

# Curriculum Vitae

## Matthew B. Hastings

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### RESEARCH INTERESTS:

- Hard Condensed Matter Physics: Correlated Electron Systems, Topological Order, and Quantum Information
- Non-Equilibrium Statistical Physics: Network Dynamics, Diffusion-Limited Aggregation, and Fractal Growth Models
- Soft Matter Physics: Granular Matter and Vortex Dynamics

### EDUCATION AND EMPLOYMENT:

- Technical Staff Member, Los Alamos National Laboratory, January 2001-present (1/2001-12/2003 as Richard P. Feynman Fellow).
- Director's Fellowship, Los Alamos National Laboratory, 2000.
- R. H. Dicke Fellow, Princeton University, 1997-2000.
- PhD in Physics September 1997. Massachusetts Institute of Technology, Thesis: "A Renormalization Approach to Diffusion Limited Aggregation", advisor Leonid Levitov.
- BS in Mathematics and Physics June 1994. Yale University, New Haven, CT, *Magna cum laude* with distinction in the major.

### PRIZES AND AWARDS:

- LANL Achievement Award, 2004.
- LANL Postdoctoral Distinguished Performance Team Award, 2003.
- Lockett Award, MIT, 1997.
- National Science Foundation Graduate Fellowship, 1994-1997.

- Compton Graduate Fellowship, MIT, 1994-1996.
- De Forest Senior Prize in Mathematics, Yale, 1994.
- Howard L. Schultz Prize in Physics, Yale, 1994.
- Anthony D. Stanley Prize in Mathematics, Yale, 1993.

### **INVITED TALKS:**

- Symposium on DLA, 1997 APS March Meeting, “A Renormalization Approach to Diffusion Limited Aggregation”.
- EU School on Multifractals - Mathematics and Applications, Jan 4-8, 1999, “Renormalization of Diffusion Limited Aggregation”.
- Conference on Scaling and Universality in Strongly Nonlinear Systems, Cuernavaca, Mexico, 2000, “High-Dimensional Diffusive Growth”.
- Workshop on Pattern Formation and Diffusion Limited Growth, Michigan Center for Theoretical Physics, August 6-10, 2001, “Growth Exponents with 3.99 Walkers”.
- James Franck Institute, University of Chicago, 1997.
- Lucent Technologies, Murray Hill, NJ, 1997.
- Institute for Theoretical Physics, University of California, Santa Barbara 1997.
- Harvard University 1997.
- Yale University, 1997.
- Lucent Technologies, 1999.
- Brookhaven National Laboratory, 1999.
- University of Catania, Italy, 1999.
- James Franck Institute, University of Chicago, 1999.
- Lucent Technologies, Murray Hill, NJ, 2000.
- NEC Research Institute, Princeton, NJ, 2000.
- Yale University, 2000.
- ExxonMobil Research and Engineering, Annandale, NJ, 2000.
- Brown University, Providence, RI, 2001.
- Princeton University, Princeton, NJ, 2001.

- Emory University, Atlanta, GA, 2001.
- James Franck Institute, University of Chicago, 2001.
- Cornell University, Ithaca, NY, 2002.
- Centro Internacional de Ciencias, Cuernavaca, Mexico, 2002.
- Institut Henri Poincare, Paris, France, 2003.
- CNLS Annual Conference, Santa Fe, NM, 2003.
- University of Arizona, Tucson, AZ, 2003.
- Rensselaer Polytechnic Institute, Troy, NY, 2003.
- MIT, Cambridge, MA, 2003.
- Harvard University, Cambridge, MA, 2003.
- University of Arizona, Tucson, AZ, 2004.
- MIT, Cambridge, MA, 2004.
- University of California Davis, Davis, CA, 2004.
- ICTP, Trieste, Italy, 2004.
- Princeton University, Princeton, NJ, 2004.
- Brown University, Providence, RI, 2004.
- Boston University, Boston, MA, 2004.
- ETH Zurich, Switzerland, 2004.
- Paul Scherrer Institute, Switzerland, 2004.
- Dynamics Days 2005 Invited Talk, Long Beach, CA, 2005.
- UC Santa Barbara Physics Colloquium, Santa Barbara, CA, 2005.
- ICTP, Trieste, Italy, 2005.
- Yale University, New Haven, CT, 2005.
- Caltech, Pasadena, CA, 2006.

**PROFESSIONAL ACTIVITIES:**

- Reviewer for Mathematical Reviews.

- Reviewer for Physical Review Letters, B, and E, Europhysics letters, Physics Letters A, and Journal of Physics; Grant reviewer for NSF, Israeli-US Binational Science Foundation, and LANL LDRD.
- Organizer, Statistical Physics of Complex Systems Summer Workshop at Los Alamos, Summer 2002, 2003, and 2004.
- Organizer, Statistical Mechanics Seminar at Los Alamos.
- Member, CNLS Director Search Committee; Member, T-13 Group Leader Search Committee

### **STUDENTS MENTORED:**

- B. Kozma, Summer 2004, Impurity Averaged Perturbation Theory of Small-World Networks.
- J. A. Drocco, Summer 2003, “Multiscaling at the Jamming Transition”, co-mentors C. J. Olson Reichhardt and C. Reichhardt.

### **PUBLICITY:**

- Work on “Ratchet Cellular Automata” featured in Physical Review Focus, June 20, 2003; Technology Research News, July 16/23, 2003; LANL Director’s Highlights, July 25, 2003; LANL Theoretical Division Research Highlights, 2003.
- Work on “Do Vortices Entangle?” featured in Nature News and Views, D. R. Nelson, Nature **430**, 839 (2004); ScienceWeek, 9/24/2004.
- Work on Large  $N$  Spin Glass featured in Bell Labs Condensed Matter Journal Club, November 2003.

### **REFERENCES:**

- Leonid S. Levitov, Professor of Physics at MIT, levitov@mit.edu, (617) 253-6817
- A. Douglas Stone, Professor of Applied Physics and Physics at Yale University, douglas.stone@yale.edu, (203) 432-4279
- Thomas C. Halsey, ExxonMobil Research and Engineering, thomas.c.chalsey@exxonmobil.com
- Shivaaji L. Sondhi, Associate Professor of Physics at Princeton University, sondhi@feynman.princeton.edu, (609) 258-4326
- Itamar Procaccia, Levinson Professorial Chair in Chemical Physics, Weizmann Institute of Science, Itamar.Procaccia@weizmann.ac.il
- Eli Ben-Naim, Technical Staff Member, T-13, Los Alamos National Laboratory, ebn@t13.lanl.gov

**GRANTS:**

- 2001: LANL ER, “Statistical Properties of Granular Chains”, with E. Ben-Naim (PI).
- 2002: LANL Start-up Grant, \$50K, with M. Chertkov and Z. Toroczkai
- 2003: LANL Start-up Grant, \$100K, with M. Chertkov and Z. Toroczkai
- 2004: LANL ER, “Quantum Devices for Electronic Circuitry and Advanced Detection”, with I. Martin (PI).
- 2004: LANL DR, “Statistical Physics of Infrastructure Networks”, \$1.2M (FY 2004), \$1.24M (FY 2005), \$1.3M (FY 2006), co-PI.

## PUBLICATIONS:

52. S. Bravyi, M. B. Hastings, and F. Verstraete, “Lieb-Robinson Bounds and the Generation of Correlations and Topological Quantum Order”, preprint quant-ph/0603121, Phys. Rev. Lett., submitted.
51. C. Amoruso, A. K. Hartmann, M. B. Hastings, M. A. Moore, “Conformal Invariance and SLE in Two-Dimensional Ising Spin Glasses”, preprint cond-mat/0601711, Phys. Rev. Lett., submitted.
50. M. B. Hastings, “Systematic Series Expansions for Processes on Networks”, preprint cond-mat/0511129, Phys. Rev. Lett. **96**, 148701 (2006).
49. M. B. Hastings, “Solving Gapped Hamiltonians Locally”, preprint cond-mat/0508554, Phys. Rev. B, in press.
48. M. B. Hastings and T. Koma, “Spectral Gap and Exponential Decay of Correlations”, preprint math-ph/0507008, Commun. Math. Phys., in press.
47. M. B. Hastings and C. Mudry, “Universal Scaling Relations in Strongly Anisotropic Materials”, preprint cond-mat/0506294, Phys. Rev. Lett. **96**, 027215 (2006).
46. M. B. Hastings and Xiao-Gang Wen, “Quasi-adiabatic Continuation of Quantum States: The Stability of Topological Ground State Degeneracy and Emergent Gauge Invariance”, preprint cond-mat/0503554, Phys. Rev. B **72**, 045141 (2005).
45. B. Kozma, M. B. Hastings, and G. Korniss, “Diffusion Processes on Power-Law Small-World Networks”, preprint cond-mat/0501509, Phys. Rev. Lett. **95**, 018701 (2005).
44. M. B. Hastings, “Sufficient Conditions for Topological Order in Insulators”, preprint cond-mat/0411094, Europhys. Lett. **70**, 824 (2005).
43. D. Mozyrsky, M. B. Hastings, and I. Martin, “Intermittent polaron dynamics: Born-Oppenheimer out of equilibrium”, preprint cond-mat/0410721, Phys. Rev. B, in press.
42. M. B. Hastings, “Statistical Mechanics of Interfering Links”, preprint cond-mat/0410038, Phys. Rev. E Rapids **72**, 015102 (2005).
41. M. B. Hastings, “An  $\epsilon$ -expansion for Small-World Networks”, preprint cond-mat/0407374, Eur. Phys. Jour. B. **42**, 297 (2004).
40. M. B. Hastings, “Decay of Correlations in Fermi Systems at Non-zero Temperature”, preprint cond-mat/0406348, Phys. Rev. Lett. **93**, 126402 (2004).
39. M. B. Hastings, “Locality in Quantum and Markov Dynamics on Lattices and Networks”, preprint cond-mat/0405587, Phys. Rev. Lett. **93**, 140402 (2004).

38. M. B. Hastings, “Spin-Orbit Scattering and Time-Reversal Symmetry: Detection of a Spin by Tunneling”, preprint cond-mat/0401151, Phys. Rev. B Rapids **70**, 161301 (2004).
37. C. Reichhardt, C.J. Olson Reichhardt, and M.B. Hastings, “Nonlinear dynamics, rectification, and phase locking for particles on symmetrical two-dimensional periodic substrates with dc and circular ac drives”, preprint cond-mat/0312620, Phys. Rev. E **69**, 056115 (2004).
36. D. Mozyrsky, I. Martin, A. Shnirman, and M. B. Hastings, “Renormalization of resonant tunneling in MOSFETs”, preprint cond-mat/0312503, Phys. Rev. Lett., submitted.
35. J. A. Drocco, M. B. Hastings, C. J. Olson Reichhardt, and C. Reichhardt, “Multiscaling at Point  $J$ : Jamming is a Critical Phenomenon”, preprint cond-mat/0310291, Phys. Rev. Lett. **95**, 088001 (2005).
34. M. B. Hastings and B. Kozma, “Critical Phenomena in a Small World”, in *Complex Networks*, edited by E. Ben-Naim, H. Frauenfelder, and Z. Toroczkai (Lecture Notes in Physics, Springer, 2004).
33. B. Kozma, M. B. Hastings, and G. Korniss, “Roughness Scaling for Edwards-Wilkinson Relaxation in Small-World Networks”, preprint cond-mat/0309196, Phys. Rev. Lett. **92**, 108701 (2004).
32. C. Reichhardt, C. J. Olson Reichhardt, and M. B. Hastings, “Glassy Ratchets for Collectively Interacting Particles”, preprint cond-mat/0308097, Phys. Lett. A **342**, 162 (2005).
31. C. J. Olson Reichhardt and M. B. Hastings, “Do Vortices Entangle?”, preprint cond-mat/0307374, Phys. Rev. Lett. **92**, 157002 (2004); featured in Nature News and Views.
30. D. Mozyrsky, I. Martin, and M. B. Hastings, “Quantum limited sensitivity of SET-based displacement detectors”, preprint cond-mat/0306480, Phys. Rev. Lett. **92**, 018303 (2004).
29. M. B. Hastings, “Lieb-Schultz-Mattis in Higher Dimensions”, preprint cond-mat/0305505, Phys. Rev. B **69**, 104431 (2004).
28. M. B. Hastings, “Mean-Field and Anomalous Behavior on a Small-World Network”, preprint cond-mat/0304530, Phys. Rev. Lett. **91**, 098701 (2003).
27. M. B. Hastings, “Random Vibrational Networks and Renormalization Group”, preprint cond-mat/0212303, Phys. Rev. Lett. **90**, 148702 (2003).

26. M. B. Hastings, C. J. Olson Reichhardt, and C. Reichhardt, “Ratchet Cellular Automata”, preprint cond-mat/0211302, Phys. Rev. Lett. **90**, 247004 (2003); featured in Phys. Rev. Focus.
25. M. B. Hastings, C. J. Olson Reichhardt, and C. Reichhardt, “Depinning by Fracture in a Glassy Background”, preprint cond-mat/0209542, Phys. Rev. Lett. **90**, 098302 (2003).
24. M. B. Hastings, I. Martin, and D. Mozyrsky. “Quantum Dynamics in Non-equilibrium Strongly Correlated Environments”, preprint cond-mat/0207005, Phys. Rev. B **68**, 035101 (2003).
23. M. B. Hastings, Z. A. Daya, E. Ben-Naim, and R. E. Ecke, “Entropic Tightening of Vibrated Chains”, preprint cond-mat/0110612, Phys. Rev. E Rapids **66**, 025102 (2002).
22. C. Reichhardt, C.J. Olson, and M.B. Hastings, “Rectification and Phase Locking for Particles on Two Dimensional Periodic Substrates”, Phys. Rev. Lett. **89**, 024101 (2002).
21. M. B. Hastings, “Comment on ‘Large- $N$  Theory of strongly commensurate dirty bosons: absence of a transition in two dimensions’”, J. Phys. A **35**, 2519 (2002).
20. M. B. Hastings, “Exact Multifractal Spectra for Arbitrary Laplacian Random Walks”, preprint cond-mat/0109304, Phys. Rev. Lett. **88**, 055506 (2002).
19. M. B. Hastings, “Scale-Invariant Branch Distribution from a Soluble Stochastic Model”, preprint cond-mat/0105440, J. Stat. Phys. **107**, 1031 (2002).
18. M. B. Hastings, “Growth Exponents with 3.99 Walkers”, preprint cond-mat/0104344, Phys. Rev. E **64**, 46104 (2001).
17. M. B. Hastings, “Fractal to Nonfractal Phase Transition in the Dielectric Breakdown Model”, preprint cond-mat/00103312, Phys. Rev. Lett. **87**, 175502 (2001).
16. M. B. Hastings, “Effective Gauge Theories of Spin Systems”, preprint cond-mat/0011125.
15. M. B. Hastings and S. L. Sondhi, “Breakdown of Conformal Invariance at Strongly Random Critical Points”, preprint cond-mat/0011124, Phys. Rev. B **64**, 94204 (2001).
14. M. B. Hastings and T. C. Halsey, “High-Dimensional Diffusive Growth”, preprint cond-mat/0010400, Europhysics Lett. **55**, 679 (2001).
13. M. B. Hastings, “Dirac Structure, RVB, and Goldstone Modes in the Kagomé Antiferromagnet”, preprint cond-mat/0005391, Phys. Rev. B **63**, 14413 (2001).
12. M. B. Hastings, “The Dielectric Breakdown Model at Small  $\eta$ : Pole Dynamics”, preprint cond-mat/9910274, Phys. Rev. E **65**, 066121 (2002).



11. M. B. Hastings, “Eigenvalue Distribution In The Self-Dual Non-Hermitian Ensemble”, preprint cond-mat/9909234, J. Stat. Phys. **103**, 903 (2001).
10. M. B. Hastings, “Fermionic Mapping For Eigenvalue Correlation Functions Of (Weakly) Non-Hermitian Symplectic Ensemble”, preprint cond-mat/9907302, Nuc. Phys. B **572** [FS] 535 (2000).
9. M. B. Hastings, “Ground State and Spin Glass Phase of the Large  $N$  Infinite Range Spin Glass Via Supersymmetry”, preprint cond-mat/9906186, J. Stat. Phys. **99**, 171 (2000).
8. M. B. Hastings, “Bose Glass in Large  $N$  Commensurate Dirty Boson Model”, preprint cond-mat/9811121, Phys. Rev. B **64**, 024517 (2001).
7. M. B. Hastings, “Renormalization Group for Large  $N$  Strongly Commensurate Dirty Boson Model”, Phys. Rev. B **60**, 9755-9762 (1999).
6. M. B. Hastings, “Non-hermitian Fermion Mapping for One-Component Plasma”, J. Stat. Phys. **90**, 311 (1998).
5. M. B. Hastings and L. S. Levitov, “Laplacian growth as one-dimensional turbulence”, Physica D **116**, 244 (1998).
4. M. B. Hastings and L. S. Levitov, “Bragg Resonances for Tunneling Between Edges of a 2D Quantum Hall System”, Phys. Rev. Lett. **77**, 4422 (1996).
3. M. B. Hastings, “Renormalization Theory of Stochastic Growth”, Phys. Rev. E **55**, 135 (1997).
2. M. B. Hastings, A. D. Stone, and H. U. Baranger, “Inequivalence of Weak Localization and Coherent Backscattering”, Phys. Rev. B **50**, 8230 (1994).
1. O. Sinanoglu, J. Alia, and M. Hastings, “Valency Interactions in  $AH_m$ ”, J. Phys. Chem. **98**, 5867 (1994).