PRABHAKAR PRADHAN, Ph.D.

Assistant Professor

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EDUCATION:

- **Ph. D. in Physics**, 1996, Indian Institute of Science, Bangalore, India
- **M. Sc. in Physics**, 1989, Tata Institute of Fundamental Research (TIFR), Bombay, and University of Poona (Pune) Joint M.S. Physics National Program, India
- **B. Sc. (Honors) in Physics**, 1987, University of Calcutta, Calcutta, India

PROFESSIONAL EMPLOYMENT HISTORY:

- **Assistant Professor,** 2018-present, Department of Physics and Astronomy, Mississippi State University, MS 39762
- **Assistant Professor**, 2013-2018, Department of Physics and Materials Science, University of Memphis, Tennessee
- **Research Assistant Professor**, 2009–2013, Biomedical Engineering, Northwestern University, Evanston, Illinois
- **Research Associate**, 2002–2008, Biomedical Engineering Department and Electrical Engineering Department, Northwestern University, Evanston, Illinois
- **Visiting Research Fellow**, 2001 – 2002, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Massachusetts
- **Research Associate**, 1999 – 2001, Dana Research Center, Physics Department, Northeastern University, Boston, Massachusetts
- **Post-Doctoral Fellow**, 1997 – 1999, Electrical Engineering Department, University of California at Los Angeles, Los Angeles, California

AWARDS AND SCHOLARSHIPS:

- Council of Scientific and Industrial Research (CSIR), Government of India, New Delhi, Junior Research Fellowship (1991-1993)
- Council of Scientific and Industrial Research (CSIR), Government of India, New Delhi, Senior Research Fellowship (1993-1996)
- International Center for Theoretical Physics, Trieste, Italy, Visiting Fellowships (1994 and 1996)
- Tata Institute of Fundamental Research (TIFR) Fellowship for the Joint M.S. Physics National Program (1987-1989)

AREAS OF INTERESTS:

Broad Areas: Biophotonics and Nanophotonics

Pradhan's BioNanoPhotonics Lab at MSU
Around 600 sq. ft. state of art lab facilities (in the process). One Ph.D. student joined, and other graduate students (2) and one post-doc in the process of joining.

Research Objectives
Studies of static and dynamic optical properties of mesoscopic to nanoscopic optical disordered media, such as biological cells/tissues. In particularly, the development of optical tools and techniques to understand the biological processes within a single cell to tissue. Main focus is on using biophotonics methods to understand and detect disease processes such as: progression of early cancer and abnormalities in brain cells/tissues.

Important techniques and instrumentations developed by my group are the following
- Enhanced spectroscopic microscopy technique to probe nanoscale structures of cells and tissues
- Low coherence backscattering technique for depth selective scattering probing
- Delay time spectroscopy technique to detect abnormalities in cells/tissues
- High-throughput and fiber optics technology development for early cancer detection
- Optical technique to probe light localization in cells for detection of cancer stages
- Speckle spectroscopic technique for ultra-rheological characterization of bio-fluids

Commercially available instruments that we are using
- Electron microscopy; Confocal microscopy; Two-photon microscopy

Large scale numerical simulations and analytical calculations to support our experiments
- Finite-difference time-domain (FDTD) method, Molecular Dynamics, and Brownian Dynamics simulations are used to support our experimental results.

Selected projects the Prdhan's Group have been working on

- Enhanced partial wave spectroscopy (EPWS) development and characterization of nano-scale scattering, and development of high-throughput instrumentation with nanoscale sensitivity: Study of nanoscopic light transport properties of single biological cells. Optical imaging of intracellular nanoscale structural disorder of a biological cell for early-stage cancer detection.
- Low-coherence enhanced backscattering spectroscopy (LEBS) and corresponding miniaturized fiber optics for *in vivo* optical tool development: Detection of low order scattering events from biological systems (tissues). Depth selectivity of LEBS photons to study early cancer progression in epithelial tissue layers.
- Light localization properties of biological cells and cancer detection using confocal microscopy: We have developed a novel technique to study the nano to submicron scales molecular specific mass-density fluctuations of biological cell nuclei by quantifying their nanoscale light-localization properties using confocal microscopy (CFM) imaging. We have successfully applied this technique for different stages of cancer detection in cells.

- Delay time spectroscopy to study biological systems: We have developed delay time spectroscopy to probe the time spent by a photon inside a biological scattering medium before it escapes. This new method is used to characterize the abnormalities in a cell/tissue.
- Dynamic properties (diffusion and displacement) of single particles and monomers in a biological cell: Use of fluorescence correlation spectroscopy and confocal microscopy to study the changes in single particle and monomer diffusion processes in biological cells with the changes in crowding in carcinogenesis.
- Electron Microscopy (EM) study of cells and tissues: Quantification of optical disorder strength resulting from nanoscale refractive index fluctuations of tissues/cells via EM. Correlation between EM and optical microscopy study to investigate the origin of cancer.
- Finite-Difference Time-Domain (FDTD) numerical simulations: Most of our scattering experiments are supported by the FDTD simulation or similar methods.
- Brownian dynamics (BD) and molecular dynamics (MD) simulations: BD/MD simulations on model chromatin systems to study the dynamic properties of the cell nucleus in order to predict the progress of carcinogenesis.

RESEARCH FUNDING:

Completed Research Grants

(1) **Source:** NIH/R01 EB016983
Title: High-throughput molecular-specific cell nanocytology for cancer screening
Major Goal: The goal of this project is to study the effect of molecular specific staining to improve the structural characterization of cells for cancer detection and to use high throughput partial wave spectroscopy method for fast detection.
Amount: $1.2 M
Period: 09/01/13-08/31/18
Role: CoI

(2) **Source:** Biologistic Research Cluster Grant (FedEx)
Title: Biologistics of lung cancer screening and management using field effect of carcinogenesis and a novel biophotonics technique
Major Goal: The goal of this project is to develop an ultrasensitive optical spectroscopic microscopy instrument to detect lung cancer from buccal/inner cheek cells.
Amount: $32,000
Period: 01/01/16-06/30/18
Role: PI

(3) **Source:** DRONES (Drones, Robotics, and Navigation Enabled Systems) Cluster Research Grant (FedEx)
Title: Drone assisted cavity ringdown sensor for real-time environmental methane gas monitoring
Major Goal: The goal of this project is to develop a cavity ringdown method that can detect methane molecules in air by multi-pass sensitive laser scattering properties of these molecules. The instrument can be attached to a drone to detect methane molecules in air at a particular altitude.
Amount: $10,000
Period: 02/01/17-06/30/18
Role: PI

(4) **Source:** NIH/R01 EB003682
Title: Mechanism of light scattering in living tissues
Major Goal: The goal of this project was to study the mechanism of light scattering in biological cells and tissues, and applications of the technique for cancer detection using tissue samples.
Amount: $1.3 M
Period: 06/01/10-05/31/15
Role: PI

(5) **Source:** Faculty Research Grant (UofM)
Title: Delay time spectroscopy for early cancer detection
Research Goal: The goal of this project was to develop a delay time optical instrumentation to characterize the refractive index fluctuation inside the cells at different length scales, and applications of the method for early cancer detection.
Amount: $6,000
Period: 07/01/14-06/30/16
Role: PI

POSTDOCS AND GRADUATE STUDENTS MENTORING:

(i) Postdocs and Graduate Students at Mississippi State University

Ph.D. Student

1. **Prakash Adhikari** 2018- Present

(ii) Postdocs and Graduate Students Completed with Dr. Pradhan at University of Memphis

Postdocs

1. **Dr. Peeyush Sahay** 2014-2018 (Completed)
2. **Dr. Vibha Tripathi** 2014-2015 (Completed)

Ph.D. Students

1. **Huda M. Almabadi** 2014- 2018 (Completed)

MS Students:

2. **Shiva Bhandari** 2016-2018 (Completed)
3. **Ethan R. Avery** 2015-2017 (Completed)
4. **Hemendra M. Ghimire** 2013-2015 (Completed)

(iii) Earlier Postdocs and Graduate Students partially mentored at Northwestern Univ.

1. **Dr. Young Kim** (Postdoc)
2. **Hariharan Subramanian** (Ph.D. Student, Graduated)
3. **Yang Liu** (Ph.D. Student, Graduated)
4. **Daniel Park** (Project Assistant Student, completed)

PUBLICATIONS:

Published Journal Papers ***(Total Journal Publications:* 50*; Total Citation* >1200 *in Google Scholar)***

Online: http://scholar.google.com/citations?user=WVU2BLYAAAAJ&hl=en

1. S. Bhandari, P. Shukla, H. M. Almabadi, P. Sahay, R.K. Rao and **P. Pradhan**, "Optical study of stress hormone-induced nanoscale structural alteration in brain using partial wave spectroscopic (PWS) microscopy," ***Journal of Biophotonics (2018),*** In press,

2. S. Bhandari, S. Choudannavar, E. R. Avery, P. Sahay and **P. Pradhan**, "Detection of colon cancer stages via fractal dimension analysis of optical transmission imaging of tissue microarrays (TMA)." ***Biomedical Physics & Engineering Express*** **4(6)**, 065020 (2018).

3. H. M. Almabadi, P. Nagesh, P. Sahay, S. Bhandari, E. C. Eckstein, M. Jaggi, S. C. Chauhan, M Yallapu and **P Pradhan**, "Optical study of chemotherapy efficiency in cancer treatment via intracellular structural disorder analysis using partial wave spectroscopy," ***Journal of Biophotonics*** (2018): e201800056.

4. P. Sahay, A. Ganju, H. M. Almabadi, H.M. Ghimire, M. M. Yallapu, O. Skalli, M. Jaggi, S.C. Chauhan, and **P. Pradhan**, "Quantification of photonic localization properties of targeted nuclear mass density variations: application in cancer stage detection." ***Journal of Biophotonics,*** (2017): e201700257.

   [This article was highlighted in ***Physics World news by the Institute of Physics (IOP,UK): https://physicsworld.com/a/photonic-technique-eases-cancer-staging/]

5. P. Sahay, H. M. Almabadi, H.M. Ghimire, O. Skalli, and **P. Pradhan**,"Light localization properties of weakly disordered optical media using confocal microscopy: application to cancer detection," ***Optics Express*** **13,** 15428-15440 (2017).

   [*This article appeared as a* ***Spotlight on Optics *by the Optical Society of America (**OSA**):* https://www.osapublishing.org/spotlight/summary.cfm?URI=oe-25-13-15428]

6. **P. Pradhan**, D.J. Park, I. Capoglu, H Subramanian, D. Damania, L. Cherkezyan, A. Taflove, V. Backman, "Reflection statistics of weakly disordered optical medium when its mean refractive index is different from an outside medium," ***Optics Communications*** **393**, 185-190 (2017).

7. P. Sahay, P. K. Shukla, H. M. Ghimire, H. M. Almabadi, V. Tripathi, S. K. Mohanty, R. K. Rao, and **P. Pradhan**, "Quantitative analysis of nanoscale intranuclear structural alterations in hippocampal cells in chronic alcoholism via transmission electron microscopy imaging," ***Physical Biology*** **14 (2)**, 026001-7 (2017).

8. S. Khan, M. Sikander, M. C. Ebeling, A. Ganju, S. Kumari, M Yallapu, B. B. Hafeez, T. Ise, S. Nagata, N. Zafar, S. W. Behrman, J.Y. Wan, H. M. Ghimire, P. Sahay, and **P. Pradhan**, S. C Chauhan, M. Jaggi, "MUC13 interaction with receptor tyrosine kinase HER2 drives pancreatic ductal adenocarcinoma progression," ***Oncogene*** (**Nature Publication**), 1-10 (2016).

9. B. Black, V. Vishwakarma, K. Dhakal, S. Bhattarai, **P. Pradhan**, A. Jain, Y. Kim, S. Mohanty, "Spatial temperature gradients guide axonal outgrowth," ***Scientific Reports*** **6 (Nature Publications)**, 29876 (2016).

10. D. J. Park, **P. Pradhan**, and V. Backman, "Enhancing the sensitivity of mesoscopic light reflection statistics in weakly disordered media by interface reflections," ***International Journal of Modern Physics B*** **30**, 165015 (2016).

11. A. J. Radosevich, J. D. Rogers, I. R. Çapoglu, N. N. Mutyal, **P. Pradhan**, and V. Backman, “Open source software for electric field Monte Carlo simulation of coherent backscattering in biological media containing birefringence,” ***Journal of Biomedical Optics*** **17**, 115001-115013 (2012).
12. D. Damania, H. Roy, H. Subramanian, D. Weinberg, D. Rex, M. Goldberg, J. Muldoon, Y. Zhu, L. Bianchi, D. Shah, **P. Pradhan**, M. Borkar, H. Lynch, and V. Backman, “ Nanocytology of rectal colonocytes to assess risk of colon cancer based on field cancerization,” ***Cancer Research*** **72**, 2720-2727 (2012).
13. **P. Pradhan**, D. Damania, H. M. Joshi, V. Turzhitsky, H. Subramanian, H. K. Roy, A. Taflove, V. P. Dravid, and V. Backman, “Quantification of nanoscale density fluctuations by electron microscopy: probing cellular alterations in early carcinogenesis,” ***Physical Biology*** **8**, 026012-026020 (2011).
14. J. S. Kim, **P. Pradhan**, V. Backman, and I. Szleifer, “Influence of chromosome density variations on the increase in nuclear disorder strength in carcinogenesis,” ***Physical Biology*** **8**, 015004-015009 (2011).
15. J. D. Rogers, V. Stoyneva, V. Turzhitsky, N. N. Mutyal, **P. Pradhan**, I. R. Capoglu, and V. Backman, "Alternate formulation of enhanced backscattering as phase conjugation and diffraction: derivation and experimental observation," ***Optics Express*** **19,** 11922-11931 (2011).
16. **P. Pradhan**, D. Damania, H. M. Joshi, V. Turzhitsky, H. Subramanian, H. K. Roy, A. Taflove, V. P. Dravid, and V. Backman, "Quantification of Nanoscale Density Fluctuations using Electron Microscopy: Light Localization Properties of Biological Cells." ***Applied Physics Letters*** **97**, 243704-243706 (2010).
17. H. K. Roy, H. Subramanian, D. Damania, T. Hensing, D. Ray, A. Bogojevic, **P. Pradhan**, J. Rogers, N. Hasabou, I. Caopglu, and V. Backman, “Optical Detection of Buccal Epithelial Nano-Architectural Alterations in Patients Harboring Lung Cancer: Implications for Screening,” ***Cancer Research*** **70**, 7748-7754 (2010).
18. D. Damania, H. Subramanian, A. K. Tiwari, Y. Stypula, D. Kunte, **P. Pradhan**, H. K. Roy, and V. Backman, “Role of Cytoskeleton in Controlling the Disorder Strength of Cellular Nanoscale Architecture,” ***Biophysical Journal*** **99**, 989-996 (2010).
19. H. Subramanian, **P. Pradhan,** Y. Liu, I. Capoglua, J. Rogers, H. K. Roy, and V. Backman, "Partial wave microscopic spectroscopy detects sub-wavelength refractive index fluctuations: an application to cancer diagnosis," ***Optics Letters*** **34**, 518-520 (2009).
20. H. Subramanian, H. K. Roy, **P. Pradhan,** M. J. Goldberg, R.E. Brand, C. Sturgis, T. Hensing, D. Ray, J. Chang, J. Mohammed, and V. Backman, "Partial Wave Spectroscopic Microscopy for Detection of Nanoscale Alterations of Field Carcinogenesis," ***Cancer Research*** **69**, 5357-5363 (2009).
21. H.K. Roy, V. Turzhitsky, Y. Kim, M. Goldberg, P. Watson, J. Rogers, A. Gomes, A. Kromine, R. Brand, M. Jameel, N. Hasabou, **P. Pradhan**, and V. Backman, "Association between Rectal Optical Signatures and Colonic Neoplasia: Potential Applications for Screening," ***Cancer Research*** **69**, 4476-4483 (2009).
22. **P. Pradhan**, G. C. Cardoso, and M.S. Shahriar, "Suppression of the Bloch-Siegert Oscillation Induced Error in Qubit Rotations via the Use of Off-Resonance Raman Excitation," ***Journal of Physics B : Atomic, Molecular and Optical Physics*** **42** , 065501-065507 (2009).
23. H. Subramanian, **P. Pradhan**, Y. Liu, I. Capoglu, X. Li, J. Rogers, A. Heifetz, D. Kunte, H. K. Roy, A. Taflove, and V. Backman, “Optical methodology for detecting histologically unapparent

nanoscale consequences of genetic alterations in biological cells," ***Proceedings of the National Academy of Sciences USA (PNAS)*** **150**, 20118-20123 (2008).

24. H. Subramanian, **P. Pradhan**, Young L. Kim, and V. Backman, "Penetration depth of low-coherence enhanced backscattering photons in the sub-diffusion regime," ***Physical Review E*** **75**, 041914-041922 (2007).
25. M.S. Shahriar, **P. Pradhan**, G.S. Pati, V. Gopal, and K. Salit, "Light-Shift Imbalance Induced Blockade of Collective Excitations Beyond the Lowest Order," ***Optics Communications*** **278,** 94-98 (2007).
26. V. Backman, Y. Kim, Y. Liu, V. Turzhitsky, H. Subramanian, **P. Pradhan**, H. K. Roy, and M. Goldberg, "Low-coherence enhanced backscattering and its applications," ***IEEE Eng. Med. Biol. Soc*.** **2007**, 521-523 (2007).
27. H. K. Roy, Y. Liu, H. Subramanian, D. Kunte, **P. Pradhan,** R. K. Wali, J. Koetsier, M. J. Goldberg, Z. Bogojevic, and V. Backman, "Detection of the colorectal cancer (CRC) field effect through partial wave spectroscopic microscopy (PWS)," ***Gastroenterology*** **132**, 169-171 (2007).
28. **P. Pradhan,** "A model for Quantum Stochastic Absorption in Absorbing Disordered Media," ***Physical Review** B* **74**, 085107-085111 (2006).
29. Y. L. Kim, V. Turzhitsky, H. Roy, R. Wali, H. Subramanian, **P. Pradhan**, and V. Backman, "Low-coherence enhanced backscattering (LEBS): Principles and applications for colon cancer screening," ***Journal of Biomedical Optics*** **11**, 041125-041134 (2006)**.**
30. Y. Kim, **P. Pradhan**, H. Subramanian, Y. Liu, M. H. Kim, and V. Backman, "Origin of Low Coherence Enhanced Backscattering," ***Optics Letters*** **31**, 1459-1461 (2006).
31. H. Subramanian, **P. Pradhan**, Y. Kim, Y. Liu, X. Li, and V. Backman, "Modeling Low-Coherence Enhanced Back Scattering Using Monte Carlo Simulation," ***Applied Optics*** **45**, 6293-6295 (2006).
32. Y. L. Kim, **P. Pradhan,** M. H. Kim, and V. Backman, "Circular Polarization Memory Effect in Low-Coherence Enhanced Backscattering of Light," ***Optics Letters*** **31**, 2744-2746 (2006).
33. M.S. Shahriar, **P. Pradhan**, G. Cardoso, V. Gopal, and G. Pati, "Wavelength locking via teleportation using distant quantum entanglement and Bloch–Siegert oscillation," ***Optics Communications*** **266**, 349-353 (2006).
34. G. Cardoso, **P. Pradhan**, and M. S. Shahriar, "In-Situ Observation of the Phase of a Microwave Field using Single-Atom Nonlinear Optics," ***Physical Review A*** **71,** 063408-063411 (2005).
35. M.S. Shahriar, **P. Pradhan**, Y. Tan, M. Jheeta, J. Morzinsky, and P.R. Hemmer, "Demonstration of a Continuously Guided Atomic Interferometer using a Single-Zone Optical Excitation," ***Journal of the Optical Society of America B*** **22,** 1566-1570 (2005).
36. A. Gangat, **P. Pradhan**, and M.S. Shahriar, "Two-dimensional Nanolithography using Atom Interferometry," ***Physical Review*** **A 71**, 043606-043620 (2005).
37. M.S. Shahriar, M. Jheeta, Y. Tan, **P. Pradhan**, and A. Gangat, "Continuously Guided Atomic Interferometry using a Single-Zone Optical Excitation: Theoretical Analysis," ***Optics Communications*** **243**, 183-201 (2004).
38. M. S. Shahriar, **P. Pradhan,** and J. Morzinski, "Determination of the phase of an electromagnetic field via incoherent detection of fluorescence," ***Physical Review A*** **69**, 032308-032311 (2004).
39. **P. Pradhan** and S. Sridhar, "From chaos to disorder: Statistics of the eigenfunctions of microwave cavities," ***Pramana - Journal of Physics*** **58**, 333-341 (2002).

40. W. Lu, K. Pance, **P. Pradhan,** and S. Sridhar, "Quantum correlations and classical resonances in an open chaotic system," ***Physica Scripta*** **T90**, 238-245 (2001).

41. **P. Pradhan** and S. Sridhar, "Correlations due to localization in quantum eigenfunctions of disordered microwave cavities," ***Physical Review Letters*** **85**, 2360-2363 (2000).

42. **P. Pradhan** and N. Kumar, "Geometric phase for a dimerized disordered continuum: Topological shot noise, " ***Europhysics Letters*** **44**, 131-136 (1998).

43. N. Kumar, **P. Pradhan,** and A. M. Jayannavar, "Statistics of Super-Reflection, "***Superlattices and Microstructures*** **23**, 853-858 (1998).

44. N. Kumar, G. V. Vijayagovindan, and **P. Pradhan**, "Spin-valve effect in manganese-oxide perovskites: CMR," ***Giant Magnetoresistance and Related Properties of Metal Oxides,*** Special Issue, Edited by C.N.R. Rao and B. Raveau (World Scientific Publishing, Singapore, 1998), 305-311 (1998).

45. **P. Pradhan** and N. Kumar, "Random Amplifying Media: Mirrorless Laser," ***Proceedings of the National (Indian) Laser Sciences*** **17,** 70-73 (1997).

46. **P. Pradhan**, "Comment on 'The mapping of the Coulomb problem in to the oscillator'," by David S. Bateman, Clinton Boyd and Binayak Dutta-Roy, [*Am. J. Phys.* 60 (9), 833-836(1992)], " ***Am. J. Phys.*** **63**, 664-664 (1995).

47. **P. Pradhan** and N. Kumar, "Localization of light in coherently amplifying random media," ***Phys. Rev. B*** **50,** 9644-9647 (1994).

48. N. Tit, **P. Pradhan** and N. Kumar, "Length-scale-dependent ensemble-averaged conductance of a 1D disordered conductor: Conductance minimum," ***Phys. Rev. B*** **49**, 14715-14717 (1994).

49. **P. Pradhan** and N. Kumar, "Suppression of conductance fluctuations in short one-dimensional conductors," ***Phys. Rev. B*** **48**, 5661-5664 (1993).

50. **P. Pradhan**, M. Arjunwadkar and A. W. Joshi, "Energy Band of One-dimensional Lattice with Two Rectangular Potential Barrier Per Unit Cell," ***Physics Education (India)*** **9**, 343-348 (1993).

Published Peer Reviewed Conference Proceedings

51. H. Subramanian, D. Damania, K. Sholanki, Y. Stypula, L. Cherkezyan, A. Tiwari, **P. Pradhan**, D. Kunte, H. K. Roy; V. Backman, "Partial Wave Spectroscopy and Its Relation to Nanoscale Disorder in Nuclear Architecture." *Proceedings of Biomedical Optics (BIOMED),* BWB4 (2010).

52. V. Backman, H. Subramanian, **P. Pradhan**, Y. Liu, I. Capoglu, J. Rogers, "Detecting Alterations in Cell Nanoarchitecture with Optical Imaging: Implications for Cancer," *Proceedings of Laser Science (LS),* LTHD3 (2008).

53. H. Subramanian, **P. Pradhan**, D. Damania, D. Balikov , S. Maheshwari, V. Backman, "Understanding cell nano-architecture and its alteration in carcinogenesis via partial wave spectroscopy," *Proceedings in Frontiers in Optics*, FWV6 (2007).

54. H. Subramanian, **P. Pradhan**, Y. Kim, and V. Backman, "Depth of penetration of low coherence enhanced backscattering photons in the sub-diffusion regime," *Proc. SPIE* **6436**, 643605 (2007).

55. Y. Kim, **P. Pradhan**, V. Turzhitsky, H. Subramanian, Y. Liu, R. Wali, H. Roy, and V. Backman, "Low-coherence enhanced backscattering of light: characteristics and applications for colon cancer screening," *Proc. SPIE* **6446**, 644606 (2007).

56. Y. L. Kim, **P. Pradhan**, H. Subramanian, Y. Liu, M. H. Kim, V. Backman, "Minimal scattering events in enhanced backscattering (EBS) of light: Origin of low-coherence EBS in discrete tissue models," *Proceedings of Photonics Materials.* MB5 (2006).

57. Y. Liu, **P. Pradhan,** X. Li, Y. L. Kim, R. K . Wali, H. K. Roy, *V.* Backman, "Partial-Wave Spectroscopy to Detect The Initial Stage of Colon Carcinogenesis" *Proceedings of the Biomedical topical Meeting (BIO*), TuD1(2006).

58. H. Subramanian, **P. Pradhan**, Y. L. Kim, Y. Liu, Vadim Backman, "Modeling low-coherence enhanced backscattering (LEBS) using photon random walk model of light scattering," *Proc. SPIE*, Complex Dynamics and Fluctuations in Biomedical Photonics III; Valery V. Tuchin, Ed. , Vol. 6085, p.1-9 (2006)

59. M.S. Shahriar, G. Pati, V. Gopal, R. Tripathi, G. Cardoso, **P. Pradhan**, M. Massal, R. Nair, "Precision rotation sensing and interferometry using slow light." Proc. of the Quantum Electronics and Laser Science Conference (QELS), 1457 (2005).

60. M. S. Shahriar and **P. Pradhan**, "Fundamental limitation on qubit operations due to the Bloch-Siegert Oscillation," The Proceedings of the 6th International Conference on Quantum Communication, Measurement and Computing (QCMC'02), MIT, Cambridge. *LANL quant-ph/ 0212121 (2003).*

Papers Under Review:

1. **P. Pradhan,** P. Sahay, and H. M. Almabadi, " Spectroscopic derivation of real delay time statistics from the imaginary delay time statistics in weakly disordered optical media," In review process, ***Physical Review Letters 2017*** (APS publications). https://arxiv.org/abs/1701.00080

INVITED TALKS/ COLLOQUIA AND CONFERENCE PRESENTATIONS:

Invited Talks/Colloquia

1. **P. Pradhan**, "Transport and localization properties of mesoscopic optical disordered media: applications in biological and soft matter systems" Physics Colloquium, Department of Physics and Astronomy, Mississippi State University, Mississippi State, MS, Feb 15, 2018.

2. **P. Pradhan**, "Transport and localization properties of mesoscopic optical disordered media: applications in biological and soft matter systems, Materials Seminars, Department of Materials Science & Engineering, University of Tennessee , Knoxville, TN, Jan 23, 2018.

3. **P. Pradhan**, "Photonic transport properties of a biological cell: application to early cancer detection." Colloquium, St. Jude Children's Research Hospital, Memphis, TN, August 26, 2016.

4. **P. Pradhan**, "Mesoscopic light transport properties of a biological cell and its applications for early cancer detection," Department of Physics, University of Southern Kentucky, Bowling Green, KY, August 31, 2015.

5. **P. Pradhan,** "Optical spectroscopic techniques to measure mesoscopic to nanoscopic light transport properties of weakly disordered media," Invited Seminar at the Department of Physics, University of North Texas, Denton, TX, February 14, 2012.

6. **P. Pradhan,**"Optical spectroscopic techniques to probe light transport properties of biological cells and tissues," Invited Seminar at the Bioengineering Department, University of Texas at Arlington, Arlington, TX, May 29, 2012

7. **P. Pradhan,** "Mesoscopic to nanoscopic light transport properties biological media," Invited Seminar at the Department of Physics, Ball State University, Muncie, IN, March 20, 2012.

8. **P. Pradhan,** “Light transport properties of a single biological cells,” Invited Talk at the Department of Biomedical Engineering, Purdue University, West Lafayette, IN, August 31, 2011.

9. **P. Pradhan**, “Mesoscopic to nanoscopic light transport properties of biological cells and detection of cancer,” Department of Physics, Western Illinois University, Macomb, IL, September 26, 2010.

10. **P. Pradhan**, “Mesoscopic light transport properties of a single biological cell: Early detection of cancer,” Department of Electrical Engineering and Department of Physics, University of Washington, Seattle, WA, November 10, 2009.

11. **P. Pradhan**, “Optical imaging of nano-architecture of a single biological cell,” Bioengineering Department, University of Washington, Seattle, WA, November 10, 2009.

Conference Presentations

1. P. Sahay, H. M. Almabadi, **P. Pradhan**, “Correlation study of real delay time and imaginary delay time in 1-dimensional weak disorder optical media,” American Physical Society March Meeting, March 13-17, 2017, New Orleans, LA.
2. H. Almabadi, P. Sahay, P. K. B. Nagesh, M. M. Yallapu, M. Jaggi, S. C. Chauhan, and **P. Pradhan**, “Partial wave spectroscopy based nanoscale structural disorder analysis for cancer diagnosis and treatment,” American Physical Society March Meeting, March 13-17, 2017, New Orleans, LA.
3. E. Avery, P. sahay, M. Robinson, **P. Pradhan**, “Characterizing Scattering Properties of Fractal Systems via Their Light Localization Properties,” American Physical Society March Meeting, March 13-17, 2017, New Orleans, LA.
4. P. Sahay, A. Ganju, H. M. Almabadi, O Skalli, M. Yallapu, S. Khan, M. Jaggi, S. Chauhan, **P. Pradhan**, “A Novel Method for Quantifying Intracellular Structural Alterations Using Confocal Fluorescence Imaging,” Workshop on Recent advances in Drug Delivery Technology, April 25, 2016, UTHSC, Memphis, TN.
5. S. Khan, M. Ebeling, M. Sikander, M. Yallapu, T. Ise, S. Nagata, S. Behrman, N. Zafar, J. Wan, H. M. Ghimire, P. Sahay, **P.Pradhan**, M. Jaggi, S. Chauhan, “MUC13 interaction with Receptor Tyrosine Kinase HER2 drives pancreatic ductal adenocarcinoma progression,” Annual meeting of the American Association of Cancer Research (AACR), April 16-20, 2016, New Orleans, LA.
6. P. Sahay, H. M. Ghimire, H. Almabadi, V. Tripathi, J. Alam, L. Thompson, O. Skalli, **P. Pradhan**, “Quantitative analysis of confocal images to characterize structural disorder in biological cells: a novel method to analyze cancerous and noncancerous cells,” Photonics West, February 12-17, 2015, San Francisco, CA.
7. H.M. Ghimire, P. Sahay, H. Almabadi**, P. Pradhan**, “Quantitative analysis of mass density fluctuation inside biological cells under the effect of alcohol using light localization properties,” American Physical Society March Meeting, March 2–6, 2015; San Antonio, TX.
8. P. Sahay, H.M. Ghimire, H. Almabadi, **P. Pradhan**, “Light localization properties of biological cells via confocal imaging,” American Physical Society March Meeting, March 2–6, 2015, San Antonio, TX.
9. H. Almabadi, P. Sahay, **P. Pradhan**, American Physical Society March Meeting, “Enhanced partial wave spectroscopy (EPWS) for nanoscale sensitive structural disorder measurement in weakly disordered media,” March 2–6, 2015, San Antonio, TX.
10. **P. Pradhan**, D. Park, H. Subramanian, D. Damania, L. Cherkezyan, V. Backman, “Delay time spectroscopy: a novel method for measuring nanoscale disorder in a biological cell and its application to early cancer detection,” SPIE Photonics West, San Francisco, CA, January 24-26, 2012.

11. **P. Pradhan**, D. Damania, H. Subramanian, V. Backman , “Quantification of optical disorder in nanoscale mass density fluctuations in biological tissue: inverse participation ratio (IPR) analysis of transmission electron microscopy (TEM) images”, BiOS: Biomedical Optics, SPIE, San Jose, January 24-29, 2009.
12. **P. Pradhan**, V. Turzhitsky, H. Subramanian, A. Heifetz, D. Damania, J. L. Hoogheem, M. J. Jung, H. K. Roy, V. Backman, "Inverse Participation Ratio (IPR) Analysis of Transmission Electron Microscopy (TEM) Images: Quantification of Optical Disorder Strength Due to Nanoscale Refractive Index Fluctuations of Tissues/Cells," American Physical Society March Meeting, New Orleans, LA, March 10-14, 2008.
13. **P. Pradhan,** Y. Liu, Y. Kim, Xu Li, R. K. Wali, H. K. Roy, Vadim Backman, "Application of mesoscopic light transport theory to ultra-early detection of cancer in a single biological cell," Proceedings of the American Physical Society March Meeting, Denver, CO, March 5-9, 2007.
14. Y. Kim, **P. Pradhan**, M. Kim, V. Backman, "Circular polarization memory effect in low-coherence enhanced backscattering of light," American Physical Society March Meeting, Denver, CO, March 5-9, 2007.
15. **P. Pradhan,** Y. Liu, Y. Kim, X. Li, R. K. Wali, H. Roy, Vadim Backman, "Alternation of Nanoscale Cell Architecture in Early Stages of Carcinogenesis Demonstrated by Single Cell Partial Wave Spectroscopy: Ultra-Early Detection of Cancer," BMES (Biomedical Engineering Society) 2006 Annual Meeting, Chicago, IL, October 2006.
16. **P. Pradhan,** Y. Liu, Y. Kim, Xu Li, R. K. Wali, H. K. Roy, Vadim Backman, "Mesoscopic light transport properties of a single biological cell: Early detection of cancer," American Physical Society March Meeting, Baltimore, MD, March 13-17, 2006.
17. **P. Pradhan,** Y. Kim, H. Subramanian, Y. Liu, and V. Backman, "Effect of the anisotropy factor of scattering and the finite spatial coherence length of light source on enhanced backscattering," American Physical Society March Meeting, Baltimore, MD, March 13-17, 2006.
18. H. Subramanian, **P. Pradhan,** Y.L. Kim, V. Backman, "Penetration depth of low-coherence enhanced backscattering (LEBS) in sub-diffusion regime," BMES (Biomedical Engineering Society) 2006 Annual Meeting, Chicago, IL, October 2006.
19. Y.L. Kim, **P. Pradhan**, H. Subramanian, Y. Liu, M.H. Kim, and V. Backman, "Origin of low-coherence enhanced backscattering of light in discrete tissue models: Double scattering," BiOS 2006, Photonics West, San Jose, CA, January 21-26, 2006.
20. Y. Liu, **P. Pradhan**, X. Li, Y. Kim, R. Wali, H. Roy, V. Backman, “Partial-wave spectroscopy for pre-neoplastic detection,” BiOS 2006, Photonics West, San Jose, CA, January 2006.
21. H. Subramanian, **P. Pradhan,** Y. Kim, Yang Liu, V. Backman, "Modeling Low-Coherence Enhanced Backscattering (LEBS) using Photon random walk model of Light Scattering," American Physical Society March Meeting, Baltimore, MD, March 13-17, 2006.

PATENT:

V. Backman, Y. Liu, Y. Kim, H. Roy, M. Goldberg, R. Brand, **P. Pradhan**, H. Subramanian, **“Method for identifying refractive-index fluctuations of a target,”** 20080278713 (November 13, 2008).

http://www.faqs.org/patents/app/20080278713

TEACHING EXPERIENCE:

COURSES TEACHING AT MISSISSIPPI STATE

1	Fall 2018	PH8313	Electromagnetic Theory I

COURSES TAUGHT AT UNIVERSITY OF MEMPHIS:

1	Spring 2017	PHYS 2010	General Physics I/Trig
2	Spring 2017	PHYS 2010	General Physics I/Trig (Hon)
3	Spring 2017	PHYS 2020	General Physics II/Trig
4	Spring 2017	PHYS 2020	General Physics II/Trig (Hon)
5	Fall 2016	PHYS 2020	General Physics II/Trig
6	Fall 2016	PHYS 2010	General Physics I/Trig
7	Spring 2016	PHYS 2010	General Physics I/Trig
8	Spring 2016	PHYS 2010	General Physics I/Trig (Hon)
9	Spring 2016	PHYS 2020	General Physics II/Trig
10	Fall 2015	PHYS 4211	Waves and Optics
11	Spring 2015	PHYS 7300	Electrodynamics
12	Fall 2014	PHYS 6410	Intro Quantum Theory
13	Spring 2014	PHYS 7200	Quantum Mechanics I
14	Fall 2013	PHYS 4-621	Waves and Optics

COURSES TAUGHT PRIOR TO UOFM:

(1). Solid State Physics, Instructor (one semester) 1993, Indian Institute of Science, Bangalore

(2). Condensed Matter Physics I. Co-Instructor (one semester), 1994, Indian Institute of Science, Bangalore

(3). Numerical Methods in Condensed Matter Physics, Instructor (one Semester), 1995, Indian Institute of Science, Bangalore

(4). Quantum Computation and communication, Partial instructor (one semester), 1999, University of California-Los Angeles.

(5). Electrodynamics and Optics, Co-instructor (one semester), 2001, Northeastern University, Boston, MA

PROFESSIONAL JOURNALS REVIEWED (SELECTED):

- Applied optics
- Biomedical Optics Express
- Journal of Optical Society of America B
- Journal of Biomedical Optics
- Optics Communications
- Nature Photonics
- Nature Scientific Reports
- Optics Letters
- Optics Express
- Physical Review Letters
- Physical Review B
- Physical Review E

PROFESSIONAL GRANTS REVIEWED:

- National Science Foundation (NSF)
- U.S. Civilian Research and Development Foundation (CRDF)
- Foundation for Fundamental Research on Matter (FOM), Netherlands
- Hong Kong University Research Council, Hong Kong.
- AFOSR

PROFESSIONAL MEMBERSHIP:

- American Physical Society
- American Optical Society
- SPIE

CONTRIBUTION TO SCIENCE:

1. Mirror-less coherent random lasers

There are two important and well known effects based on coherent scattering of waves in optical matter: (1) **Coherent Back Scattering (CBS)** is responsible for disorder induced localization (i.e. Anderson localization) in a disordered medium; and (2) **Coherent Amplification (CA)** is responsible for photons/light amplification (stimulated) in an amplifying medium (e.g. laser, maser). These two effects have been studied independently in great details. We have proposed that the combination of the above two coherent phenomena (1) CBS, and (2) CA, brings an interesting aspect of light amplification using localization and showed possibility of "Mirrorless Random Lasers" in a coherently amplifying disordered medium. Coherent nature of the amplification does not affect the coherent back scattering which is responsible for localization. Now light is more amplified in interplay between localization and amplification, and the system can show lasing action (by non-resonant feedback by localization) where localization gives the necessary confinement of a virtual high Q cavity (whose length is order of localization length) for the lasing action. The proposal has been theoretically and experimentally supported verified and extended by several research groups. It has been also shown the applications of the random lasers in production of very high intense non focused light in a very small space.

a) **P. Pradhan**, "A model for Quantum Stochastic Absorption in Absorbing Disordered Media," *Physical Review B* 74, 085107 (2006).

b) **P. Pradhan** and N. Kumar, "Localization of light in coherently amplifying random media," Prabhakar Pradhan, *Phys. Rev. B* 50, 9644(1994).

2. Mesoscopic light transport properties of single biological cells: partial wave spectroscopy (PWS) and ultra-early cancer detection

Most cancers are curable if they are diagnosed and treated at an early stage. Recent studies suggest that nanoarchitectural changes occur within cells during early carcinogenesis which precede microscopically evident tissue changes. It follows that the ability to comprehensively interrogate cell nanoarchitecture (e.g., macromolecular complexes, DNA, RNA, proteins, and lipid membranes) could be critical to the study of early carcinogenesis. Dr. Pradhan proposed and developed (with colleagues) a mesoscopic partial wave spectroscopy (PWS) technique to measure the nanoscopic light transport properties of weakly disordered dielectric mesoscopic systems such as biological cells. Using mesoscopic approach, he has statistically quantified the light reflection coefficient and its correlation due to nanoscale refractive index fluctuations within a biological cell. Finally, using these parameters, he has imaged and quantified the nanoscale optical disorder strength within the biological cells. Results of animal models, precancerous cell lines, and human tissue/cells studies show the potential applications of the technique in early cancer detection. In particular, the results show a strong relationship between increase in nanoscale mass density fluctuations and early-progression of carcinogenesis. Furthermore, the method is so sensitive that one can detect cancer, far from cancer sites. Dr. Pradhan and his colleagues have shown that: lung cancer can be detected from buccal/inner cheek cells, colon cancer can be detected from rectal cells using the field effect of carcinogenesis. This is a powerful method for cancer screening and open up new horizon for early cancer detection.

a) H. Subramanian, **P. Pradhan**, Y. Liu, I. Capoglua, X. Li, J. Rogers, A. Heifetz, D. Kunte, H. K. Roy, A. Taflove, and V. Backman, "Optical methodology for detecting histologically unapparent nanoscale consequences of genetic alterations in biological cells," *Proceedings of the National Academy of Sciences USA* (PNAS) 150, 20124 (2008). PMC2629261

b) H. Subramanian, H. K. Roy, **P. Pradhan,** M. J. Goldberg, J. Muldoon, R. E. Brand, C. Sturgis, T. Hensing, D. Ray, A. Bogojevic, J. Mohammed, J-S Chang and V. Backman, "Nanoscale Cellular Changes in Field Carcinogenesis Detected by Partial Wave Spectroscopy," *Cancer Research* 69, 5357 (2009). PMC2802178

c) H. K. Roy, H. Subramanian, D. Damania, T. A. Hensing, W. N. Rom, H. I. Pass, D. Ray, J. D. Rogers, A. Bogojevic, M. Shah, T. Kuzniar, **P. Pradhan,** and V. Backman, "Optical Detection of Buccal Epithelial Nanoarchitectural Alterations in Patients Harboring Lung Cancer: Implications for Screening," *Cancer Research 70(20),* 7748 (2010).

d) D. Damania, H. Roy, H. Subramanian, D. Weinberg, D. Rex, M. Goldberg, J. Muldoon, Y. Zhu, L. Bianchi, D. Shah, **P. Pradhan,** M. Borkar, H. Lynch, and V. Backman, "Nanocytology of rectal colonocytes to assess risk of colon cancer based on field cancerization," *Cancer Research* **72**, 2720-2727 (2012).

3. Light localization properties of biological cells using confocal microscopy imaging: Inverse Participation Ratio (IPR) technique to detect cancer

Most cancers are curable if they are detected and treated early. It is now known that the nano-structural alteration in a cell nucleus are associated with the early progressive carcinogenesis due to the rearrangements of the basic building blocks of the cell nuclei. These nanoscale alterations produce nanoscale mass density variations in the cell nuclei. Dr. Pradhan has developed a novel technique to study the nano to submicron scale mass-density fluctuations of biological cell nuclei by quantifying their nanoscale light-localization properties. Confocal microscopy (CFM) images of pre-cancer and normal cells are used to construct corresponding effective disordered optical lattices. Light-localization properties of these lattices were studied by statistical analysis of the inverse participation ratio (IPR) of the eigenfunctions of these optical lattices at the nano to submicron scales. The IPR technique can quantify minute changes in structural disorder that are associated with early carcinogenesis, from their confocal imaging, and can have potential applications in early carcinogenic detection. Furthermore, by using confocal, one can image cells in their native states inside tissues, therefore, the method has extra advantages than other used methods. Furthermore, the quantification technique also can be generalize to the other imaging techniques, such as transmission electron microscopy imaging of cells/tissues involving changes in mass density fluctuations.

a) P. Sahay, H.M. Almabadi, H..M Ghimire, O. Skalli, and **P. Pradhan.** "Light localization properties of weakly disordered optical media using confocal microscopy: application to cancer detection," *Optics Express* 13, 15428-15440 (2017)

b) Daniel Park, **P. Pradhan,** and V. Backman, "Enhancing the sensitivity of mesoscopic reflection statistics in weakly disordered media by interface reflections", *International Journal of Modern Physics,* B30, 1650155 (2016).

c) **P. Pradhan**, D. Damania, H. Joshi, V. Turzhitsky, H. Subramanian, H. K. Roy, A. Taflove, V. P. Dravid, V. Backman, "Quantification of Nanoscale Density Fluctuations using Electron Microscopy: Light Localization Properties of Biological Cells" *Applied Physics Letters* 97 , 243704 (2010). PMC3017571

d) **P. Pradhan,** D. Damania, H. Joshi, V. Turzhitsky, H. Subramanian, H. K. Roy, A. Taflove, V. P. Dravid, V. Backman "Quantification of nanoscale density fluctuations by electron microscopy: probing cellular alterations in early carcinogenesis," *Physical Biology* 8, 026012 (2011). PMC3332100

4. Low coherence enhanced back scattering spectroscopy (LEBS) and cancer detection: probing nanoscale to submicron scale fluctuations in biological tissues

Dr. Pradhan with colleagues have developed techniques in low coherence enhanced backscattering spectroscopy (LEBS) that can probe low order scattering (1, 2, 3 order scattering) events in tissues. The phenomenon of enhanced backscattering (EBS) of light, also known as coherent backscattering (CBS) of light, is a spectacular manifestation of self-interference effects in elastic light scattering, which gives rise to an enhanced scattered intensity in the backward direction. Although EBS has been the object of intensive investigation in non-biological media, there have been only a few attempts to explore EBS for tissue characterization and diagnosis. We have recently made progress in the EBS measurements of biological tissue by taking advantage of low-coherence (or partially coherent) illumination, which is referred to as low-coherence EBS (LEBS) of light. Application of LEBS technique to cancer detection.
We have applied LEBS technique to characterize the nano to submicron-scale morphological changes in precancerous tissues relative to control tissues, in early carcinogenesis. We are also designing probes for in-vivo cancer detection for different types of cancers: Colon, pancreatic, etc.

a) Y. L. Kim, V. Turzhitsky, H. Roy, R. Wali, H. Subramanian, **P. Pradhan,** and V. Backman, "Low-coherence enhanced backscattering (LEBS): Principles and applications for colon cancer screening," *Journal of Biomedical Optics* 11, 041125 (2006). PMID: 16965153
b) H. Subramanian, **P. Pradhan,** Y. Kim, Y. Liu, X. Li, and V. Backman, "Modeling Low-Coherence Enhanced Back Scattering Using Monte Carlo Simulation," *Applied Optics* 45, 6293 (2006). PMID: 16892135
c) H. K. Roy, V. Turzhitsky, Y. Kim, M. J. Goldberg, P. Watson, J. D. Rogers, A. J. Gomes, A. Kromine, R. E. Brand, M. Jameel1, A. Bogovejic1, **P. Pradhan,** and V. Backman, “Association between Rectal Optical Signatures and Colonic Neoplasia: Potential Applications for Screening,” *Cancer Research* 69, 4476 (2009). PMC2722930
d) J. D. Rogers, V. Stoyneva, V. Turzhitsky, N. Mutyal, **P. Pradhan**, I. R.Capoglu, and V. Backman, “ Alternate formulation of enhanced backscattering as phase conjugation and diffraction: derivation and experimental observation,” *Optics Express* 8, 11922 (2011). PMC3319707