Sandip Ghosal

Northwestern University
Department of Mechanical Engineering
and
Engineering Sciences & Applied Mathematics
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Education

Columbia University, New York, NY 1987-92
M.Phil & Ph.D. in Physics
Thesis advisor: Professor Edward A. Spiegel

Presidency College, Calcutta, India 1982-85
B.Sc. (First Class with Honours in Physics)

Academic Positions

Leverhulme Visiting Professor, Department of Physics 2012-13
University of Cambridge, Cambridge, UK

Visiting Professor, Department of Mechanical Engineering 2004
Stanford University, Stanford, CA

Associate Professor, Department of Mechanical Engineering 1999-
& Department of Engineering Sciences and Applied Mathematics
Northwestern University, Evanston, IL
Tenured since Fall of 2004

Scientific Research Staff, Combustion Research Facility 1998-99
Sandia National Laboratories, Livermore, CA

Postdoctoral fellow, Center for Nonlinear Studies 1995-98
Los Alamos National Laboratory, Los Alamos, NM

Institut National des Sciences Appliquées de Rouen 1996-97
(University of Rouen & CNRS-CORIA)

Saint-Etienne-du-Rouvray, Rouen (France)
Poste Rouge CNRS (Invited Senior Researcher at CNRS, 3 months)
Professeur invité (Invited Professor, 9 months)

Research Fellow, Center for Turbulence Research 1992-95
Stanford University, Stanford, CA

Teaching Experience

Courses taught at Northwestern University:

Graduate Level:
ME420: Micro & Nano Scale Fluid Dynamics [*introduced*]
ME432: Optimization Methods in Science & Engineering [*introduced*]
ME425: Fundamentals of Fluid Dynamics
ME427: Viscous Fluid Dynamics
ME 513: Teaching Practicum
ME 512: Graduate Seminar

Undergraduate Level:
ME241: Fluid Mechanics I
ME373: Engineering Fluid Mechanics
ME305-3: Engineering Analysis 3
ME395: Combustion/Energy Systems [*introduced*, co-taught]

Other Teaching engagements:

Micro & Nano Scale Fluid Dynamics (6 Graduate Level Lectures)
Indian Institute of Technology, Kharagpur Dec 9–17, 2015
(Fulbright Specialist Grant)

Awards, Honors & Fellowships

Fulbright-Nehru Academic and Professional Excellence Awards	2017
Fulbright Specialist grant in Engineering Education	2015
Leverhulme Visiting Professorship, Cambridge University (UK)	2012-13
Life Member, Clare Hall, Cambridge University	2012
Fellow of the American Physical Society (Division of Fluid Dynamics)	2011
Stanford University (Ctr. Turbulence Res.) Summer Research Fellow	2004,06
NASA ASEE Summer Faculty Fellowship	2002,04,06
Woods Hole Oceanographic Institution (Geophysical Fluid Dynamics Fellow)	1989
Columbia University, Fellow of the faculty (Physics)	1987
J. Bose National Science Talent Search Award (India)	1982

Sponsored Research

NIH Research Award (R01HG004842) 2009-13
Title: "Mathematical modeling of the voltage driven translocation of polyelectrolytes through nanopores" by S. Ghosal (PI)

NIH Research Award (R01EB007596) 2007-10
Title: "One dimensional transport equations for CE systems by asymptotic homogenization" by S. Ghosal (PI)

NSF Research Award (CTS-0330604) 2004-07
Title: "Dispersion in capillary electrophoresis due to sample induced modification of the electroosmotic flow" by S. Ghosal (PI)

NSF Research Award (CTS-0121051) 2002-05
Title: "Dynamics of ignition & extinction fronts on diffusion flame sheets" by S. Ghosal (PI)

Walter P. Murphy Society Award (Northwestern Alumni Association) 2002
Title: "Nanobiomechanics Seminar Series" (with S. Lichter)

Research Interests

micro-hydrodynamics of small scale systems, particularly involving ionic fluids and interfacial charge. Application areas: biology, biotechnology, micro & nano fluidics

Academic Service

Editorships

Editorial Board Member, 2014-present
Journal of Applied Mathematics (Hindawi Publishing Corporation)
Editorial Board Member, 2011-present
Open Journal of Fluid Dynamics (Scientific Research Publishing)
Editorial Advisory Board Member, 2007-present
The Open Mechanics Journal (Bentham Science)

Society Offices

Global McCormick! Faculty Ambassador for UK, Northwestern University 2014-16
Selection Committee Member, Stanely Corrsin Award, APS DFD 2014
Selection Committee Member, Stanely Corrsin Award, APS DFD 2013
Member of Faculty Senate, Northwestern University 2013-17
Chair, Acrivos Dissertation Award Committee, APS DFD 2007

Vice Chair, Acrivos Dissertation Award Committee, APS DFD 2006

Referee

Nature Nanotechnology, Journal of Fluid Mechanics, Journal of Computational Physics, Physics of Fluids, Physics of Plasmas, Proceedings of Royal Society A, Combustion & Flame, Combustion Theory & Modeling, Physics Letters A, Physical Review E, Physical Review Letters, Journal of Fluids Engineering, AIAA Journal, Nuclear Technology, International J. for Numerical Methods in Eng., Computer Methods in Applied Mechanics and Engineering, Analytical Chemistry, Journal of Chromatography, Electrophoresis

Session Chair

American Physical Society, Division Fluid Mechanics
54th Annual Meeting, Nov 2001, San Diego, Session JE (LES III)
American Physical Society, Division Fluid Mechanics
58th Annual Meeting, Nov 2005, Chicago, Session NC (Microfluidics II)
6th International Conference on Nonlinear Mechanics
Aug 2013, Shanghai, People's Republic of China, Session IX

Conference Organization

"Nanobiomechanics" Seminar Series, Northwestern University 2000-03
founding member of steering committee
Midwest Mechanics Seminar Series 2003-04
Faculty representative & organizer for Northwestern University
ASME International Mechanical Engineering Congress 2003
Co-organized session on Microfluidics
Member of organizing committee 2005
APS Annual Meeting Division of Fluid Mechanics, Chicago, IL
Member of the Scientific Committee: The 8th WSEAS Int. Conf. on 2007
mathematics and computers in biology and chemistry (MCBC'07)
Institute of Mathematics & its Applications (IMA) 2009
Member of Organizing Committee, Annual Program
Thematic Year on *Complex Fluids & Complex Flows*
Chair, "Microfluidics: Electrokinetics and Interfacial Phenomena" 2009
workshop, the IMA Program on "Complex Fluids & Complex Flows"

Member of Jury

Thesis defense (Ph.d) J. Réveillon Université de Rouen, Dec 13, 1996
Thesis defense (Ph.d) G. Wagner Northwestern University, April 11, 2000
Ph.d Qual. Exam M. Sun Northwestern University, Dec 12, 2000
Ph.d Qual. Exam J. Schwille Northwestern University, May 30, 2002
Ph.d Qual. Exam (Chair) Z. Lu Northwestern University, Dec 05, 2002
Thesis defense (Chair) Z. Lu Northwestern University, Dec 01, 2003

Ph.d Qual. Exam N. Sharma Northwestern University, Feb 20, 2004
Thesis defense J. Schwille Northwestern University, April 28, 2004
Ph.d Qual. Exam Y. Chen Northwestern University, June 07, 2004
Ph.d Qual. Exam T. Tickel Northwestern University, Nov 30, 2004
Ph.d Qual. Exam (Chair) J. Horek Northwestern University, April 05, 2005
Thesis defense Y. Chen Northwestern University, Nov 16, 2005
Ph.d Qual. Exam (Chair) S. Dutta Northwestern University, Nov 23, 2005
Ph.d Qual. Exam (Chair) J. Renner Northwestern University, Nov 23, 2005
Thesis defense (Chair) J. Horek Northwestern University, Feb 21, 2006
Thesis defense (Chair) S. Dutta Northwestern University, May 1, 2007
Thesis defense (Chair) J. Renner Northwestern University, May 7, 2008
Ph.d Qual. Exam (Chair) Z. Chen Northwestern University, May 27, 2010
Thesis Defense (Chair) Z. Chen Northwestern University, Dec 1, 2011
Ph.d Qual. Exam (Chair) M. Mao Northwestern University, Dec 06, 2012

Committee Work

Governance Committee, Faculty Senate, Northwestern University	2013-present
Proposal Review, Israel Science Foundation (ISF)	2012
NSF Panel Review of Proposals (Panel Member)	2011
Chair, Undergraduate Curriculum Committee, Northwestern University	2007-09
Member, McCormick Curriculum Committee, Northwestern University	2001-07
National Academies: Panelist for review of AFOSR proposals in fluids	2005
NSF Panel Review of Proposals (Panel Member)	2004
DOE review of CALTECH's ASCI Program (Panel Member)	2002

Thesis Supervision

Gregory J. Wagner, Ph.D. (primary advisor, co-advisor: Prof. W.K. Liu, ME) 2001
Thesis: "A Numerical Investigation of Particulate Channel Flows"
Current position: Associate Professor, Northwestern University

Zhanbin Lu, Ph.D. 2003
Thesis: "Ignition & Extinction Dynamics on Diffusion Flame Sheets"
Current position: Associate Professor, Institute of Applied Mathematics & Mechanics, Shanghai University, China

Gogi Singh, Ph.D. (co-advisor, primary advisor: Prof. A. Golovin, ESAM) 2005
Thesis: "Mathematical Modeling of Self-Organized Nanoscale Porous Structures in Anodic Aluminum Oxide"
Current position: post doctoral fellow, MIT

Jon Horek, Ph.D. 2006
Thesis: "Mathematical modeling of sample stacking methods in microfluidic systems"

Current position: Applications Engineer, Modine Thermal Systems, Wisconsin USA

Subhra Datta, Ph.D. 2007

Thesis: "Electroosmotic flow & dispersion in microfluidic separation systems"
Current position: Assistant Professor, IIT Delhi

Jocelyn Renner, Ph.D. 2008

Thesis: "Numerical and Experimental Studies of the Dynamics of Diffusion Flame Sheets"
Current position: Research Engineer, GE Corporation, Cincinnati, OH

Zhen Chen, Ph.D 2011

Thesis: "Electromigration Dispersion in Capillary Electrophoresis"
Current position: Senior Associate, Discover Financial Services, Chicago, IL

Mao Mao, Ph.D 2015

Thesis: "Electrokinetically driven fluid flows in nanopores"
Current position: Sales Engineer, COMSOL, Boston, MA

Membership in Professional Societies

American Physical Society - Division of Fluid Dynamics (Fellow)
American Society of Mechanical Engineers
Society for Mathematical Biology

Publications[1]

1. Ghosal S. & Spiegel E.A., "On thermonuclear convection: I. Shellular convection," *Geophys. Astrophys. Fluid Dynamics* (1991) **61**, 161-178

2. Ghosal S. & Moin P., "The basic equations for the LES of turbulent flows in complex geometry," *J. Comp. Phys.* (1995) **118**, 24-37

3. Ghosal S., Lund T.S., Moin P. & Akselvoll K., "A dynamic localization model for large-eddy simulation of turbulent flows," *J. Fluid Mech.* (1995) **286**, 229-255 [Corrigendum: **297**, 402]

4. Carati D., Ghosal S. & Moin P., "On the representation of backscatter in dynamic localization models," *Phys. of Fluids* (1995) **7**(3), 606-616

[1] citation data at `http://scholar.google.com/citations?user=Z2x5KF4AAAAJ`

5. Ghosal S., "An analysis of numerical errors in large-eddy simulations of turbulence," *J. Comp. Phys.* (1996) **125**, 187-206

6. Ghosal S. & Rogers M., "A numerical study of self-similarity in a turbulent plane wake using large-eddy simulation," *Phys. Fluids* (1997) **9**(6), 1729-1739

7. Ghosal S. & Rose H.A., "Two dimensional plasma flow past a laser beam," *Phys. Plasmas* (1997) **4**(7), 2376-2396

8. Ghosal S. & Rose H.A., "Effect of ISI on flow induced laser beam deflection: analytic theory," *Phys. Plasmas* (1997) **4**(12), 4189-4450

9. Rose H.A. & Ghosal S., "Effect of smoothing by spectral dispersion on flow induced laser beam deflection: The random phase modulation scheme," *Phys. Plasmas* (1998) **5**(3), 775-781

10. Rose H.A. & Ghosal S., "Nonlinear theory of power transfer between multiple crossed laser beams in a flowing plasma," *Phys. Plasmas* (1998) **5**(5), 1461-1466

11. Ghosal S., "Mathematical & physical constraints on LES of turbulence," *AIAA J.* (1999) **37**(4), 425-433

12. Ghosal S. & Vervisch L., "Theoretical and Numerical Study of a Symmetrical Triple Flame using the Parabolic Flame Path Approximation," *J. Fluid Mech.* (2000) **415**, 227-260

13. Ghosal S. & Keller J.B., "A hyperbolic equation for turbulent diffusion," *Nonlinearity* (2000) **13**, 1855-1866

14. Ghosal S. & Vervisch L., "Stability diagram for lift-off and blowout of a round jet laminar diffusion flame," *Combustion & Flame* (2001) **124**(4), 646-655

15. Ghosal S. "Lubrication theory for electroosmotic flow in a microfluidic channel of slowly varying cross-section and wall charge," *J. Fluid Mech.* (2002) **459**, 103-128

16. Ghosal S. "Effect of analyte adsorption on the electroosmotic flow through microfluidic channels," *Analytical Chemistry* (2002) **74**, 771-775

17. Ghosal S. "Band broadening in a micro-capillary with a step-wise change in the ζ-potential," *Anal. Chem.* (2002) **74**, 4198-4203

18. Wagner, G.J., Ghosal S. & Liu, W.K. "Particulate flow simulations using lubrication theory solution enrichment" *Int. J. Num. Methods in Eng.* (2003) **56**(9), 1261-1289

19. Ghosal S. & Mandre S. "A Simple Model Illustrating the Role of Turbulence on Phytoplankton Blooms" *J. Math. Biol.* (2003) **46**, 333-346

20. Boulanger, J., Vervisch, L., Reveillon & Ghosal, S. "Effects of heat release in laminar diffusion flames lifted on round jets" *Comb. & Flame* (2003) **134**, 355-368

21. Ghosal, S. "The effect of wall interactions in capillary zone electrophoresis" *J. Fluid Mech.* (2003) **491**, 285-300

22. Lu, Z. & Ghosal, S. "A similarity solution describing the collision of two planar premixed flames" *Comb. Th. & Modeling* (2003) **7**, 645-652

23. Shariff, K. & Ghosal, S. "Peak tailing in electrophoresis due to alteration of the wall charge by adsorbed analytes: Numerical simulations & asymptotic theory" *Analytica Chimica Acta* (2004) **507**, 87-93 (special volume on 'Microfluidics & Lab-on-a-chip technology')

24. Lu, Z. & Ghosal, S. "Flame holes & flame disks on the surface of a diffusion flame" *J. Fluid Mech.* (2004) **513**, 287-307

25. Shariff, K., Ghosal, S. & Matouschek, A. "The force exerted by the membrane potential during protein import into the mitochondrial matrix" *Biophys. J.* (2004) **86**, 3647-3652

26. Ghosal, S. & Horek, J. "A Mathematical Model Describing Gradient Focusing Methods for Concentrating Trace Analytes" *Anal. Chem.* (2005) **77**, 5380-5384

27. Datta, S., Ghosal, S. & Patankar, N. "Electroosmotic flow in a rectangular channel with variable wall zeta-potential: comparison of numerical simulation with asymptotic theory" *Electrophoresis* (2006) **27**, 611-619

28. Ghosal, S. "Electrophoresis of a polyelectrolyte through a nanopore" *Phys. Rev. E* (2006) **74**, 041901

    Selected for publication in the *Virtual Journal of Nanoscale Science & Technology*[2] **14** (16) October 16, 2006 and in the *Virtual Journal of Biological Physics Research* **12** (8) October 15, 2006

29. Hawkins, K.R., Steedman, M.R., Baldwin, R.R., Fu, E., Ghosal, S. & Yager, P. "Technical Note: A method for characterizing adsorption of flowing solutes to microfluidic device surfaces" *Lab On a Chip* (2007) **7**, 281-285

30. Ghosal, S. "Effect of salt concentration on the electrophoretic speed of a polyelectrolyte through a nanopore" *Phys. Rev. Lett.* (2007) **98**, 238104

    Selected for publication in the *Virtual Journal of Nanoscale Science & Technology* **15** (24) June 18, 2007 and in the *Virtual Journal of Biological Physics Research* **13** (12) June 15, 2007

[2]the *Virtual Journal of Nanoscale Science & Technology* and the *Virtual Journal of Biological Physics Research* are published jointly by the *Americal Institute of Physics* and the *American Physical Society.* Articles are selected by the Editors from participating journals and reprinted in the Virtual Journals for wider dissemination.

31. Ghosal, S. "Electrokinetic-flow-induced viscous drag on a tethered DNA inside a nanopore" *Phys. Rev. E* (2007) **76**, 061916

    Selected for publication in the *Virtual Journal of Biological Physics Research* **15** (1) January 1, 2008

32. Datta, S. & Ghosal, S. "Dispersion due to wall interactions in microfluidic separation systems" *Phys. of Fluids* (2008) **20**, 012103

    Selected for publication in the *Virtual Journal of Nanoscale Science & Technology* **17** (6) February 11, 2008

33. Ghosal, S. & Chen, Z. "A nonlinear equation for ionic diffusion in a strong binary electrolyte" *Proc. Royal Soc. Lond. A* (2010), **466**, 2145-2154

34. Ghosal, S. & Chen, Z. "Nonlinear waves in capillary electrophoresis" *Bulletin of Mathematical Biology* (2010) **72**(8), 2047-2066

35. Ghosal, S. & Fukui, Y. "Does buckling instability of the pseudopodium limit how well an amoeba can climb?" *Journal of Theoretical Biology* (2011), **271**(1), 202-204

36. Chen Z. & Ghosal, S. "Electromigration dispersion in Capillary Electrophoresis" *Bulletin of Mathematical Biology* (2012), **74**(2), 346-355

37. Ghosal, S. & Chen Z. "Electromigration dispersion in a capillary in the presence of electro-osmotic flow" *J. Fluid Mech.* (2012) **697**, 436-454

38. Chen Z. & Ghosal, S. "Strongly nonlinear waves in Capillary Electrophoresis" *Phys. Rev. E* (2012), **85**, 051918

39. Chen Z. & Ghosal, S. "The nonlinear electromigration of analytes into confined spaces" *Proc. Royal Soc. Lond. A* (2012), **468**, 3139-3152

40. Ghosal S. & Apte S. "Modeling evaporating droplets in complex unsteady flows" *Open J. Fluid Dynamics* (2012), **2**(2), 35-43

41. Hu G., Mao M. & Ghosal S. "Ion transport through a graphene nanopore" *Nanotechnology* (2012), **23**(39), 395501

42. Ghosal S. "A capstan friction model for DNA ejection from bacteriophages" *Phys. Rev. Lett.* (2012), **109**(24), 248105

43. Thacker V., Ghosal S., Hernández-Ainsa S. & Keyser U. "Studying DNA translocation in nanocapillaries using single molecule fluorescence" *Appl. Phys. Lett.* (2012), **101**(22), 223704

44. Mao M., Ghosal, S. & Hu, G. "Hydrodynamic flow in the vicinity of a nanopore induced by an applied voltage" *Nanotechnology* (2013) **24**(24), 245202

45. Laohakunakorn N., Ghosal S., Otto O., Misiunas K. & Keyser U. "DNA Interactions in Crowded Nanopores" *Nano Letters* (2013), **13** (6), 2798–2802

46. Laohakunakorn N., Gollnick B., Moreno-Herrero F., Aarts D., Dullens R., Ghosal S. & Keyser U. "A Landau-Squire nanojet" *Nano Letters* (2013) **13**, 5141-5146

47. Mao M., Sherwood J.D. & Ghosal S. "Electro-osmotic flow through a nanopore" *J. Fluid Mech.* (2014) **749**, 167-183

48. Sherwood J.D., Mao M., & Ghosal S. "Electroosmosis in a Finite Cylindrical Pore: Simple Models of End Effects" *Langmuir* (2014), **30** (31), 9261 - 9272

49. Sherwood J.D., Mao M., & Ghosal S. "Electrically generated eddies at an eight-fold stagnation point within a nanopore" *Phys. Fluids* (2014) **26** (11), 112004

50. Dey R., Shaik V.A. Chakraborty D., Ghosal S. & Chakraborty S. "AC electric field induced trapping of microparticles in pinched microconfinements" *Langmuir* (2015) **31** (21), 5952-5961

51. Ghosal S. & Sherwood J.D. "Repulsion Between Finite Charged Plates with Strongly Overlapped Electric Double Layers" *Langmuir* (2016) **32** (37), 9445-9450

52. Ghosal S. & Sherwood J.D. "Screened Coulomb Interactions With Non-uniform Surface Charge" *Proc. Royal Soc. A* (2017) **473** (2199), 20160906

53. Arun R. & Ghosal S. "A mechanical model of bacteriophage DNA ejection" *Physics Letters A* (2017) **381** (30), 2386-2390

54. Bell N.A.W., Chen K., Ghosal S., Ricci M. & Keyser U.F. "Asymmetric dynamics of DNA entering and exiting a strongly confining nanopore" *Nature Communications* (2017) **8** (380), 1-8

55. Sherwood J.D. & Ghosal S. "Nonlinear electrophoresis of a tightly fitting sphere in a cylindrical tube" *J. Fluid Mech.* (2018) **843**, 847-871

<u>*Invited Reviews*</u>

56. Ghosal, S. "Fluid mechanics of electroosmotic flow and its effect on band broadening in capillary electrophoresis" *Electrophoresis* (2004) **25**, 214-228

57. Ghosal, S. "Electrokinetic Flow & Dispersion in Capillary Electrophoresis", *Ann. Rev. Fluid Mech.* (2006), **38**, 309-338

58. Datta, S. & Ghosal, S. "Critical Review: Characterizing Dispersion in Microfluidic Channels" *Lab on a Chip* (2009), **9**, 2537-2550

59. Ghosal S., Sherwood J.D. & Chang, H.C. "Electrokinetic Flow and Transport through Nanopores" *Biomicrofluidics* [in preparation]

Peer Reviewed Conference Proceedings

60. Moin P., Carati D., Lund T., Ghosal S. & Akselvoll K., "Developments and applications of dynamic models for large eddy simulation of complex flows," AGARD (NATO) meeting, 74th fluid dynamics panel on application of direct and large eddy simulation to transition and turbulence, Chania, Crete, Greece, 18-21 April 1994

61. Boulanger, J., Ghosal, S., Reveillon, J. & Vervisch, L. "Heat release effects in lifted laminar jet diffusion flames," Proceedings of 18th ICDERS meeting, Seattle, WA July 29 - Aug. 3, 2001

62. Ghosal, S. & Lu, Z. "Electroosmotic flow and zone broadening in microfluidic channels of variable cross-section and wall charge," In "*Nanotech 2002, Technical Proceedings of the 5th International Conference on Modeling & Simulation of Microsystems*" ed: Laudon, M. & Romanowicz. B., Computational Publications, Boston, Geneva, San Francisco

63. Hu G., Mao M. & Ghosal, S. "MS04-004: Nanoscale vortices in transport of salty solution through a graphene nanopore" In session *Mechanics of transport in microfluidic devices*, 23rd International Conference on Theoretical and Applied Mechanics (ICTAM), Beijing Aug 20 - Aug. 24, 2012

64. Laohakunakorn, N., Ghosal, S., Misiunas, K., Otto, O. & Keyser, U.F. "Electrophoretic forces on multiple DNA molecules in a nanopore" In *Biophys J.* **104**(2) 517a – Abstracts Issue Biophysical Society 57th Annual Meeting Philadelphia, PA Feb 2-6, 2013. Session Title: Single Molecule Techniques II

Conference (Others)

1. Ghosal S., "Mathematical & physical constraints on LES," 29th AIAA Fluid Dynamics Conference, Albuquerque, NM, 15-18 June 1998

2. Lund T.S., Ghosal S. & Moin P., "Numerical experiments with highly variable eddy viscosity models," Proceedings of A.S.M.E. Fluids Engineering Conference (1993)

Technical Reports:

1. Ghosal S. & Spiegel E.A., "Convection with heat sources," Woods Hole Oceanog. Inst. Tech. Rept. (1989), WHOI-89-54, page 311

2. Ghosal S., Lund T.S. & Moin P., "A local dynamic model for large eddy simulation," CTR Annual Research Briefs (1992), page 3

3. Ghosal S., "On the large eddy simulation of turbulent flows in complex geometry," CTR Annual Research Briefs (1993), page 111

4. Ghosal S. & Rogers M., "Large-eddy simulation of a plane wake," CTR Annual Research Briefs (1994), page 127

5. Ghosal S., "Analysis of discretization errors in LES," CTR Annual Research Briefs (1995), page 3

6. Ghosal S. & Rose H.A., "Transverse plasma flow past a laser beam," CNLS Newsletter, September (1996)

7. Ghosal S. & Rogers M., "A numerical study of self-similarity in a turbulent plane wake using LES," CTR Annual Research Briefs (1996), page 257

8. Ghosal S. & Vervisch L., "Triple flames," T-division Special Feature, LANL, May 1998

9. Ghosal S. & Vervisch L., "Triple flames," T-division Quarterly, LANL, Summer 1998

10. Ghosal S., Rogers M. & Wray, A. "The turbulent life of phytoplankton," CTR Proceedings of the 2000 Summer Program (2000), page 31

11. Paoli, R., Hélie, J., Poinsot, T.J. & Ghosal, S. "Contrail formation in aircraft wakes using Large Eddy Simulations," CTR Proceedings of the 2002 Summer Program, Stanford University

12. Apte S. & Ghosal, S. "A presumed pdf approach to modeling evaporating or condensing droplets in complex flows" CTR Annual Research Briefs (2004)

13. Ghosal, S. & Hermann, M. "Modeling sprays by the method of Laplace Transforms," CTR Proceedings of the 2006 Summer Program, Stanford University

Books & Book Chapters:

1. "Analysis and control of errors in the numerical simulation of turbulence," Chapter 4 of *Turbulent Flow Computation*, Vol. 66 in series *Fluid Mechanics & its Applications*, edited: D. Drikakis & B.J. Geurts, Kluwer Academic Publishers, Dordrecht, The Netherlands, March 2002.

2. "Electrokinetic Flow and Ion Transport in Nanochannels," in *Encyclopedia of Micro- and Nano-Fluidics*, Ed. Li, D. Springer-Verlag, Heidelberg, Germany 2008.

3. "Microfluidics" in *Encyclopedia of Complexity and Systems Science* Ed. Meyers, R., Springer-Verlag, Heidelberg, Germany 2009

4. "Mathematical Modeling of Electrokinetic Effects in Micro and Nano Fluidics" Chapter 2 in *Microfluidics & Microfabrication* Springer-Verlag, Heidelberg, Germany 2009

5. "Band Broadening Theories in Capillary Electrophoresis" In: Dutta D. (eds) *Microfluidic Electrophoresis. Methods in Molecular Biology*, Vol. 1906. Humana Press, New York, NY 2019

Lectures at Professional Meetings

1. American Physical Society, Division of Fluid Dynamics — Nov. 24-26, 2013
   66th annual meeting, Pittsburgh, PA
   Title: "A Landau-Squire Nanojet"
   (with N. Laohakunakorn, B. Gollnick, F. Moreno-Herrero, D. Aarts, R. Dullens & U. Keyser)

2. American Physical Society, Division of Fluid Dynamics — Nov. 24-26, 2013
   66th annual meeting, Pittsburgh, PA
   Title: "Hydrodynamic flow in the vicinity of a nanopore in response to an applied voltage"
   (with M. Mao)

3. 6th International Conference on Nonlinear Mechanics — Aug. 12-15, 2013
   Shanghai, People's Republic of China
   Title: "Key Note Lecture (Fluids): The interaction of polymers with nanopores: the role of hydrodynamics" [**invited**]

4. Biophysical Society — Feb. 2-6, 2013
   57th Annual Meeting, Philadelphia, PA
   Title: "Electrophoretic forces on multiple DNA molecules in a nanopore" [with Laohakunakorn, N., Misiunas, K., Otto, O., Steinbock, L.J. and Keyser, U.]

5. 7th biennial workshop on Single Molecule Biophysics — Jan. 6-11, 2013
   Aspen Center for Physics, Aspen, CO
   Title: "Electrophoretic forces on multiple DNA molecules in a nanopore" [with Laohakunakorn, N., Misiunas, K., Otto, O., Steinbock, L.J. and Keyser, U.]

6. American Physical Society, Division of Fluid Dynamics — Nov. 20-22, 2011
   64th annual meeting, Baltimore, MD
   Title: "Electromigration dispersion: theory vs. experiment" [with Chen, Z.]

7. American Physical Society, Division of Fluid Dynamics — Nov. 20-22, 2011
   64th annual meeting, Baltimore, MD
   Title: "Electromigration dispersion in the presence of a zeta-potential" [with Chen, Z.]

8. American Physical Society, Division of Fluid Dynamics — Nov. 22-24, 2009
   62nd annual meeting, Minneapolis, MN
   Title: "A nonlinear equation for ionic diffusion in a strong binary electrolyte" [with Chen, Z.]

9. Society of Engineering Science — Oct. 12-14, 2011
   Annual Technical Conference, Northwestern University, USA
   Title: "Electromigration Dispersion In Capillary Zone Electrophoresis" [**invited**]

10. Electrokinetic Phenomena in Nano-colloids and Nano-fluidics — Dec. 19-23, 2010
    Technion - Israel Institute of Technology, Haifa, Israel
    Title: "Electromigration Dispersion and the Burgers' Equation" [**invited**]

11. American Physical Society, Division of Fluid Dynamics — Nov. 21-23, 2010
    63rd annual meeting, Long Beach, CA
    Title: "Nonlinear waves in electromigration dispersion" [with Chen, Z.]

12. AICHE Annual Meeting Topical 3: — Nov. 7-12, 2010
    2010 Annual Meeting of the American Electrophoresis Society
    Title: "DNA Electrophoresis through Nanopores" [**invited**]

13. American Physical Society, Division of Fluid Dynamics — Nov. 22-24, 2009
    62nd annual meeting, Minneapolis, MN
    Title: "A nonlinear equation for ionic diffusion in a strong binary electrolyte" [with Chen, Z.]

14. Indo-US Workshop on Microfluidics & Fabrionics — Jan.9-11, 2009
    (Microfabrication), IIT Kharagpur (India)
    Title:"The mathematics of micro and nano fluidics"

15. American Physical Society, Division of Fluid Dynamics — Nov. 18-20, 2007
    60th annual meeting, Salt Lake City, UT
    Title: "DNA translocation through nanopores: effect of salt concentration"

16. American Physical Society, Division of Fluid Dynamics — Nov. 18-20, 2007
    60th annual meeting, Salt Lake City, UT
    Title: "Dispersion in microfluidic separation systems in presence of wall interactions and axial inhomogeneites" [with Datta, S.]

17. American Physical Society — March 5-9, 2007
    2007 March Meeting, Denver, CO
    Title: "Electrophoretic speed of a polyelectrolyte in a nanopore"

18. American Physical Society, Division of Fluid Dynamics — Nov. 19-22, 2006
    59th annual meeting, Tampa, FL
    Title: "Electrophoresis of a polyelectrolyte through a nanopore"

19. American Physical Society, Division of Fluid Dynamics Nov. 19-22, 2006
    59th annual meeting, Tampa, FL
    Title: "Dispersion in channels with adsorption and desorption at walls" [with Datta, S.]

20. American Physical Society, Division of Fluid Dynamics Nov. 20-22, 2005
    58th annual meeting, Chicago, IL
    Title: "Electroosmotic flow in rectangular microchannels: numerical simulation and asymptotic theory" [with Datta, S. & Patankar, N.]

21. American Physical Society, Division of Fluid Dynamics Nov. 20-22, 2005
    58th annual meeting, Chicago, IL
    Title: "A Mathematical Model Describing Gradient Focusing Methods for Trace Analytes" [with Horek, J.]

22. American Physical Society, Division of Fluid Dynamics Nov. 21-23, 2004
    57th annual meeting, Seattle, WA
    Title: "A presumed pdf method for evaporating droplets and sprays" [with Apte, S.]

23. SIAM Conference on Mathematical Aspects of May 23-26, 2004
    Material Science, Los Angeles, CA
    Title: "Fluid Flow and Dispersion in the Electrophoretic Separation of Biomolecules" [**invited**]

24. 7th US Congress on Computational Mechanics July 28-30, 2003
    Albuquerque, New Mexico
    Title: "Analysis of Wall Adsorption of Analytes in Capillary Electrophoresis" [**invited**]

25. ICIAM 2003 (5th Int. Congress on Indstrl. & Appl. Math.) July 7-11, 2003
    Minisymposium on *Mathematical Problems in Microscale Systems*
    Title: "The effect of wall interactions on EOF and dispersion in free solution Zone Electrophoresis" [**invited**]

26. Joint IGERT workshop (Cornell, Northwestern, Arizona) Oct. 14, 2002
    Title: "Electroosmotic flow and Taylor-Aris dispersion in channels with slow variations in wall properties"

27. 5th Intl. Conf. on Modeling & Simulation of Microsystems April, 2002
    San Juan, Puerto Rico
    Title: "Electroosmotic flow and zone broadening in microfluidic channels of variable cross-section and wall charge" [*peer reviewed*]

28. American Physical Society, Division of Fluid Dynamics Nov. 2001
    54rd annual meeting, San Diego, CA
    Title: "Electroosmotic flow in a microfluidic channel of variable cross-section and zeta potential"

29. American Physical Society, Division of Fluid Dynamics Nov. 2000
    53rd annual meeting, Washington, DC
    Title: "Stability diagram for lift-off & blowout of a round jet laminar diffusion flame" [with Vervisch, L.]

30. American Physical Society, Division of Fluid Dynamics Nov. 2000
    53rd annual meeting, Washington, DC
    Title: "The turbulent life of phytoplankton"

31. CTR Summer Program (Stanford Univ. & NASA Ames Res. Ctr.) July 2000
    Title: "The turbulent life of phytoplankton"

32. IMA Workshop, Low Speed Combustion, Minneapolis Sept. 1999
    Title: "AEA of Triple Flames: Introducing Corrections Due to Compressibility "

33. American Physical Society, Division of Fluid Dynamics Nov. 1998
    51st annual meeting, Philadelphia, PA
    Title: "Triple Flames: the effects of heat release" [with Vervisch, L.]

34. 29th AIAA Fluid Dynamics Conference, Albuquerque June 1998
    Title: "Mathematical & physical constraints on LES (Invited Review)"

35. SIAM (UK & Republic of Ireland) March/April 1998
    7th International Conference on Numerical Combustion, York, UK
    Title: "Asymptotic theory of triple flames"

36. American Physical Society, Division of Fluid Dynamics Nov. 1997
    50th annual meeting, San Francisco, CA
    Title: "Asymptotic theory of triple flames"

37. American Physical Society, Division of Plasma Physics Nov. 1997
    39th annual meeting, Pittsburgh, PA
    Title: "Effect of ISI on flow induced laser beam deflection" [with Rose, H.]

38. 75th Statistical Mechanics Conference, Rutgers, NJ May 1996
    Title: "A hyperbolic equation for turbulent diffusion" [with Keller, J.]

39. CNLS, Los Alamos National Laboratory Aug. 1995
    Conference on scaling dynamics & fluid turbulence, Los Alamos, NM
    Title: "Turbulent diffusion"

40. American Physical Society, Division of Fluid Dynamics Nov. 1994
    47th annual meeting, Atlanta, GA
    Title: "The dynamic localization model with backscatter" [with Carati, D.]

41. CNLS, Los Alamos National Laboratory Aug. 1994
    Conference on geophysical turbulence & subgrid modeling, Los Alamos, NM
    Title: "A dynamic localization model for LES of turbulent flows"

42. American Physical Society, Division of Fluid Dynamics Nov. 1993
    46th annual meeting, Albuquerque, NM
    Title: "The basic equations for the LES of turbulent flows
    in complex geometry"

43. American Physical Society, Division of Fluid Dynamics Nov. 1992
    45th annual meeting, Tallahassee, FL
    Title: "A dynamic localization model for LES of
    turbulent flows" [with Lund T., Moin P. & Akselvoll K.]

44. Woods Hole Oceanographic Institution, GFD summer program Aug. 1989
    Fellowship lecture, Woods Hole, MA
    Title: "Convection with heat sources"

Other Invited Lectures

1. Institute of Mathematics & its Applications, Univ. of Minnesota Mar. 12-16, 2018
   Electrohydrodynamics and Electrodiffusion in Material Sciences and Biology
   Title: "Twenty years of Resistive Pulse experiments: What do we understand?"

2. The Batsheva de Rothschild Seminar, Sde Boker, Israel Jan. 3-8, 2017
   Physics of Microfluidics
   Title: "Electrokinetic flows with applications to Soft Matter and Biology"

3. University of Cambridge Sept. 16, 2013
   Biological & Soft Systems, Cavendish Laboratory
   Title: "Single molecule experiments with nano capillaries and optical tweezers:
   the role of electrokinetic flows" (Leverhulme Lecture III)

4. Chinese Academy of Sciences Aug. 9, 2013
   Institute of Mechanics, Beijing
   Title: "A Landau-Squire Nanojet"

5. University of Birmingham July 26, 2013
   Department of Chemistry
   Title: "Through the eye of a needle: how polymers
   go through nanopores"

6. University of Cambridge — July 15, 2013
   Biological & Soft Systems, Cavendish Laboratory
   Title: "The Mathematics of Electromigration Dispersion: Nonlinear Waves, Burger's Equation and Electrokinetic Shocks" (Leverhulme Lecture II)"

7. King Abdullah University of Science & Technology (KAUST) — April 7, 2013
   Division of Physical Sciences & Engineering
   Title: "Adventures in Nanofluidics"

8. King Abdullah University of Science & Technology (KAUST) — April 6, 2013
   Division of Physical Sciences & Engineering
   Title: "Adventures in Microfluidics"

9. TU Delft — Feb. 11, 2013
   Kavli Institute of Nanoscience
   Title: "Polymer translocation across membranes in physics and biology: Can we understand the data?"

10. Oxford University — Feb. 1, 2013
    Mathematical Biology & Ecology Seminar
    Title:"Polymer Translocation across Membranes"

11. University of Cambridge — Jan. 18, 2013
    Biological & Soft Systems, Cavendish Laboratory
    Title: "The translocation of polymers across nanometer sized pores in membranes" (Leverhulme Lecture I)

12. University of Cambridge — July 5, 2012
    Biological & Soft Systems, Cavendish Laboratory
    Title: "Force rectification in nanocapillaries"

13. University of Notre Dame — Feb. 3, 2012
    Department of Chemical & Biomolecular Engineering
    Title: "Nonlinear waves and electrokinetic shocks in Capillary Electrophoresis"

14. Brown University — Oct. 25, 2011
    Department of Mechanical Engineering
    Title: "Nonlinear waves and electrokinetic shocks in Capillary Electrophoresis"

15. Georgia Institute of Technology — April 6, 2010
    Department of Mechanical Engineering
    Title: "Transport problems in Capillary Electrophoresis"

16. University of South Carolina at Columbia — March 24, 2010
    Department of Mathematics
    Title: "Transport of ionic fluids at micro-and nanometer scales: principles and applications"

17. University of Illinois at Urbana-Champaign — Feb. 26, 2010
    Department of Mechanical Science & Engineering
    Title: "Electrophoretic shocks, Burgers' equation and electromigration dispersion"

18. Indian Institute of Science — Jan. 29, 2009
    Department of Chemical Engineering
    Title:"The mechanics of flow and transport in ionic fluids at micro and nanometer scales: principles and applications"

19. Oregon State University — Sept. 21, 2007
    Department of Mechanical Engineering
    Title:"Electrophoresis of DNA and other polyelectrolytes through nanometer size pores"

20. University of Michigan — March 30, 2007
    Department of Mathematics
    Title: "The hydrodynamics of ionic liquids near charged interfaces and some of its applications"

21. Stanford University — Oct. 17, 2006
    Fluid Mechanics Seminar
    Title: "The flow of liquids near charged interfaces and some of its applications"

22. University of California at SantaCruz (Bioengineering) — Oct. 9, 2006
    Title:"Electrophoresis of a polyelectrolyte through a nanopore"

23. Sandia National Laboratories, CA (Microfluidics) — August 24, 2004
    Title:"Analysis of Dispersion in Capillary Zone Electrophoresis"

24. University of California at SantaCruz (Bioengineering) — August 18, 2004
    Title:"Analysis of Dispersion in Capillary Zone Electrophoresis"

25. Harvard University (Engineering & Applied Sciences) — April 30, 2003
    Title: "A sticky problem in electroosmotic flow"

26. University of Cambridge, DAMTP — March 14, 2003
    Title: "Electoosmotic flow and band broadening in free solution Zone Electrophoresis"

27. Stanford University (Engineering) Oct. 8, 2002
    Title:"Electroosmotic flow and Taylor-Aris dispersion in channels with slow variations in wall properties"

28. Baxter Laboratories, Illinois Feb. 8, 2002
    Title:"Electroosmotic flow and zone broadening in microfluidic channels of variable cross-section and wall charge"

29. University of Illinois, Urbana-Champaign (TAM) Jan. 31, 2002
    Title:"Electroosmotic flow and zone broadening in microfluidic channels of variable cross-section and wall charge"

30. California Institute of Technology (GALCIT) Jan. 18, 2002
    Title:"Electroosmotic flow and zone broadening in microfluidic channels of variable cross-section and wall charge"

31. University of California at Santa Barbara (Mech./Envir. Eng.) Jan. 17, 2002
    Title:"Electroosmotic flow and zone broadening in microfluidic channels of variable cross-section and wall charge"

32. Sandia National Laboratories, CA (Microfluidics) Nov. 16, 2001
    Title:"Electroosmotic flow and zone broadening in microfluidic channels of variable cross-section and wall charge"

33. California Institute of Technology (GALCIT) May 15, 2000
    Title:"Analysis of the structure and propagation of triple flames"

34. University of California at San Diego (Mech./Aero. Eng.) May 5, 2000
    Title:"Analysis of the structure and propagation of triple flames"

35. Univ. Illinois, Urbana-Champaign (TAM/CSAR) April 29, 1998
    Title:"Asymptotic Theory of Triple Flames"

36. University of New Mexico (Mechanical Engineering) April 28, 1998
    Title:"Asymptotic Theory of Triple Flames"

37. Univ. Manchester Inst. Sci. Tech., UK (Mathematics) April 2, 1998
    Title: "Asymptotic Theory of Triple Flames"

38. Los Alamos National Laboratories ("Arizona days" Seminar) Jan. 30, 1998
    Title:"Asymptotic Theory of Triple Flames"

39. Columbia University (Plasma Physics) March 28, 1997
    Title:"Two-Dimensional Plasma Flow Past a Laser Beam"

40. Los Alamos National Laboratories (CNLS/T-13) March 25, 1997
    Title:"Deflection of Laser Beams Due to Transverse Plasma Flows"

41. Univ. Illinois, Urbana-Champaign (TAM) Sept. 19, 1996
    Title:"Mathematical developments in large-eddy simulation"