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Curriculum Vitae of Ambar N. Sengupta

a. Professional Preparation

Institution	Major	Degree	Year
University of Calcutta	Mathematics	B. Sc.	1984
Cornell University	Mathematics	M.S.	1987
Cornell University	Mathematics	Ph. D.	1990

b. Principal Appointments

- Presently (since 2001): Professor, Department of Mathematics, Louisiana State University
- 1996-2001 : Associate Professor, Department of Mathematics, Louisiana State University
- 1991-1996 : Assistant Professor, Department of Mathematics, Louisiana State University
- 1990-1991 : Instructor/Post-Doctoral Research, Department of Physics, Princeton University
- Visiting positions at Max Planck Institute Bonn, University of Bonn, the Indian Statistical Institute, S.N. Bose Centre (Kolkata, India), and the École Normale Supérieure, Paris.

c. Research Support and Grants

- National Science Foundation, NSF DMS 0601141 (2006-2009) Geometric and Probabilistic Problems from Low Dimensional Gauge Theories, \$125,726
- National Science Foundation, NSF DMS 0201683 (2002-2005; ext. 2006), Mathematical Problems from Geometric/Topological Quantum Field Theories. \$109,932
- National Science Foundation, NSF DMS 9800955 (1998-2001; ext. 2002), Mathematical Problems in Low Dimensional Gauge Theories. \$74,646.
- National Science Foundation, DMS 9400961 (1994-1997) Gauge Theory on Compact Surfaces. \$51,953.
- DePSCOR (Defense Experimental Program to Stimulate Competitive Research) 1994-1997 (jointly with W.G. Cochran, H. -H. Kuo, P. Sundar) US Army Research Office DAAH 04-94-G-0249: Stochastic Analysis and Applications.
- Alexander von Humboldt Fellowship (1995-1996 and extensions).
- Visiting Experts Program in Mathematics LEQSF (2002-2004) ENH -TR-13 (jointly with P. Gilmer).
- Louisiana Education Quality Support Fund : LEQSF (1992-93) RD -A -08 (jointly with W.G. Cochran, H. -H. Kuo, P. Sundar).
- Louisiana State University Faculty Summer Research Fellowship (1992).

d. Five Selected Publications

- Jeremy Becnel and Ambar N. Sengupta, *An infinite dimensional integral identity for the Segal-Bargmann transform*, Proceedings of the American Mathematical Society **135** (2007), 2995-3003.
- Ambar N. Sengupta, *The Moduli Space of Flat Connections over Compact Oriented Surfaces with Boundary*, Journal of Functional Analysis **190**, 179-232 (2002) : Special Issue dedicated to the memory of I. E. Segal.
- Sergio Albeverio and Ambar Sengupta, *A Mathematical Construction of the non-Abelian Chern-Simons Functional Integral*, Communications Mathematical Physics **186**, 563-579 (1997).
- Ambar Sengupta, *Gauge Theory on Compact Surfaces*, Memoirs of the American Mathematical Society **126** number 600 (1997)
- Christopher King and Ambar Sengupta, *The Semiclassical Limit of the Two Dimensional Quantum Yang-Mills Model*, Journal of Mathematical Physics (Special Issue on Topology and Physics), **35**, 5354-5361 (1994).

e. Selected Other Activities

- Ph.D. students: Vochita Mihai (August 2004), Jeremy Becnel (August 2006), Chao Meng (August 2008). MS thesis student: Ryan Coelho (December 2006).
- Co-organized Special Sessions at AMS Annual Meetings in New Orleans, January 10-13, 2001, January 7, 2007, and sectional meeting in Baton Rouge, March 2008. Overall local organizer of the American Mathematical Society (AMS) Meeting held in Baton Rouge in March 2003. Co-organized conference on Quantum Gauge Theory and Gravity at a physics institute in Kolkata, India, January 2008.
- Editorial Board, "Infinite Dimensional Analysis, Quantum Probability, and Related Topics," and "Communications on Stochastic Analysis."
- Referee for Journal of Functional Analysis, Communications in Mathematical Physics, and numerous other journals, and funding agencies such as the US National Science Foundation. Referee on promotion cases at several universities.
- Consultant on financial derivatives. Author of *Pricing Derivatives* (McGraw Hill, 2005).

f. Award

- LSU Alumni Association Faculty Excellence Award, 2004.

Research Support/Grants and Awards

US Federal
<ul style="list-style-type: none">• National Science Foundation, NSF DMS 0601141 (2006-2009; extended to 2010) Geometric and Probabilistic Problems from Low Dimensional Gauge Theories. \$125,726• National Science Foundation, NSF DMS 0201683 (2002-2005; extended to 2006), Mathematical Problems from Geometric/Topological Quantum Field Theories. \$109,932• National Science Foundation, NSF DMS 9800955 (1998-2001; extended to 2002), Mathematical Problems in Low Dimensional Gauge Theories. \$74,646• National Science Foundation, DMS 9400961 (1994-1997) : Gauge Theory on Compact Surfaces. \$51,953• DePSCOR (Defense Experimental Program to Stimulate Competitive Research) 1994-1997 (jointly with W.G. Cochran, H. -H. Kuo, P. Sundar) US Army Research Office DAAH 04-94-G-0249: Stochastic Analysis and Applications.
State of Louisiana
<ul style="list-style-type: none">• Visiting Experts Program in Mathematics LEQSF (2002-2004) ENH -TR-13 (jointly with P. Gilmer).• Louisiana Education Quality Support Fund : LEQSF (1992-93) RD -A -08 (jointly with W.G. Cochran, H. -H. Kuo, P. Sundar).
International
<ul style="list-style-type: none">• Alexander von Humboldt Fellowship (1995-1996 and extensions).
University (Louisiana State University)
<ul style="list-style-type: none">• LSU Alumni Association Faculty Excellence Award, 2004.• Louisiana State University Faculty Summer Research Fellowship. (1992)

Scholarly Works

Refereed Papers

1. Bires K. Bandyopadhyay and Ambar Sengupta, *Magnetic Monopoles : A Brief Review*, Fortschritte der Physik **32**, 175-184 (1984).
2. Francois Destrempes and Ambar Sengupta, *Configurations of Points in Sets of Positive Measure and in Baire Sets of Second Category*, Fundamenta Mathematicae, **133**, 155-159 (1989).
3. Leonard Gross, Christopher King, and Ambar Sengupta, *Two Dimensional Yang-Mills Theory via Stochastic Differential Equations*, Annals of Physics, **194**, 65-112 (1989).
4. Ambar Sengupta, *The Yang-Mills Measure for S^2* , Journal of Functional Analysis, **108**, 231-271 (1992).
5. Ambar Sengupta, *The Yang-Mills Measure for the Two-Sphere*, in Differential Geometry II : Geometry and Mathematical Physics , PSUPM342 (American Mathematical Society), 539-546 (1993). [This is largely a description of the work in item 4.]
6. Ambar Sengupta, *The Semiclassical Limit of the Yang-Mills Measure on S^2* , Communications in Mathematical Physics, **147**, 191-197 (1992).
7. Ambar Sengupta, *Quantum Gauge Theory on Compact Surfaces*, Annals of Physics, **221**, 17-52 (1993).
8. Ambar Sengupta, *Quantum Yang-Mills Theory on Compact Surfaces*, in Stochastic Analysis and Applications in Physics , ed. A.I. Cardoso et al., NATO ASI Series, Kluwer Academic Publishers (1994). [This is largely descriptive of item 7.]
9. Ambar Sengupta, *Limiting Measure in Yang-Mills Theory*, in Stochastic Analysis on Infinite Dimensional Spaces, ed. H. Kunita and H. -H. Kuo, Pitman Research Notes in Mathematics **310**, 297-307 (1994).
10. Ambar Sengupta, *Gauge Invariant Functions of Connections*, Proceedings of the American Mathematical Society, **121**, 897-905 (1994).
11. Christopher King and Ambar Sengupta, *An Explicit Description of the Symplectic Structure of Moduli Spaces of Flat Connections*, Journal of Mathematical Physics (Special Issue on Topology and Physics) **35**, 5338-5353 (1994).
12. Christopher King and Ambar Sengupta, *The Semiclassical Limit of the Two Dimensional Quantum Yang-Mills Model*, Journal of Mathematical Physics (Special Issue on Topology and Physics) **35**, 5354-5361 (1994).
13. Ambar Sengupta, *The Semiclassical Limit of $SU(2)$ and $SO(3)$ Gauge Theory over the Torus*, Communications in Mathematical Physics, **169**, 297-314 (1995).
14. Christopher King and Ambar Sengupta, *A New 2-form for Connections on Surfaces with Boundary*, Letters in Mathematical Physics **34**, 135-147 (1995).

15. Christopher King and Ambar Sengupta, *A Symplectic Structure for Connections on Surfaces with Boundary*, Communications in Mathematical Physics **175**, 657-671 (1996).
16. Ambar Sengupta, *The Moduli Space of Yang-Mills Connections over Compact Surfaces*, Reviews in Mathematical Physics **9**, 77-121 (1997).
17. Ambar Sengupta, *Yang-Mills on Surfaces with Boundary : Quantum Theory and Symplectic Limit*, Communications in Mathematical Physics **183**, 661-706 (1997).
18. Sergio Albeverio and Ambar Sengupta, *A Mathematical Construction of the non-Abelian Chern-Simons Functional Integral*, Commun. Math. Phys. **186**, 563-579 (1997).
19. Sergio Albeverio and Ambar N. Sengupta, *The Chern-Simons Functional Integral as an Infinite Dimensional Distribution*, in Proceedings of the Second World Congress of Nonlinear Analysts , Elsevier Science Ltd (1997). [This is largely descriptive of item 18.]
20. Ambar Sengupta, *Gauge Theory on Compact Surfaces*, Memoirs of the American Math. Soc. 126 number 600 (1997).
21. Brian C. Hall and Ambar N. Sengupta, *The Segal-Bargmann transform for path spaces in groups*, Journal of Functional Analysis **152** (1998).
22. Claas Becker and Ambar Sengupta, *Sewing Yang-Mills Measures and Moduli Spaces over Compact Surfaces*, Journal of Functional Analysis **152**, 74-99, (1998).
23. Ambar Sengupta, *A Yang-Mills Inequality for Compact Surfaces*, Infinite Dimensional Analysis, Quantum Probability and Related Topics **1** (1998) 1-16.
24. W. George Cochran, Hui-Hsiung Kuo and Ambar Sengupta, *A new class of white noise generalized functions*, Infinite Dimensional Analysis, Quantum Probability and Related Topics **1** (1998) 43-67.
25. Ambar Sengupta, *The Moduli Space of Flat $SU(2)$ and $SO(3)$ Connections over Surfaces*, Journal of Geometry and Physics, **28** (1998) 209-254.
26. Sergio Albeverio, Brian C. Hall and Ambar N. Sengupta, *The Segal-Bargmann Transform for Two Dimensional Yang-Mills*, Infinite Dimensional Analysis, Quantum Probability and Related Topics **2** (1999) 27-49.
27. Hui-Hsiung Kuo, Izumi Kubo and Ambar Sengupta, *White Noise Analysis on a New Space of Hida Distributions*, Infinite Dimensional Analysis, Quantum Probability and Related Topics **2** (1999) 315-335.
28. Ambar N. Sengupta, *Sewing Symplectic Volumes for Flat Connections over Compact Surfaces*, Journal of Geometry and Physics, **32** (2000) 269-292.
29. Ambar N. Sengupta, *The Yang-Mills Measure and Symplectic Structure on Spaces of Connections*, in Quantization of Singular Symplectic Quotients, edited by N. P. Landsman, M. Pflaum and M. Schlichenmaier. Progress in Mathematics, vol. 198. Publisher: Birkhauser. (2001)

30. Ambar N. Sengupta, *The Moduli Space of Flat Connections over Compact Oriented Surfaces with Boundary*, Journal of Functional Analysis **190** (2002) 179-232. This is a *special volume* in honor of Irving E. Segal, founder of this journal.
31. Ambar N. Sengupta, *Sewing Yang–Mills Measures for Non-Trivial Bundles*, Infinite Dimensional Analysis, Quantum Probability and Related Topics **6** (Special Issue on Probability and Geometry) (2003) 39-52.
32. Sergio Albeverio, Atle Hahn, Ambar N. Sengupta, *Chern-Simons theory, Hida distributions and State Models*, Infinite Dimensional Analysis, Quantum Probability and Related Topics **6**(Special Issue on Probability and Geometry) (2003) 65-81.
33. Sergio Albeverio, Atle Hahn, Ambar N. Sengupta, *Rigorous Feynman Path Integrals, with Applications to Quantum Theory, Gauge Fields, and Topological Invariants*, Pages 1-60 in “Stochastic Analysis and Mathematical Physics” (Editors: R. Rebolledo, J. Rezende, and J.-C. Zambrini), World Scientific (2004).
34. Jeffrey Mitchell and Ambar N. Sengupta, *Monopole Charge Quantization or Why Electromagnetism is a $U(1)$ -Gauge Theory*, Annals of Physics, **312**, Issue 2, August 2004, Pages 411-430.
35. Ambar N. Sengupta, *The Volume Measure for Flat Connections as Limit of the Yang–Mills Measure*, Journal of Geometry and Physics **47** 398-426 (2003).
36. Ambar N. Sengupta, *Symplectic Reduction for Yang-Mills on a Cylinder*. International Journal of Geometric Methods in Modern Physics, Vol. 1, Number 4, August 2004, 289-298.
37. Ambar N. Sengupta, *Connections over Two-Dimensional Cell Complexes*. Reviews in Mathematical Physics, Vol. 16, No. 3 (2004) 331-352.
38. Ambar Sengupta, *Rigorous Models for Chern-Simons Functional Integrals*, in the *Encyclopedia of mathematical physics*, edited by Jean-Pierre Francoise, Gregory L. Naber, Tsou Sheung Tsun. Elsevier (2006).
39. Ambar N. Sengupta, *A functional integral applied to topology and algebra*, in *XIVth International Congress on Mathematical Physics: Lisbon 28 July - 2 August 2003*, World Scientific Publishing Company (2006)
40. Ray Fabec, Gestur Ólafsson, Ambar N. Sengupta, *Fock spaces corresponding to positive definite linear transformations*. Mathematica Scandinavica, **98**, 262-282 (2006).
41. Jeremy Becnel and Ambar N. Sengupta, *An infinite dimensional integral identity for the Segal-Bargmann transform*, Proceedings of the American Mathematical Society **135** (2007), 2995-3003.
42. Vochita Mihai and Ambar N. Sengupta, *The Radon-Gauss transform*, Soochow J. Math. **33**, 415-434 (2007).
43. Ambar N. Sengupta, *Traces in Two-Dimensional QCD: The Large- N Limit*, pages 193-212 in ‘Traces in Geometry, Number Theory and Quantum Fields’, edited by Sergio Albeverio,

Matilde Marcolli, Sylvie Paycha, and Jorge Plazas, published by Vieweg (2008). Online at <http://www.math.lsu.edu/~sengupta/papers.html>

44. Ambar N. Sengupta, *Gauge Theory in Two Dimensions: Topological, Geometric and Probabilistic Aspects*, pages 109-129 in ‘Stochastic Analysis in Mathematical Physics’ edited by Gerard Ben Arous, Ana Bela Cruzeiro, Yves Le Jan, and Jean-Claude Zambrini, published by World Scientific (2008). Online at <http://arxiv.org/abs/0707.4136>
45. Jeremy J. Becnel and Ambar N. Sengupta, *White Noise Analysis: Background and a Recent Application*, 18 pages, in “Infinite-dimensional Stochastic Analysis honoring H.-H. Kuo”, edited by P. Sundar and Ambar N. Sengupta, World Scientific (2008).
46. Saikat Chatterjee, Amitabha Lahiri, Ambar N. Sengupta, *Negative forms and path space forms*, International Journal of Geometric Methods in Modern Physics, Vol. 5, No. 4 (June 2008) 573-586. Online at <http://arxiv.org/abs/0706.1143>
47. Eric Hillebrand and Ambar N. Sengupta, *Pricing Functionals and Measures*, Communications on Stochastic Analysis, Vol. 2 Number 1 (2008) 53-70. Online at <http://www.math.lsu.edu/~sengupta/papers.html>
48. Ambar N. Sengupta, *The Large-N Yang-Mills Field on the Plane and Free Noise*, pages 121-132 in “Geometric Methods in Physics - Proceedings of the XVII Workshop on Geometric Methods in Physics” edited by P. Kielanowski, A. Odziejewicz, M. Schlichenmaier, and T. Voronov, published by the American Institute of Physics (2008). Online at <http://www.math.lsu.edu/~sengupta/papers/YMfreeSengupta16Sep08.pdf>
49. Ambar N. Sengupta, *Finite Geometries with Qubit Operators*, Infinite Dimensional Analysis, Quantum Probability, and Related Topics, Volume: 12, Issue: 2 (2009) pp. 359-366. Online at <http://www.math.lsu.edu/~sengupta/papers.html>
50. Saikat Chatterjee, Amitabha Lahiri, Ambar N. Sengupta, *Path space forms and surface holonomy*, to appear in “Geometric Methods in Physics - Proceedings of the XVIII Workshop on Geometric Methods in Physics” (expected 2009).

Book

- Ambar N. Sengupta, *Pricing Derivatives: The Financial Concepts Underlying the Mathematics of Pricing Derivatives*, McGraw-Hill (2005).

Other Paper

- Ambar Sengupta, *The “Theorema Elegantissima” of Gauss* (1989). This presents a proof of the Gauss-Bonnet formula. Though this paper has not been published, exposition of its contents appears in *Riemannian Geometry : A Beginner’s Guide* by Frank Morgan, A.K. Peters (1992).

Edited Books

- *Finite and Infinite dimensional Analysis in Honor of Leonard Gross*, Edited by Hui-Hsiung Kuo and Ambar N. Sengupta, *Contemporary Mathematics Series*, American Mathematical Society (2003).
- *Infinite Dimensional Analysis Honoring H.-H. Kuo*, edited by Ambar N. Sengupta and P. Sundar, World Scientific (2008).

Other works

- Ambar N. Sengupta, *Notes on Representations of Algebras and Finite Groups*, (172 pages) online at <http://www.math.lsu.edu/~sengupta/notes.html>
- Ambar N. Sengupta, *Notes in Introductory Real Analysis*, (123 pages) last update November 2008, posted at <http://www.math.lsu.edu/~sengupta/notes.html>
- Ambar N. Sengupta, *Topics in Number Theory, Algebra, and Geometry*, (77 pages) last update December 2006, posted at <http://www.math.lsu.edu/~sengupta/notes.html>

Preprints/Working Papers

1. Chao Meng and Ambar N. Sengupta, *CDO tranche sensitivities in the Gaussian Copula Model* (16 pages), submitted, available online at <http://www.math.lsu.edu/~sengupta/papers/MengSenguptaTranche08.pdf>
2. Saikat Chatterjee, Amitabha Lahiri, Ambar N. Sengupta, *Parallel Transport over Path Spaces*, (31 pages), submitted. [math.lsu.edu/~sengupta/papers/CLSptpathSep2009.pdf](http://www.math.lsu.edu/~sengupta/papers/CLSptpathSep2009.pdf)
3. Jeremy Becnel and Ambar N. Sengupta, *A Support Theorem for the Radon Transform in Infinite Dimensions*, (20 pages) August 2009, submitted.
4. Eric Hillebrand, Ambar N. Sengupta, Junyue Xu, *Serially Correlated Defaults in Subprime Securitization*, working paper 2009.

Research Activities

Much of my research program centers on mathematical ideas and results inspired by physical theories, especially geometric quantum field theories. Mathematically, my work is a mix of several areas, with probability theory and geometry being the principal components. I am also active in mathematical work connected with finance.

Work on Gauge Theories

Much of my research program to date has involved setting up rigorous frameworks for geometric quantum field theories, and then solving specific problems within these frameworks.

Gauge fields mediate the interactions between the fundamental constituents of matter. The most familiar gauge field is electromagnetism. Other gauge fields include the strong forces between nucleons. Mathematically, a gauge field is a *connection* on a principal bundle over a manifold. The manifold, physically, corresponds to spacetime, and the principal bundle encodes the symmetries of the force field. These symmetries are expressed through a Lie group G (typically a subgroup of the unitary group $U(N)$), called the gauge group or structure group of the bundle. The connection allows one to *parallel transport* vectors, or other geometric entities, along curves on the manifold. This parallel-transport, in the physical context, allows one to relate the values of matter fields at different points in spacetime. Two connections corresponding to the same physical gauge field are related by an automorphism of the bundle, i.e. a *gauge transformation*. For a loop C in spacetime, the *holonomy* of a connection ω around C describes the effect of parallel transporting according to ω around C . With a choice of basepoint, the holonomy is an element $h(C; \omega)$ in the structure group G . The classical theory of gauge fields is pure geometry, and the allowed gauge configurations are solutions of variational equations known as the *Yang-Mills equations*; they are extrema of the *Yang-Mills action functional* S_{YM} . In quantum theory, from the Euclidean path integral point of view, one needs a quantum field measure on the space of gauge fields. Formally, it is given by the expression

$$d\mu_g(\omega) = \frac{1}{Z_g} e^{-S_{\text{YM}}(\omega)/g^2} [D\omega],$$

where g is a physical constant and $[D\omega]$ corresponds to a (non-existent) formal Lebesgue measure on the infinite-dimensional space of gauge equivalence classes of connections. Among the central mathematical challenges of gauge theory is the task of constructing a mathematically rigorous form of the measure μ_g and calculating $\int f d\mu_g$ for interesting functions f . Such functions include the *Wilson loop observables*: these are products of $\text{Tr}(\rho(h(C; \omega)))$, with C running over loops and ρ over representations of the group G .

In a series of papers spread out over several years, I constructed the rigorous Yang-Mills measure for the case where the base manifold (spacetime) is two-dimensional. For the case of the plane \mathbb{R}^2 , the measure is simply Gaussian. However, the connections on which the measure lives are quite rough and so parallel-transport has to be redefined through a stochastic differential equation. The Wilson loop expectation values were computed explicitly in the paper [7] with L. Gross and C. King. This was done independently and by a different method by B. Driver [5] at the same time. The results agreed with those known in the physics literature. After this, in several works [16, 18, 21, 22], I constructed the Yang-Mills measure over compact surfaces, with or without boundary, and for bundles with non-trivial topology.

The Yang-Mills measure for surfaces has been constructed by T. Lévy [14] in a different way using the loop expectation values as starting point. The measure has also been developed as a

functional integral in works of D. Fine [6]. The nature of the two-dimensional Yang-Mills measure has also been investigated in works of D. Pickrell ([15], for instance).

The limit of the measure μ_g , for compact surfaces, as the coupling constant g goes down to 0 is of interest. If we think of g as ‘temperature’, the limit μ_0 is what the measure μ_g ‘freezes’ down to as the temperature is reduced to 0. Witten [29, 30] showed what the limiting measure μ_0 ought to be, and that it should be a measure on the moduli space of flat connections (if the gauge group is semisimple). For closed oriented surfaces, the measure should be the volume measure on this moduli space arising from a certain natural symplectic structure. In the works [10, 11, 12, 13, 17, 19, 20, 21, 23, 24], some of which are joint with C. King, this limiting measure was determined by rigorous methods in a variety of contexts, including for closed oriented surfaces of genus > 1 with simply-connected structure group.

The three-dimensional gauge theory of greatest interest is governed by the *Chern-Simons action functional*. This theory gained prominence following Witten’s discovery [32] of the relationship between this gauge theory and three-dimensional topological invariants of systems of knots. In the work [1], S. Albeverio and I developed a framework for a rigorous formulation of the Chern-Simons functional integral. This framework has been carried forward successfully, connecting functional integrals with link invariants, by A. Hahn (an account is in the joint paper [2]).

The research program described above led to a variety of other results. Examples include investigation of infinite-dimensional distribution theory [4] (joint with C. Cochran and H.-H. Kuo) and results for the Segal-Bargmann transform [8, 3] (joint with B. Hall, and with J. Becnel, respectively).

Current Research Program and Objectives

My current research program continues to center on aspects of Yang-Mills gauge theory and other geometric/topological quantum field theories.

A new direction for my research work now is the exploration of the large N limit of gauge theory with structure group $U(N)$. This involves studying certain specific types of integrals over spaces of $N \times N$ matrices and determining the limit as N goes to ∞ . A simple example of such an integral is

$$\int_{U(N)} \text{tr}(M^{n_1}) \dots \text{tr}(M^{n_k}) Q_t(M) dM$$

where $Q_t(M)$ is the solution of the heat equation on the group $U(N)$. Interest in the large- N behavior of such integrals arose from the work of G.’t Hooft [27] in the 1970s on the large N behavior of quantum gauge theory. The central object of interest is the Wilson loop expectation

$$W_N(C) = \int N^{-1} \text{Tr}(h(C)) d\mu_g,$$

where $h(C)$ is the holonomy around the loop C and μ_g the Yang-Mills measure for gauge theory on the plane with group $U(N)$. As a sampler of what Wilson loop expectation values look like on the plane, we have:

$$W_N(C) = e^{-(Ng^2/2)(S_2+2S_1)} (\cosh(g^2 S_1) - N \sinh(g^2 S_1))$$

for a heart-shaped loop C , with an outer loop folding in to an inner loop, the inner loop enclosing area S_1 , with area S_2 lying between the inner loop and outer loop of C (I have worked out other similar examples in [25]). More recently, Lévy has derived an elegant general series expansion (in powers of N^{-1}) for such loop expectations.

I. M. Singer's analysis [26] suggests a rich theory exists in the $N = \infty$ limiting situation. This would connect with *free probability theory* (Voiculescu et al. [28]). A large body of physics literature (such as Kazakov and Kostov [9]) also provides a vast array of questions and conjectures to explore.

A major objective of my current work is *developing and studying the $N \rightarrow \infty$ limit and the limiting $N = \infty$ theory itself*.

My work on gauge theory also continues to explore geometric and topological aspects of the theory.

As a longer term objective, I would also like to take up Yang-Mills in three dimensions. This is a harder problem but there is sufficient work in the physics literature to suggest that a mathematical theory could be constructed.

Applied work

Aside from my academic research work, I have been a consultant on mathematical issues in pricing complex financial derivative instruments. Some of my earlier work in this area is contained in my book *Pricing Derivatives*, published by McGraw-Hill (2005).

I did consulting work for Dresdner Kleinwort on pricing and risk management of synthetic CDO (collateralized debt obligation) tranche instruments. Several lengthy internal research documents were produced from this work. These concern development and implementation of specific portfolio default loss models. I continue to have industry collaboration on work on problems in this area.

The work in financial mathematics uses stochastic analysis and probability theory. Some techniques, such as the use of the Feynman-Kac formula, connect with physics, whereas others, such as the study of defaults in a portfolio use notions in probability theory, such as branching processes, whose origins lie in biological applications.

References

- [1] Sergio Albeverio and Ambar Sengupta, *A Mathematical Construction of the non-Abelian Chern-Simons Functional Integral*, Commun. Math. Phys. **186**, 563-579 (1997)
- [2] Sergio Albeverio, Atle Hahn, Ambar N. Sengupta, *Chern-Simons theory, Hida distributions and State Models*, Infinite Dimensional Analysis, Quantum Probability and Related Topics **6**(Special Issue on Probability and Geometry) (2003) 65-81.
- [3] Jeremy Becnel and Ambar N. Sengupta, *An infinite dimensional integral identity for the Segal-Bargmann transform*, Proceedings of the American Mathematical Society 135 (2007), 2995-3003.
- [4] W. George Cochran, Hui-Hsiung Kuo and Ambar Sengupta, *A new class of white noise generalized functions*, Infinite Dimensional Analysis, Quantum Probability and Related Topics **1** (1998) 43-67.
- [5] B. K. Driver, *YM_2 : Continuum Expectations, Lattice Convergence, and Lassos*, Commun. Math. Phys. **123**, 575-616 (1989).
- [6] D. Fine, *Topological Sectors and Measures on Moduli Space in quantum Yang-Mills on a Riemann Surface*, J. Math. Phys. **37**, no. 3, 1161-1170 (1996).

- [7] Leonard Gross, Christopher King, and Ambar Sengupta, *Two Dimensional Yang-Mills Theory via Stochastic Differential Equations*, Annals of Physics, 194, 65-112 (1989).
- [8] Brian C. Hall and Ambar N. Sengupta, *The Segal-Bargmann transform for path spaces in groups*, Journal of Functional Analysis **152** (1998).
- [9] V. Kazakov and I. Kostov, *Nonlinear Strings in two dimensional $U(\infty)$ gauge theory* Nucl. Phys. B **176**, 199 (1980).
- [10] Christopher King and Ambar Sengupta, *An Explicit Description of the Symplectic Structure of Moduli Spaces of Flat Connections*, Journal of Mathematical Physics (Special Issue on Topology and Physics) **35**, 5338-5353 (1994).
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- [12] Christopher King and Ambar Sengupta, *A New 2-form for Connections on Surfaces with Boundary*, Letters in Mathematical Physics **34**, 135-147 (1995).
- [13] Christopher King and Ambar Sengupta, *A Symplectic Structure for Connections on Surfaces with Boundary*, Communications in Mathematical Physics **175**, 657-671 (1996)
- [14] T. Lévy, *The Yang-Mills measure for compact surfaces*, Memoirs Amer. Math. Soc. 166 (790)(2003).
- [15] D. Pickrell, *On YM_2 measures and area-preserving diffeomorphisms*, Journal of Geometry and Physics **19**, 315-367 (1996).
- [16] Ambar Sengupta, *The Yang-Mills Measure for S^2* , Journal of Functional Analysis, 108, 231-271 (1992).
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Thesis Supervision

- Vochita Mihai, PhD (August 2004), developed an infinite-dimensional form of the Radon transform.
- Jeremy Becnel, PhD (August 2006), on a mathematical problem originating in quantum-computing using infinite dimensional Gaussian analysis.
- Ryan Coelho, MS (December 2006), application of the copula method to study currency exchange rates.
- Chao Meng, PhD (August 2008), mathematical problems related to CDO tranche prices and risk management.

Participation in Professional Society Activities and Conferences

Memberships

- American Mathematical Society
- American Physical Society

Conference Organization Activity

1. American Mathematical Society Annual Meeting, Baton Rouge, March, 2008. Co-organizer (with Arkadev Chatterjee) of a Special Session *Challenges in Financial Mathematics*.
2. Co-organizer of international conference *Non-perturbative gauge theories and gravity* (<http://www.math.lsu.edu/~sengupta/qgt08.pdf>) in January 2008, in Kolkata, India.
3. American Mathematical Society Annual Meeting, New Orleans, January 7, 2007. Co-organized (with Padmanabhan Sundar) the Special Session *Infinite Dimensional Analysis Honoring Hui-Hsiung Kuo*.
4. Co-organized (with Padmanabhan Sundar) Workshop on Stochastic Analysis at LSU, January 5, 2007.
5. American Mathematical Society meeting, Baton Rouge, March 14-16, 2003. Overall local organizer.
6. American Mathematical Society Annual Meeting, New Orleans January 10-13, 2001. Co-organized (with Hui-Hsiung Kuo) the Special Session “Analysis on Infinite Dimensional Spaces (in Honor of Leonard Gross)”
7. Organizer of a section of the Midwest Geometry Conference in Baton Rouge, in October 1998.
8. Member, Local Committee, US-Japan Seminar on Probability Theory, Baton Rouge, 1994.

Presentations at Selected Recent Meetings

1. *Functional Integrals in Low-Dimensional Gauge Theories*, 4th August, 2009, at the conference ‘Chern-Simons Gauge Theory: 20 years after’ held by the Hausdorff Center for Mathematics at the Max Planck Institute for Mathematics in Bonn, Germany.
2. *The Gaussian Copula in Modeling Correlated Events*, February 28, 2009, Lamar University Mathematics Conference.
3. *Mathematical Problems in Low-Dimensional Gauge Theories*, June 2008, Plenary Lecture at XXVII Workshop on Geometric Methods in Physics, Białowieża, Poland.
4. *Large-N Aspects of Two-dimensional Yang-Mills Theory*, American Mathematical Society meeting, Baton Rouge, March 30, 2008, Special Session on Lie Groups and Holomorphic Function Spaces: Analysis, Geometry, and Mathematical Physics.

5. *Yang-Mills in Two Dimensions and Its Large N Limit*, on March 27, 2007 at the conference *Free Probability and Large N Limit*, organized by A. Guionnet, D. Shlyakhtenko, and D. Voiculescu at the University of California, Berkeley.
6. Lecture at *Stochastic Analysis in Mathematics*, a satellite meeting of the International Congress of Mathematicians 2006, in Lisbon, Portugal.
7. *Functional Integrals in Low-dimensional Gauge Theories*, at the conference *The Feynman Integral and Related Topics in Mathematical Physics in Honor of G. W. Johnson and David Skoug*, Lincoln, Nebraska, May 12th, 2006.
8. *Traces in 2-dimensional QCD*, at the workshop ‘Traces in Geometry, Number Theory and Quantum Fields’, at the Max Planck Institute for Mathematics, Bonn, 27th October, 2005.
9. *A Quantum Algorithm and an Integral Identity*, international conference on ‘Operator Theory, Quantum Theory, and Noncommutative Geometry’ at the Indian Statistical Institute (Kolkata), December 23, 2004.
10. *A Rigorous Study of the Kauffman-Lomonaco Algorithm*, at an international conference ‘Infinite Dimensional Analysis and Path Integrals’, in Luminy, France, on 29th November, 2004.
11. *Pricing Functionals and Pricing Measures*, AMS Meeting Albuquerque October 17, 2004.
12. *Functional Integrals applied to Topology and Algebra* at the International Congress of Mathematical Physics, Lisbon (Portugal) July 28-August 2, 2003, on August 1, 2003.
13. *The Dirac Magnetic Charge Quantization Condition*, at the American Mathematical Society meeting, Baton Rouge, March 14-16, 2003, on March 16, 2003.
14. *The 2-D Yang Mills Functional Integral: Physics applied to Geometry* at a conference on ‘The Feynman Integral with Related Topics and Applications’ at the Mathematical Sciences Research Institute, Berkeley, December 9-12, 2002. on December 11, 2002.
15. *Functional Integrals from Geometric QFTs* at the conference ‘The Mathematical Legacy of Feynman’s Path Integral Approach: Analysis, Geometry, and Probability,’ in Lisbon (Portugal), June 25-28, 2002, on June 26, 2002.

Service Activities

LSU Mathematics Department

- Executive Committee (several terms, and current)
- Hiring Committee (several terms, and current)
- LSU VIGRE Grant proposal committee (till 2005)
- Department of Mathematics Internal Review Committee (2002-2003)
- Textbook selection committee (Chair) for Math 3355, Spring 2008.
- Committee for administering the Carruth McGehee Award (LSU)
- Several graduate committees
- Colloquium Chair (1996-97, 2002-2003, co-chair 2003-2004)
- Probability Seminar Coordinator (2002, 2003)
- Co-organizer of joint Mathematics Department - Physics Department Colloquium
- Coordinator, with Patrick Gilmer, of the Visiting Experts Program in the Department of Mathematics (2003-2005)
- Department of Mathematics representative (along with W. George Cochran) to National Science Foundation conference April 30-May 2, 2004
- Represented Mathematics Department at the IAFE (International Association of Financial Engineers) Meeting at NYU, October 8, 2004
- Chair for a Promotional Case Committee, Department of Mathematics, 2002
- Member, Committee on Redesigning Math 1431 (2003) [this is a basic Calculus course which was successfully redesigned for large-lecture and online delivery from the original small-sections format.]

University

- Chair, Committee of the Faculty (appointed by the Chancellor) Jan 2004-May 2005.
- Dean's Representative at several PhD Examinations (most recently April 10, 2007).
- President, LSU Faculty Science Club, Jan-Dec 2003. Treasurer for Spring 2004.

Professional

- Advisory Committee, XVIII Workshop on Geometric Methods in Physics, Białowiesza (Poland), 2009.
- Referee, Board of Experts of the CIVR (Committee for Research Evaluation of Italian Universities), 2005.
- Referee for several journals including Annals of Physics, Communications in Mathematical Physics, Journal of Functional Analysis, and Probability Theory and Related Fields.
- Referee for numerous grant proposals for the US National Science Foundation and CRDF.
- Referee for promotion cases at several universities.
- Judge, Baton Rouge Science Fair, March 2000.