99-04
- Member of the OSA's Committees: *New Focus Student Award* (1998 and 1999), Book Publishing and Web Committees (2003), Holonyak Award Committee (2004-2006).
- Member of IEEE-LEOS Program Committee on *Nonlinear Optics*, 2003

Personal: US Citizen, Married, DOB: 1956

Scientific Contribution Highlights:

- Invented the Z-scan technique (with coworkers, Eric van Stryland and Ali Said). Z-scan is a sensitive and powerful experimental method for absolute measurement of optical nonlinearities of materials. This technique and its mathematical analysis were published in a series of nine original papers by myself and co-workers. Z-scan is now being used extensively in many universities and research institutes around the world. It is also described and analyzed in most text books in nonlinear optics. According to Google Scholar, the collection of papers we authored on Z-scan has been cited more than 7600 times (Oct. 2013). One of these papers (IEEE/JQE/1990) has been named the most cited paper of JQE history (2007). It was reprinted in an SPIE's Milestone Series of Selected Reprints on *Ultrashort Laser Pulse Bioeffects*, edited by William P. Roach, Thomas E. Johnson (2003). Sheik-Bahae and Van Stryland were awarded the OSA's R. W. Wood Prize for the invention of Z-scan.
- Developed a simple, comprehensive quantum mechanical theory for predicting the ultrafast electronic optical nonlinear coefficients of semiconductors. This work required a better understanding and formulation of the Kramers-Kronig transformation as applied to nonlinear optics. The theory gives a universal and consistent relationship between absorptive and refractive components of the nonlinear coefficients in optical solids. This has proven to be of great importance in device applications such as ultrafast all-optical switching and sensor protection. There are seven papers authored by myself and co-authors on this subject, which have been cited more than 1200 times (Google Scholar, 2013).
- Performed pioneering work on the physics, measurement, and applications of the cascaded second-order nonlinearities. The definitive papers on this topic were authored by myself and co-workers and have been cited more than 920 times (Google Scholar, 2011).
- Have made key theoretical and experimental contributions to the field of solid state laser cooling. In 2009, UNM team reported the first laser cooling to cryogenic temperatures. Also (together with Richard Epstein of LANL) developed a theory (known as SB-E model) for laser-cooling in semiconductors under arbitrary external efficiency (PRL, 2004). This theory and the experimental procedure (time-gated differential luminescence thermometry) developed by MSB were recently employed by scientists in Singapore to demonstrate the first laser cooling in a semiconductors; a major scientific breakthrough reported in the Journal of Nature. Also a co-inventor of the "nano gap thermal barrier" for solving the luminescence trapping problem. (U.S. Patent # 6,378,321), and has 4 other pending patent applications in this area. Our papers in this filed have been cited more than 500 times since year 2000.
- Developed the MOSAIC algorithm together with the Kerr-Lens-Autocorrelation experimental technique for ultrashort laser pulse characterization. This resulted in the issuance of a U.S. Patent (6,108,085). Two manufacturers (Femtochrome, Berkeley, CA, and APE in Germany) have been exploring the use of MOSAIC algorithm in their commercial autocorrelators. Number of citations to pulse characterization papers: >170.

Other Research Recognitions:

- Elected Fellow of the Optical Society of America (OSA) in 2000 for "Insight into the Application of Causality in Nonlinear Optics" and "Invention of Z-Scan". Also recognized by IEEE-LEOS for authoring the most cited paper (for Z-scan) in the history of the IEEE-JQE in 2007.
- Results of research on laser cooling of solids (*Physical Review Letters* **17**, 3600, 2000) was highlighted in the journal of *Nature* (News and Views, May 2000).
- Achievement of cryogenic laser cooling was highlighted in numerous science magazines (online and print) such as *Physics Today* (April 2010) and *Photonics Spectra*. It was also subject of press releases by AFOSR and CLEO/QELS committees.
- Our paper [Appl. Phys. Lett. 102, 252102 \(2013\)](#) reporting an external quantum efficiency of 99.5% in GaAs -a world record in any material- was selected for the journal's Recent Research Highlights.
- Our recent paper on terahertz nano plasmonics (published in *Phys. Rev. B*) became an Editor's Selection. It was also written about in the Research Highlights section of the *Nature Photonics* (Dec. 2011).
- PhD Students Awards:

- Chad Hoyt: OSA *New Focus Student Award* (2000). His work on optical refrigeration earned the top prize of \$10,000. Also received NRC postdoc fellowship (2004).
- Denis Seletskiy: Mary-Curie Fellow (2013), NRC postdoc fellowship (2010). Part of US Student Delegation at Lindau meeting of Nobel Laureates (2007).
- Wendy Patterson: *Los Alamos National Lab (LANL) Student Distinguished Performance Award* (2008)
- Daniel Bender: *Best Poster Prize* for “Ultrafast lasers: identifying the *perfect* pulse”, SPIE Photonics West (2008).
- Seth Melgaard: NRC Postdoctoral Fellow (2012-2014), Best Paper Prize at UNM’s Research Exposition (2013)

My Google Scholar Page:

http://scholar.google.com/citations?hl=en&user=yHqdWmsAAAAJ&view_op=list_works&cstart=20

Current Research Activities:

Laser Cooling in Solids: As the director of Consortium for Laser Cooling in Solids (CLCS), I lead a multidisciplinary team of world class scientists from multiple universities and national labs working toward first observation of laser cooling in semiconductors as well as achieving cryogenic temperatures in rare-earth doped solids. My group recently reported a breakthrough in achieving the first ever all-solid-state cryocooler by laser cooling a Yb:YLF crystal to about 150K starting from room temperature. Overall, together with Epstein’s group at LANL and our other collaborators, we have achieved great progress with multitude of innovations in both experimental and theoretical areas. A few sample publications are:

(1) C. W. Hoyt, M. Sheik-Bahae, R. I. Epstein, B. Edwards, J. Anderson “Observation of anti-Stokes fluorescence cooling in Tm-dopes glass”, *Phys. Rev. Lett.* Vol. 17, 3600 (2000) (2) M. Sheik-Bahae and R. I. Epstein, “Can Laser Light Cool Semiconductors?”, *Phys. Review Lett.* . **92**, 247403 (2004). (3) B. Imangholi, M.P. Hasselbeck, and M. Sheik-Bahae. R. I Epstein, S. Kurtz, “Effects of epitaxial lift-off on interface recombination and laser cooling in GaInP/GaAs heterostructures,” *Appl. Phys. Lett.* **86**, 81104 (2005) (4) M. Sheik-Bahae and R.I. Epstein, “Optical Refrigeration”, Invited Progress Article, *Nature (Photonics)*, Vol. 1, 693-699 (2007). (5) W. Patterson, M. Sheik-Bahae, S. Bigotta, D. Parisi, M. Tonelli, and R. I. Epstein, “Anti-Stokes luminescence cooling of Tm³⁺-doped BaY₂F₈,” *Optics Express*, Vol. 16, No. 3, 1704 (2008). (6) Denis V. Seletskiya, Seth D. Melgaard, Stefano Bigottab, Alberto Di Lietob, Mauro Tonellib, and Mansoor Sheik-Bahae, “Laser Cooling of Solids to Cryogenic Temperatures”, *Nature Photonics*, 4, 161-164 (2010)

Ultrafast Phenomena and Nonlinear Optics: Various projects are underway in my group involving ultrashort laser pulse characterization, extreme wavelength generation and detection, and semiconductor plasmonics:

◆ **Ultrafast Diagnostics:** Group has been active in the area of ultrashort laser pulse characterization. Following are our recent publications involving our Modified Spectrum Auto Interferometric Correlation (MOSAIC) technique:

(1) T. Hirayama, and M. Sheik-Bahae, “Real-time chirp diagnostic in ultrashort laser pulses,” *Opt. Lett.* Vol. 27, 860-862 (2002). (2) D. Bender, M.P. Hasselbeck, and M. Sheik-Bahae, “Sensitive ultrashort pulse chirp measurement,” *Opt. Lett.* Vol. **31**, 122-124 (2006). (3) D. Bender and M. Sheik-Bahae, “Modified spectrum autointerferometric correlation (MOSAIC) for single-shot pulse characterization,” *Opt. Lett.* Vol. **32**, 2822-2824 (2007). (4) D. A. Bender, M. Sheik-Bahae, “Complementary ultrashort laser pulse characterization using MOSAIC and SHG FROG,” *Opt. Lett.* Volume: 35 2191 (2010)

◆ **Novel Concepts and Applications in Optically-Pumped Semiconductor Lasers (OPSL) :** Based on evanescent wave coupling and total internal reflection I have developed a novel active mirror configuration that could potentially resolve the thermal issues encountered in power scaling of such lasers. A patent application was awarded, another one pending. In collaboration with Sandia National Labs, we have developed high power narrow linewidth OPSLs at 1020 nm for intracavity laser cooling of Yb:YLF resulting in first demonstration of

compact diode-pumped cryocoolers. Most recently, we have developed model and demonstrated self-mode locking in OPSLs based on negative ultrafast Kerr effect in semiconductor gain chip.

(1) M. Sheik-Bahae, Evanescent-Wave Subcavity Amplifiers and Lasers, U.S. Patent # 11/845,367. (2) M. Ghasemkhani, Sheik-Bahae, et al. submitted to Optics Express 2013. (3) A. Albrecht, M. Sheik-Bahae et al Optics Express (2013)

◆ **Coherent Control in XUV/THz Generation:** An ongoing project investigates correlations and coherent control in simultaneous generation of XUV bursts and single-cycle THz pulses by two-color laser fields. We have developed a simple hybrid-model based on classical trajectories that remarkably explains most of our observations.

(1) A. Gragossian, D. V. Seletkisy, M. Sheik-Bahae, CLEO 2013, NLO 2013, Also manuscript in preparation for submission to Phys. Rev. Lett. (Nov. 2013)

◆ **Semiconductor Plasmonics and THz Spectroscopy:** In collaboration with Sandia National Labs, we use femtosecond technology to probe coherent plasmon and phonon oscillations via THz emission in semiconductor bulk and nano structures. Our recent experiments show (a) first direct observation of Landau damping in a semiconductor plasma, and (b) first THz emission from semiconductor nanowires resulting from surface acoustic plasmons. Most recently we have observed strong linear electro-absorption in asymmetric double quantum wells for THz coherent detection and imaging. Sample publications are:

(1) M.P. Hasselbeck, D. Stalnaker, L.A. Schlie, T.J. Rotter, A. Stintz, M. Sheik-Bahae, "Emission of terahertz radiation from coupled plasmon-phonon modes in InAs," Phys. Rev. B 65, 233203 (2002), (2) M.P. Hasselbeck, D. Seletskiy, L. R. Dawson, and M. Sheik-Bahae, "Direct observation of Landau damping in a solid state plasma", Phys. Stat. Solidi (c), Vol. 5, 253-256 (2008). (3) Denis Seletskiy, Michael P. Hasselbeck, Mansoor Sheik-Bahae, Jeffrey G. Cederberg, Linus C. Chuang, Michael Moewe, Connie J. Chang-Hasnain, "Observation of THz Emission from InAs Nanowires", CLEO 2008, San Jose, CA paper CMM2, (4) D. V. Seletskiy, M. P. Hasselbeck, J. G. Cederberg, A. Katzenmeyer, M. E. Toimil-Molares, F. Leonard, A. A. Talin, A. and M. Sheik-Bahae, "Efficient terahertz emission from InAs nanowires," Phys. Rev. B 84, 115421 (2011) [PRB's Editors' Selection]

Research Funding at University of New Mexico

Total > \$ 17M (since 1995)

- | | |
|---|--------------------------------------|
| ◆ NSF: \$4M
(CAREER, IGERT, MRI, and regular grants) | ◆ NASA \$ 0.9 M |
| ◆ AFOSR \$6.3M
(MURI, DURIP, HSI, STTR and regular grants) | ◆ DTRA \$2.5 M |
| | ◆ LANL/ Univ. of California: \$ 0.3M |
| | ◆ DARPA \$1.35M |
| | ◆ NATO |

Also was awarded the UNM's STC Gap Funding in 2010 for project "Intra-Cavity Enhanced Cryogenic Optical Refrigerator (ICE-CORE)".

One SBIR and two STTR grants (Phase-I) on the subject of solid-state laser cooling were awarded in 2011 (in collaboration with Thermodynamic Films LLC). One STTR was awarded a Phase-II grant.

PUBLICATIONS

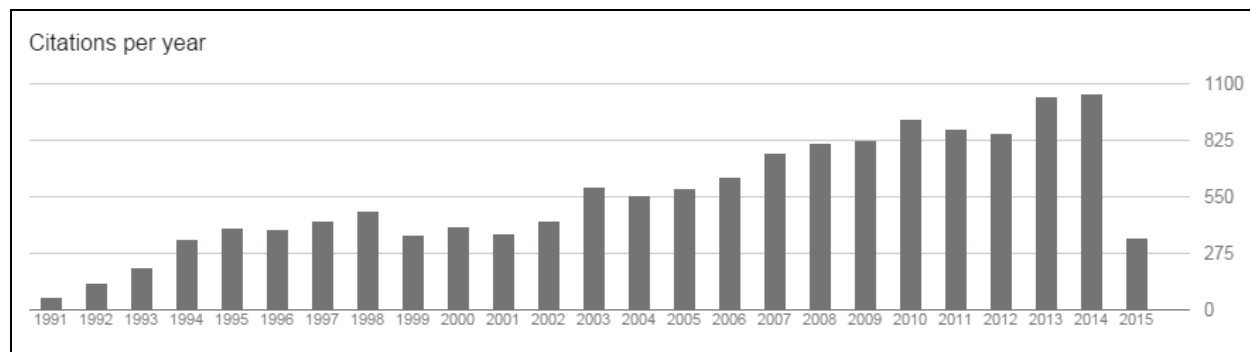
Summary:

7 edited books, 9 book chapters, >150 refereed publications (18 invited),

>200 presentations at the meetings (45 invited), 4 US patents, 4 pending

Total Citations > 13000 (>5000 since 2008)

H-index: 37, i10-index: 78, i100-index: 20



Source: [Google Scholar](#)

Edited Books and Proceedings:

[Laser Refrigeration of Solids VII](#) (Conference Volume)

Editors: Richard Epstein, Denis Seletskiy, Mansoor Sheik-Bahae

Published: 24 Mar 2014

[Laser Refrigeration of Solids VI](#) (Conference Volume)

Editors: Richard Epstein, Denis Seletskiy, Mansoor Sheik-Bahae

Published: 22 Mar 2013

[Laser Refrigeration of Solids V](#) (Conference Volume)

Editors: Richard Epstein, Denis Seletskiy, Mansoor Sheik-Bahae

Published: 22 Feb 2012 Softcover, ISBN: 9780819489180

[Laser Refrigeration of Solids IV](#) (Conference Volume)

Editors: Richard Epstein, Mansoor Sheik-Bahae

Published: 3 Feb 2011 Softcover, 110 pages; ISBN: 9780819484888

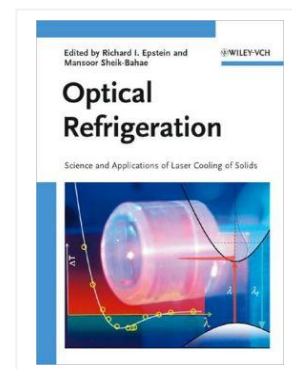
[Laser Refrigeration of Solids III](#) (Conference Volume)

Editors: Richard Epstein, Mansoor Sheik-Bahae

Published: 8 Feb 2010 Softcover, ISBN: 9780819480101

[Optical Refrigeration: Science and Applications of Laser Cooling of Solids,](#)

R. I. Epstein and M. Sheik-Bahae, Wiley-VCH, ISBN-10: 3527408762 (June 15, 2009)



[Laser cooling of solids](#) (Conference Volume)

Editors: Richard Epstein, Mansoor Sheik-Bahae

Published: Feb 2007 Softcover, SPIE, 2007 (ISBN 9780819465740)

Invited Book Chapters:

1. Characterization and Modeling of Nonlinear Optical Absorption and Refraction, E.W. Van Stryland, M. Sheik-Bahae and D.J. Hagan, in *Nonlinear and Quantum Optics*, ed. N. Bloembergen, pp. 527-578, Research Trends in Physics Series, Institute for Advanced Studies Press, 1997.
2. Z-scan Technique for Materials Characterization, Eric Van Stryland and M. Sheik-Bahae, in *Materials Characterization and Optical Probe Techniques, Critical Reviews of Optical Science and Technology*, Vol. CR69, 501-524, SPIE 1997.
3. Nonlinear Optics of Bound-Electrons in Solids, M. Sheik-Bahae, in *IMA Volumes in Mathematics and Applications*, ed. J.V. Moloney, Volume 101, page 205-220, Springer-Verlag, 1998
4. Z-Scan, E. W. Van Stryland and M. Sheik-Bahae, , in *Characterization Techniques and Tabulations for Organic Nonlinear Materials*, M. G. Kuzyk and C. W. Dirk, Eds., page 655-692, Marcel Dekker, Inc., 1998
5. Optical Nonlinearities in the Transparency Region of Bulk Semiconductors, M. Sheik-Bahae and E.W. Van Stryland, in *Nonlinear Optics of Semiconductors*, E. Garmire and A. Kost, Eds., Volume 58 of Semiconductor and Semimetals, pp. 257-318, Academic Press (1998)
6. Third Order Optical Nonlinearities, M. Sheik-Bahae and M. P. Hasselbeck, in *OSA Handbook of Optics*, Vol. IV, pp 17.3-17.38, McGraw-Hill, 2001
7. Nonlinear Refraction, M. Sheik-Bahae, in *Encyclopedia of Optical Engineering*, Dekker, (2003) ISBN: 0-8247-4258-3
8. Nonlinear Optics Basics: Kramers-Krönig Relations in Nonlinear Optics, M. Sheik-Bahae, in *Encyclopedia of Modern Optics*, edited by Robert D. Guenther, Duncan G. Steel and Leopold Bayvel, Elsevier, Oxford, 2004, ISBN 0-12-227600-0.
9. Laser Cooling of Solids, R. I. Epstein & M. Sheik-Bahae, in McGraw-Hill Yearbook of Science and Technology 2011, pp. 174-177, ISBN: 978-0071763714 (December , 2010)

Patents:

1. *Interferometric Auto-Correlator Using Third-Order Nonlinearity*

U.S. Patent #6,108,085; 2000; M. Sheik-Bahae

2. *Semiconductor-Based Optical Refrigerator*

U.S. Patent #6,378,321; 2002; R. I. Epstein, B. C. Edwards, and M. Sheik-Bahae

3. *Evanescent-Wave Subcavity Amplifiers and Lasers*

U.S. Patent # 11,845,367, M. Sheik-Bahae

4. *High Frequency Thin Film Liquid Crystal Thermal Switches* (pending)

U.S. Patent Application, Richard Epstein, Kevin Malloy and M. Sheik-Bahae

5. *Optical Coupled-Cavity Photo-Acoustic Spectroscopy* (awarded)

Provisional Application, Denis Seletskiy, M. P. Hasselbeck, M. Sheik-Bahae

6. *A Novel Method for Solid State Optical Refrigeration* (pending, STC-PS-1002)

Provisional Application, R. Epstein; M. Hehlen, D. Seletskiy, M. Sheik-Bahae

7. *All-Solid-State Optical Cryocooler Using Intracavity Optically Pumped Semiconductor Lasers*,
US Patent 8,720,219 (M. Sheik-Bahae)

Refereed Journal Publications:

1. M. Sheik-Bahae, H.S. Kwok, "Characterization of a picosecond CO₂ laser system", *Appl. Opt.* 24, 666 (1985).
2. M. Sheik-Bahae, P. Mukherjee, and H.S. Kwok, "Two-photon and three-photon absorption coefficients in InSb," *J. Opt. Soc. Am. B*, 3, 379 (1986).
3. M. Sheik-Bahae, H.S. Kwok, "The frequency spectrum of Optical Free Induction Decay ultrashort CO₂ laser pulses," *Appl. Opt.* 25, 3333 (1986).
4. P. Mukherjee, M. Sheik-Bahae, H.S. Kwok, "New method of measuring relaxation times in semiconductors and metals," *Appl. Phys. Lett.* 46, 770(1985).
5. M. Sheik-Bahae, M.P. Hasselbeck, H.S. Kwok, "High intensity CO₂ laser interaction with InSb," *J. Opt. Soc. Am. B* 3, 1082(1986).
6. M. Sheik-Bahae, H.S. Kwok, "Picosecond CO₂ laser induced self-defocusing in InSb," *IEEE J. Quantum Electron.* QE-23, 1974 (1987).
7. M. Sheik-Bahae, T. Rossi, H.S. Kwok, "Frequency dependence of the two-photon absorption coefficient in InSb: tunneling effects," *J. Opt. Soc. Am. B* 4, 1964 (1987).
8. M. Sheik-Bahae, H.S. Kwok, "Controlled CO₂ laser melting of Silicon," *J. Appl. Phys.* 63, 518 (1987).
9. M. Sheik-Bahae, H.S. Kwok, "Dynamic reflectivity switching of infrared lasers by an inhomogeneous plasma," *Opt. Lett.* 12, 702 (1987).
10. H.S. Kwok, P. Mukherjee, and M. Sheik-Bahae, "Ultrashort Laser Pulse Duration Dependent Free Carrier Absorption in Thin Gold Films," *Phys. Lett. A*, 122, 191(1987).
11. M. Sheik-Bahae, A.A. Said, and E.W. Van Stryland, "High Sensitivity, Single Beam n₂ Measurements," *Opt. Lett.* 14, 955-957 (1989).
12. M. Sheik-Bahae, A.A. Said, T.H. Wei, D.J. Hagan, and E.W. Van Stryland, "Sensitive Measurement of Optical Nonlinearities Using a Single Beam," *IEEE Journal of Quantum Electronics*, QE-26, 760-769 (1989).
13. M. Sheik-Bahae, D.J. Hagan, and E.W. Van Stryland, "Dispersion and Band-Gap Scaling of the Electronic Kerr Effect in Solids Associated with Two-Photon Absorption", *Phys. Rev. Lett.* 65, 96(1990).
14. **(Invited)** M.J. Soileau, T.H. Wei, M. Sheik-Bahae, D.J. Hagan, Martine Sence, and E.W. Van Stryland, "Nonlinear Optical Characterization of Organic Materials", *Mol. Cryst. Liq. Cryst.* 207, 97-101(1991).
15. M. Sheik-Bahae, A.A. Said, D.J. Hagan, and E.W. Van Stryland, "Nonlinear Refraction and Optical Limiting in Thick Media," *Opt. Eng.* 30, 1228(1991).
16. **(Invited)** P. Palffy-Mulhoray, H.J. Yuan, L. Li, M.A. Lee, J.R. DeSalvo, T.H. Wei, M. Sheik-Bahae, D.J. Hagan, and E.W. Van Stryland, "Measurements of Third Order Nonlinearities of Nematic Liquid Crystals", *Mol. Cryst. Liq. Cryst.* 207, (1991).
17. M. Sheik-Bahae, D.C. Hutchings, D.J. Hagan, and E.W. Van Stryland, "Dispersion of Bound Electronic Nonlinear Refraction in Solids," *IEEE J. Quantum Electron.* QE-27, 1296(1991).
18. **(Invited)** D.C. Hutchings, M. Sheik-Bahae, D.J. Hagan, and E.W. Van Stryland, "Kramers-Kronig Relations in Nonlinear Optics", *Optical and Quantum Electronics*, Tutorial Review 24, 1-30 (1992).

19. A. A. Said, M. Sheik-Bahae, D.J. Hagan, T.H. Wei, J. Wang, J. Young, E.W. Van Stryland, "Determination of Bound and Free-Carrier Nonlinearities in ZnSe, GaAs, CdTe, and ZnTe," *J. Opt. Soc. Am. B.* **9**, 409 (1992).
20. R. DeSalvo, D.J. Hagan, M. Sheik-Bahae, G. Stegeman, H. Vanherzeele, E.W. Van Stryland, "Self-focusing and Defocusing by Cascaded Second Order Effects in KTP," *Opt. Lett.* **17**, 28 (1992).
21. M. Sheik-Bahae, J. Wang, J.R. DeSalvo, D.J. Hagan, E.W. Van Stryland, "Measurement of Nondegenerate Nonlinearities Using a Two-Color Z-scan," *Opt. Lett.* **29**, 258(1992).
22. M. Sheik-Bahae, D.C. Hutchings, D.J. Hagan, E.W. Van Stryland, "Universal Dispersion and Band-Gap Scaling of n_2 in Solids," *Optics and Photonics News*, vol. 2, pp. 22, December 1991.
23. M. Sheik-Bahae, R. DeSalvo, D.J. Hagan, G. Assanto, G.I. Stegeman, E.W. Van Stryland, "Nonlinear Phase Shifts Using Second Order Nonlinearities," *Optics and Photonics News*, Vol.3, pp. 11, Dec. 1992.
24. E.W. Van Stryland, M. Sheik-Bahae, A.A. Said, D.J. Hagan, "Characterization of Nonlinear Optical Absorption and Refraction," *Prog. Crystal Growth and Charact.* **27**, 279-311 (1993).
25. R. DeSalvo, M. Sheik-Bahae, A.A. Said, D.J. Hagan, E.W. Van Stryland, "Z-scan Measurement of the Anisotropy of Nonlinear Refraction and Absorption in Crystals," *Opt. Lett.* **18**, 194-197 (1993).
26. G.I. Stegeman, M. Sheik-Bahae, E.W. Van Stryland, "Large Nonlinear Phase Shifts in Second Order Nonlinear Optical Processes," *Opt. Lett.* **18**, 13-15(1993).
27. G. Assanto, G.I. Stegeman, M. Sheik-Bahae, E.W. Van Stryland, "All Optical Switching Devices Based on Large Nonlinear Phase Shifts from Second Harmonic Generation," *Appl. Phys. Lett.*, **62**, 1323-1325 (1993)
28. M. Sheik-Bahae, J. Wang, E.W. Van Stryland, "Nondegenerate Optical Kerr Effect in Semiconductors," *IEEE J. Quantum Electron.* **QE-29**, 30, 249-255 (1994).
29. T. Xia, D.J. Hagan, M. Sheik-Bahae, and E.W. Van Stryland, "Eclipsing Z-scan Measurements of $\lambda/10^4$ Wavefront Distortion," *Opt. Lett.* **19**, 317-319 (1994).
30. J. Wang, M. Sheik-Bahae, A.A. Said, D.J. Hagan, E.W. Van Stryland, "Time-Resolved Z-scan Measurements of Optical Nonlinearities," *J. Opt. Soc. Am. B.* **11**, 1009-1017(1994).
31. J.U. Kang, A. Villeneuve, M. Sheik-Bahae, G.I. Stegeman, K. Al-hemyari, J.S. Aitchison, C.N. Ironside, "Limitation Due to Three Photon Absorption on Useful Spectral Range for Nonlinear Optics in AlGaAs Below Half Bandgap," *Appl. Phys. Lett.* **65**, 147-149 (1994).
32. T. Xia, M. Sheik-Bahae, A.A. Said, D. J. Hagan, E.W. Van Stryland, "Z-scan and EZ-scan measurements of optical nonlinearities," *International J. Nonlinear Opt. Phys.* **3**, 489-500 (1994).
33. D.J. Hagan, Z. Wang, G. I. Stegeman, E.W. Van Stryland, "Phase-controlled transistor action by cascading of second-order nonlinearities in KTP," M. Sheik-Bahae, G. Assanto, *Opt. Lett.* **19**, 1305-1307 (1994)
34. M. Sheik-Bahae, E.W. Van Stryland, "Ultrafast nonlinearities in semiconductor laser amplifiers," *Phys. Rev. B*, **50**, 14171-14178 (1994).
35. C.A. Aversa, J.E. Sipe, M. Sheik-Bahae, E.W. Van Stryland, "Third-order optical nonlinearities in semiconductors: The two-band model," *Phys. Rev. B*, **50**, 18073-18082 (1994).
36. G. Assanto, G.I. Stegeman, M. Sheik-Bahae, E.W. Van Stryland, "Coherent Interactions for All-Optical Signal Processing via Quadratic Nonlinearities," *IEEE J. Quantum Electron.* **QE-31**, 673-681 (1995).
37. M. Sheik-Bahae, J. Wang, E.J. Canto-Said, R. DeSalvo, D.J. Hagan, and E.W. Van Stryland, "Polarization-dependent four-wave-mixing and two-photon coherence in solids," *IEEE J. Quantum Electron.* **QE-31**, 1270-1273 (1995).
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55. D.V. Seletskiy, S.D. Melgaard, Mansoor Sheik-Bahae, “Thermal imaging with high spatial and temperature resolution”, Photonics West (San Francisco, Jan 21-26, 2012), paper 8275
56. A. Albrecht, M. Ghasemkhani, D. V. Seletskiy, J. G. Cederberg, J. M. Moloney, M. Sheik-Bahae, “Progress towards cryogenic temperatures in intracavity optical refrigeration using a VECSEL”, Photonics West (San Francisco, Feb 2-7, 2013), paper OE120-13
57. **[Invited]** S. D. Melgaard, D. V. Seletskiy, A. Di Lieto, M. Tonelli, M. Sheik-Bahae, “Optical refrigeration progress: cooling below NIST cryogenic temperature of 123 K”, Photonics West (San Francisco, Feb 2-7, 2013), paper OE120-14
58. **[Invited]** M. Sheik-Bahae, M. Ghasemkhani, A. R. Albrecht, D. V. Seletskiy, J. G. Cederberg, S. D. Melgaard, “Intracavity-enhanced solid-state laser cooling using high power VECSELs at 1020 nm”, Photonics West (San Francisco, Feb 2-7, 2013), paper 8606-9
59. C. Wang, M. Sheik-Bahae, J. Cederberg, and D. Bender, “Accurate measurement of external quantum efficiency in semiconductors,” in *SPIE OPTO*, 2013, p. 86380H–86380H.
60. C.-Y. Li, D. V Seletskiy, and M. Sheik-Bahae, “Air-breakdown coherent detection of terahertz using controlled optical bias,” in *SPIE OPTO*, 2013, p. 86231V–86231V.
61. C.-Y. Li, D. V Seletskiy, J. G. Cederberg, and M. Sheik-Bahae, “Observation of strong and broadband terahertz induced electroabsorption in multiple quantum wells,” in *SPIE OPTO*, 2013, p. 86230O–86230O.
62. A. Gragossian, D. V Seletskiy, and M. Sheik-Bahae, “Simultaneous generation and coherent control of terahertz and XUV using two-color laser field,” in *SPIE OPTO*, 2013, p. 86231A–86231A.
63. R. I. Epstein, M. Sheik-Bahae, S. D. Melgaard, D. V Seletskiy, A. R. Albrecht, and M. Ghasemkhani, “Optical cryocoolers,” in *Superconductive Electronics Conference (ISEC), 2013 IEEE 14th International*, 2013, pp. 1–3.
64. J. G. Cederberg, A. R. Albrecht, M. Ghasemkhani, S. D. Melgaard, and M. Sheik-Bahae, “Growth and testing of vertical external cavity surface emitting lasers (VECSELs) for intracavity cooling of Yb: YLF,” *J. Cryst. Growth*, 2013.

Invited and Contributed Presentations at Scholarly Meetings:

1. M. Sheik-Bahae, P. Mukherjee, and H.S. Kwok, "Picosecond CO₂ Laser Induced Self-Defocusing in InSb," IQEC, San Francisco, California 1986.
2. M. Sheik-Bahae, A. Tavano, P. Mukherjee, H.S. Kwok, "New Method of Measuring Relaxation Times in Semiconductors," CLEO, Baltimore, Maryland 1985.
3. M. Sheik-Bahae, T. Rossi, and H.S. Kwok, "Tunneling Induced Two-Photon Absorption in InSb" OSA Annual Meeting, Rochester, New York, 1987.
4. D.J. Hagan, E.W. Van Stryland, Jim Young, T.H. Wei, M. Sheik-Bahae, A.A. Said, K. Mansour, and M.J. Soileau, "Passive Broadband High-Dynamic-Range Semiconductor Limits", SPIE's conference 1105 Technical Symposium, Orlando, Florida 1989.
5. M. Sheik-Bahae, A. Said, E.W. Van Stryland, and M.J. Soileau, "Thermal Lensing in CS₂ at 10 μm ," Annual Meeting of the Optical Society of America, Santa Clara, Ca., 1988.
6. **(INVITED)** M. Sheik-Bahae, D.J. Hagan and E.W. Van Stryland, "Dispersion of the Electronic n₂ originating from two-photon absorption in semiconductors", OSA Annual Meeting, Orlando FL, 1989.
7. **(INVITED)** E.W. Van Stryland, M. Sheik-Bahae, D.J. Hagan, T.H. Wei, A.A. Said, J. Young, E. Canto and A. Miller, "Measurement of the Fast Electronic n₂ Associated with Two-Photon Absorption in Semiconductors", Lasers 89, New Orleans, Dec. 1989.
8. **(INVITED)** E.W. Van Stryland, M. Sheik-Bahae, A.A. Said, T.H. Wei, D.J. Hagan, Y.Y. Wu, and M.J. Soileau, "Sensitive, Single Beam n₂ Measurements", Interdisciplinary Laser Science Conference ILS-V, Stanford, California, Aug. 28-31, 1989.
9. E.W. Van Stryland, M. Sheik-Bahae, D.J. Hagan, "Sensitive n₂ Measurement and Relation of n₂ to Two-Photon-Absorption", Gordon Conference on Nonlinear Optics and Lasers, July, 1989.
10. A.A. Said, M. Sheik-Bahae, T.H. Wei, J. Young, D.J. Hagan, M.J. Soileau and E.W. Van Stryland, "Z-scan: A simple Sensitive Technique for Measuring Refractive Nonlinearities", OSA Annual Meeting, Orlando FL, 1989.
11. M. Sheik-Bahae, A.A. Said, T.H. Wei, Y.Y. Wu, D.J. Hagan, M.J. Soileau and E.W. Van Stryland, "Z-Scan: A Simple and Sensitive Technique for Nonlinear Refraction Measurements", SPIE-OELASE, San Diego, Aug., 1989.
12. D.J. Hagan, J. Young, M. Sheik-Bahae, M.J. Soileau, and E.W. Van Stryland, "Nonlinear Optical Characterization of CdTe as Applied to Limiting at 1.06 Microns", Conference on Lasers and Electro-Optics (CLEO), Baltimore, Md., 1989.
13. M. Sheik-Bahae, A.A. Said, Y.Y. Wu, T.H. Wei, D.J. Hagan, and E.W. Van Stryland, "A Simple and Sensitive Technique for Determining Refractive Nonlinearities", Conference on Lasers and Electro-Optics (CLEO), Baltimore, Md., 1989.
14. M. Sheik-Bahae, Ali A. Said, T.H. Wei, D.J. Hagan, E.W. Van Stryland, and M.J. Soileau, "Sensitive n₂ Measurements Using a Single Beam", 1989 Boulder Damage Conference, Boulder, Co., 1989.
15. Ali A. Said, M. Sheik-Bahae, M.J. Soileau, and E.W. Van Stryland, "LID to TAS", 1989 Boulder Damage Conference, Boulder, Co., 1989.
16. M. Sheik-Bahae, D.J. Hagan, A. Miller, and E.W. Van Stryland, "Relation Between n₂ and Two-Photon Absorption", 1989 Boulder Damage Conference, Boulder, Co., 1989.
17. M. Sheik-Bahae, A.A. Said, and E.W. Van Stryland, "Simple Analysis and Geometrical Optimization of a Passive Optical Limiter Based on Internal Self-action", SPIE's 1089 Technical Symposium, Orlando, Florida 1989.

18. **(INVITED)** E.W. Van Stryland, D.J. Hagan, M. Sheik-Bahae and M.J. Soileau, "Semiconductor Nonlinearities for Optical Limiting", conference on Nonlinear Optics: Materials, Phenomena and Devices, Kauai, Hawaii, July 16-20, 1990.
19. **(INVITED)** M.J. Soileau, T.H. Wei, M. Sheik-Bahae, D.J. Hagan, Martine Sence, and E.W. Van Stryland, "Nonlinear Optical Characterization of Organic Materials", III International Topical Meeting on Optics of Liquid Crystals, Optical Properties and Applications of Liquid Crystals and Organic Materials, Cetraro, Italy, Oct. 1-5, 1990.
20. **(INVITED)** P. Palffy-Mulhoray, H.J. Yuan, L. Li, M.A. Lee, J.R. DeSalvo, T.H. Wei, M. Sheik-Bahae, D.J. Hagan, and E.W. Van Stryland, "Measurements of Third Order Nonlinearities of Nematic Liquid Crystals", III International Topical Meeting on Optics of Liquid Crystals, Optical Properties and Applications of Liquid Crystals and Organic Materials, Cetraro, Italy, Oct. 1-5, 1990.
21. **(INVITED)** D.J. Hagan, M. Sheik-Bahae, D.C. Hutchings, A.A. Said, T.H. Wei, and E.W. Van Stryland, "Kramers-Kronig Relations for Bound-Carrier (fast) Nonlinearities", Lasers 90, San Diego, Ca., Nov. 1990.
22. J.R. DeSalvo, D.J. Hagan, M. Sheik-Bahae, and E.W. Van Stryland, "Sensitive Measurement of Anisotropy of Third Order Nonlinearities", OSA Annual meeting, Boston, Mass., 1990.
23. A.A. Said, M. Sheik-Bahae, D.J. Hagan, and E.W. Van Stryland, "Alternative Z-scan Geometries", OSA Annual Meeting, Boston, Mass., 1990.
24. M. Sheik-Bahae, D.J. Hagan, A.A. Said, James Young, T.H. Wei, and E.W. Van Stryland, "Kramers-Kronig Relation Between n_2 and Two-Photon Absorption", SPIE meeting on Materials for Optical Switches, and Limiters II, Orlando, Fl., 1990.
25. A.A. Said, M. Sheik-Bahae, D.J. Hagan, E. Canto, Y.Y. Wu, James Young, T.H. Wei, and E.W. Van Stryland, "Nonlinearities in Semiconductors for Optical Limiting", SPIE meeting on Materials for Optical Switches, and Limiters II, Orlando, Fl., 1990.
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27. A.A. Said, M. Sheik-Bahae, T.H. Wei, J. Young, M Junnarkar, D.J. Hagan and E.W. Van Stryland, "Z-scan measurements of high-order optical nonlinearities in semiconductors", CLEO, Anaheim CA, (1990)
28. M. Sheik-Bahae, D.C. Hutchings, D.J. Hagan, M.J. Soileau, and E.W. Van Stryland, "Dispersion of n_2 in Solids", 1990 Boulder Damage Conference, Boulder, Co., 1990.
29. D.J. Hagan, M. Sheik-Bahae, D.C. Hutchings, and E.W. Van Stryland, "Scaling Laws for Ultrafast All Optical Switching", Annual Meeting of LEOS '90, Boston, Mass., 1990.
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32. M. Sheik-Bahae, D.C. Hutchings, D.J. Hagan, E.W. Van Stryland, "Nondegenerate Bound Electronic Kerr Effect n_2 in Semiconductors," QELS, Baltimore, Maryland 1991.
33. M. Sheik-Bahae, A.A. Said, D.J. Hagan, M.J. Soileau, E.W. Van Stryland, "Nonlinear Absorption and Refraction in UV Transmitting Materials," 1991 Boulder Damage Symposium, Boulder, CO. 1991.
34. M. Sheik-Bahae, E.W. Van Stryland, "Theory of Ultrafast Nonlinear Refraction in Semiconductor Lasers," Post deadline paper, Annual Meeting of the Optical Society of America, San Jose, CA. Nov. 3-8, 1991.
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36. **(INVITED)** M.J. Soileau, M. Sheik-Bahae, D.C. Hutchings, D.J. Hagan, E.W. Van Stryland, "Wavelength Dependence of Nonlinear Absorption and Refraction in Solids," XIV International Conference on Coherence and Nonlinear Optics, Leningrad, USSR 1991.
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38. **(INVITED)** E.W. Van Stryland, M. Sheik-Bahae, G. Stegeman, "Characterization of Nonlinear Optical Materials," American Association for Crystal Growth, 4-th Conference, Atlantic City, NJ, Oct. 2-4, 1991.
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43. M. Sheik-Bahae, J. Wang, D.C. Hutchings, J.R. DeSalvo, A.A. Said, D.J. Hagan, E.W. Van Stryland, "Measurement and Theory of Nondegenerate Bound Electronic Nonlinearities in Semiconductors," OSA Annual Meeting, Nov. 3-8, San Jose, CA, 1991.
44. R. DeSalvo, M. Sheik-Bahae, D.J. Hagan, E.W. Van Stryland, G.I. Stegeman, "Nonlinear Refraction from $\chi(2):\chi(2)$ in KTP," OSA Annual Meeting, Nov. 3-8, San Jose, CA 1991.
45. **(INVITED)** E.W. Van Stryland, M. Sheik-Bahae "Measurement and Theory of Dispersion on n_2 in Solids," 22nd Winter Colloquium on Quantum Electronics, Snowbird, Utah Jan. 5-8, 1992.
46. **(INVITED)** E.W. Van Stryland, M. Sheik-Bahae, D.C. Hutchings and D.J. Hagan, "Z-scans and Nonlinear Kramers-Kronig Relation," Invited lecture at the International School on Nonlinear Photonics and Optical Physics, Capri, Italy, June 1-5, 1992.
47. **(INVITED)** M. Sheik-Bahae, M.J. Soileau and E.W. Van Stryland, "Measurement of Nonlinear Absorption and Refraction of Light by Matter", AAPT Winter Meeting Orlando, FL, 1992.
48. **(INVITED)** G.I. Stegeman, M. Sheik-Bahae, E.W. Van Stryland, "Very Large Third Order Nonlinearities via Cascading of Second Order Effects," IQEC, Vienna, 1992.
49. **(INVITED)** M. Sheik-Bahae "Ultrafast Nonlinearities in Semiconductor Lasers", , US-Australian Bilateral Workshop on Nonlinear Optics, Cocoa Beach, FL, Aug. 1992.
50. **(INVITED)** E.W. Van Stryland, G.I. Stegeman, R. DeSalvo, D.J. Hagan, and M. Sheik-Bahae, "Cascading of $\chi^{(2)}$ for $\chi^{(3)}$ Nonlinearities," Nonlinear Optics 2nd Topical Meeting, Maui, Hawaii, 1992.
51. J. Wang, M. Sheik-Bahae, A.A. Said, D.J. Hagan, and E.W. Van Stryland, "Time-Resolved Measurements of Nondegenerate of Nondegenerate Optical Nonlinearities," CLEO, Anaheim CA, May 1992.
52. M. Sheik-Bahae, E.W. Van Stryland, "Theory of Ultrafast Nonlinear Refraction in Semiconductor Optical Amplifiers," QELS Conference, Anaheim, CA, May 1992.

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56. J. Wang, A.A. Said, D.J. Hagan, M. Sheik-Bahae , and E.W. Van Stryland, "Two-Color Time Resolved Measurements of Optical Nonlinearities," Annual Meeting of Optical Society of America, Albuquerque NM, 1992.
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- 160.** Melgaard, S.D.; Seletskiy, D.V.; Di Lieto, A.; Tonelli, M.; Sheik-Bahae, M.; , "Optical refrigeration to NIST cryogenic temperature at 123K," Lasers and Electro-Optics (CLEO), 2012 Conference on , vol., no., pp.1-2, 6-11 May 2012
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171. **(INVITED FEATURE ARTICLE)** Optical cryocoolers outshine thermoelectrics, RI Epstein, MP Hehlen, M Sheik-Bahae, SD Melgaard, SPIE Defense+ Security, 90702K-90702K-10
172. Solid-state cryo-cooling using optical refrigeration, SD Melgaard, A Albrecht, DV Seletskiy, R Epstein, J Alden, M. Sheik-Bahae, Lasers and Electro-Optics (CLEO), 2014 Conference on, 1-2
173. Optical refrigeration cools below 100K, S Melgaard, AR Albrecht, M Hehlen, D Seletskiy, M Sheik-Bahae, CLEO: QELS_Fundamental Science, FTh4D. 4
174. Optical cryocoolers for sensors and electronics, RI Epstein, MP Hehlen, M Sheik-Bahae, SD Melgaard, Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 9070
175. Broadband THz imaging in gas and multiple quantum-well media, CY Li, DV Seletskiy, JG Cederberg, M Sheik-Bahae, SPIE OPTO, 898413-898413-8
176. **(Invited)** Exploring ultrafast negative Kerr Effect for self-mode-locking vertical external-cavity surface-emitting lasers, AR Albrecht, DV Seletskiy, Y Wang, JG Cederberg, M Sheik-Bahae, SPIE LASE, 896604-896604-9
177. Device applications of cryogenic optical refrigeration, SD Melgaard, DV Seletskiy, R Epstein, D Sills, M Sheik-Bahae, SPIE OPTO, 900002-900002-5
178. Intracavity optical refrigeration to 131K using high-power vertical external-cavity surface-emitting lasers (VECSELs), M Ghasemkhani, AR Albrecht, SD Melgaard, DV Seletskiy, JG Cedeberg, M. Sheik-Bahae, SPIE OPTO, 900005-900005-7

Seminars and Colloquia:

1. "*Picosecond CO₂ Laser Interaction with Semiconductors*", Center for Applied Quantum Electronics, North Texas State University, Denton, Texas, Feb. 1987.
2. "*Kerr Lensing in Optical Resonators*", CREOL, University of Central Florida, Orlando, FL, Aug. 1991.
3. "*Ultrafast Optical Nonlinearities in Diode Lasers*," CREOL, University of Central Florida, Orlando, FL, Oct. 1991.
4. "*Kramers-Kronig Dispersion Relations in Nonlinear Optics*," AT&T Bell Laboratories, Holmdel, NJ, Feb. 1992.
5. "*Bound-Electronic Nonlinear Refraction in Semiconductors*," AT&T Bell Laboratories, Murray Hill, NJ, Feb. 1992.
6. "*Theory and Measurements of Optical Nonlinearities in Solids*," Colloquium: Department of Physics, University of South Florida, Tampa FL, April 1992.
7. "*Ultrafast Optical Nonlinearities in Solids*", Department of Physics and Astronomy, University of New Mexico, Albuquerque, NM, April 1994.
8. "*Development and Applications of Z-Scan*," Wright Laboratories, Wright-Patterson AFB, Dayton, OH, April 1994.
9. "*Nonlinear Optical Measurement Techniques*," Los Alamos National Laboratories, New Mexico, January 1998.
10. "*Measurement, Theory and Application of Bound-Electronic Nonlinearities in Solids*," Colloquium: Department of Physics and Astronomy, New Mexico State University (NMSU), Las Cruces, NM, April 1998.
11. "*All –Solid-State Optical Cryocoolers*" Wright Laboratories, Wright-Patterson AFB, Dayton, OH, May 2000.
12. "*Chilling with Light*" CREOL/School of Optics, Univ. of Central Florida, May 2003
13. "*Nonlinear Optics for the Masses, and Virtues of Ignorance!*", Center for High Technology Materials (CHTM), University of New Mexico, LEOS Chapter. May 2007
14. "*Chilling with Light: Advances in Laser Cooling of Solids*", ICFO, Barcelona, Spain July 2009
15. "*Solid-State Optical Refrigeration: Lasers Running in Reverse*", Purdue University, Dept. of Physics, April 2010
16. "*Solid-State Optical Refrigeration: Lasers Running in Reverse*", University of Arizona, Optical Sciences Center, Sept. 2010.
17. "Optical Cryocoolers", University of Illinois, Urbana-Champaign, Oct. 2013