

# Curriculum Vitae

## Zoltán Toroczkai

### Acting Deputy Director

Center for Nonlinear Studies, and

### Technical Staff member

Complex Systems Group, T-13

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Family: Married + 2

Immigration: US permanent resident

Citizenship: Romania

LANGUAGES: English, Hungarian, Romanian

### RESEARCH INTERESTS:

- Complex Networks: statistical physics of complex networks with applications to infrastructure networks and social systems.
- Agent-based Systems Modelling: multi-player games, game theory, collective intelligence and optimization
- Massively parallel computation: computational and measurement scalability
- Statistical Physics and Non-equilibrium Statistical Mechanics: spin systems, exactly solvable models, random walks
- Nonlinear Dynamical Systems and Chaos: nonlinear time series analysis, thermodynamic formalism, chaos control and synchronization
- Biophysics: population dynamics, genetic sequence modelling, species coexistence
- Fluid Dynamics: chaotic advection, chemical/biological activity in chaotic flows
- Surface growth, interface dynamics: Molecular Beam Epitaxy, growth instabilities

### EMPLOYMENT and EDUCATION HISTORY:

- Acting Deputy Director, Center for Nonlinear Studies, LANL, 2004-present
- Technical Staff Member, Complex Systems Group, LANL, 2002-present
- Director's Fellowship, Los Alamos National Laboratory, 2000-2002.
- Research Associate, University of Maryland at College Park, 98–2000.
- Graduate Research Assistant and Research Associate, Virginia Tech, 94–98.
- MHB research fellow, Eötvös University, Hungary, 1992-94.

### EDUCATION:

- **Ph.D.** : May 9, 1997, Virginia Tech, in Physics. Thesis: “Analytic Results for Hopping Models with Excluded Volume Constraint”, advisor Royce K.P. Zia.
- **Diploma de Licență (MSc.)**: June 1992, Babeş-Bolyai University, Romania, in Physics.

## AWARDS AND HONORS:

- 1999 Special Merit Award for Outstanding Participation in the Materials Research Science and Engineering Center's Education Outreach Program, University of Maryland
- 1997 National Science Foundation and the Georgia Institute of Technology ICMP Travel Grant for the XIIth International Congress of Mathematical Physics, Brisbane, Australia
- 1996 C.H. Wan Scholarship for academic excellence in physics, Virginia Tech
- 1995 Bolyai College of Eötvös University, Supplementary Grant for Summer School and Workshop, Budapest, Hungary
- 1993 Niels Bohr Institute Supplementary Grant for Summer School, Humlabæk, Denmark
- 1992 Erdélyi Múzeum Egyesület and the Department of Education of Hungary Scholarship
- 1989 Special Prize, "Traian Lalescu" National Problem Solving Competition in Physics, Romania

## PROFESSIONAL ACTIVITIES:

- **Conference/Seminar organizer for:**
  - LANL-IMA workshop on *Agent based Modeling and Simulations*, November 3-6, 2003, Minnesota
  - CNLS 23rd Annual International Conference on *Networks: Structure, Dynamics, and Function*, May 12-16, 2003, Hotel La Fonda, Santa Fe, over 350 participants
  - Agent-based Modelling and Simulations Seminar series, February - November 2001, LANL, Los Alamos
  - International Workshop on *Chemical and Biological Activity in Flows*, Max-Planck Institute for Complex Systems, August 26 - September 27, 2002, Dresden, GERMANY
  - CNLS/TDO LANL Workshop on *Anomalous Distributions, Nonlinear Dynamical Systems, and Nonextensivity*, November 04-08, 2002, LANL, Los Alamos
  - CNLS-LANL International Workshop on *Active Chaotic Flow*, May 2001, Los Alamos, USA;
  - SIAM-DS01 Minisymposium on *Active Chaos in Environmental Flows*, May 2001, Snowbird, Utah, USA;
  - Dynamics Days, Fifteenth Annual Informal Workshop, June, 1994, Budapest, HUNGARY (over 300 participants)
- **Referee for:** Physics Today, Journal of Fluid Mechanics, Journal of Theoretical Biology, Physics of Fluids, Physical Review Letters, Physical Review, Physics Letters A, Surface Science, Chaos, and AIP Conference Proceedings, ANDM'97
- **Proposal reviewer for** National Science Foundation, NASA, and Los Alamos National Laboratory.

- **Editor for:** Lecture Notes in Physics Series, volume on *Complex Networks*, Eds. E. Ben-Naim, Z. Toroczkai and H. Frauenfelder, Springer-Verlag, 2004.
- **Guest Editor for:** CHAOS, Special Focus Issue on Active Chaotic Flow, June 2002.

## GRANTS:

- Principal Investigator, LANL LDRD-20040141DR, budget: \$4.5 Million, project title: *Statistical Physics of Infrastructure Networks*, duration: 3 years, Sept. 2003 - Sept. 2006, status: awarded.
- Co-Principal Investigator, NSF-INT99, US-Hungarian International Agreement Project, NSF Number: INT0000526, budget: \$49,470; project title: *Effects of tracer inertia in active chaotic flows*, duration: 3 years, 1999-2002, status: awarded, expired.

## Media appearances, interviews:

- Interviewed by Ian Austen of New York Times, interview published in New York Times, February 27, (2003): *With 6 Degrees of Separation, Computers Stay in Sync*, <http://www.nytimes.com/2003/02/27/technology/circuits/27next.html?ex=1047357089&ei=1&en=be1b5dd6ca6ef132>
- Interviewed by Mike Martin of Science Newsweek, interview published in Newsfactor, February 6, 2003: *Cascading Failures Could Crash the Global Internet*, <http://www.newsfactor.com/perl/story/20686.html>
- Nature Science Update Article published in Nature, 15 December, (2000): *Still waters run species out* by Phillip Ball, on the PNAS article [29].

## COMPLETE LIST OF PUBLICATIONS:

### Book:

*Complex Networks*, Lecture Notes in Physics, Springer-Verlag, Eds. E. Ben-Naim, H. Frauenfelder, Z. Toroczkai, summer (2004)

### Peer reviewed

51. Z. Toroczkai, K.E. Bassler. Network dynamics: Jamming is Limited in Scale-free Systems, *Nature*, **428** 716 (2004).
50. S. Eubank, H. Guclu, V.S.A. Kumar, M. Marathe, A. Srinivasan, Z. Toroczkai and N. Wang. Controlling Epidemics in Realistic Urban Social Networks. *Nature*, in press (2004).

49. T. Tél, T. Nishikawa, A.E. Motter, C. Grebogi, and Z. Toroczkai. Universality in active chaos. *Chaos*, **14**, 72 (2004); LA-UR-02-7579
48. M. Anghel, Z. Toroczkai, K.E. Bassler, G. Korniss. Competition-driven Network Dynamics: Emergence of a Scale-free Leadership Structure and Collective Efficiency. *Phys.Rev.Lett.*, **92** 058701 (2004) (2003). LA-UR-02-7580
47. I.J. Benczik, Z. Toroczkai and T. Tél. Advection of Finite-size Particles in Open Flows. *Phys.Rev.E* **67** 036303 (2003).
46. I. Scheuring, T. Czárán, P. Szabó, G. Károlyi, and Z. Toroczkai. Spatial models of prebiotic evolution: soup before pizza? *Origins of Life and Evolution of the Biosphere*, **33**, 319 (2003).
45. G. Korniss, M.A. Novotny, H. Guclu, Z. Toroczkai, P.A. Rikvold, Suppressing Roughness of Virtual Times in Parallel Discrete-Event Simulations. *Science*, **299**, 677 (2003); LA-UR-02-5811.
44. I.J. Benczik, Z. Toroczkai and T. Tél. Selective Sensitivity of Open Chaotic Flows on Inertial Tracer Advection: Catching Particles with a Stick. *Phys.Rev.Lett.* **89**, 164501 (2002); cover-page article; LA-UR-02-2364
43. I.Scheuring, G.Károlyi, Z. Toroczkai, T. Tél, and Á. Péntek. Competing populations in flows with chaotic mixing. *Theor.Pop.Biol.* **63**(#2), 77 (2003); LA-UR-01-4666.
42. J.M. Finn, J.D. Goette, Z. Toroczkai, M. Anghel and B.P. Wood. Estimation of Entropies and Dimensions by Nonlinear Symbolic Time Series Analysis. *Chaos*, **13**(# 2), 444 (2003); LA-UR-02-3386.
41. S. Das Sarma, P.P. Chatrathorn, Z. Toroczkai. Universality class of discrete solid-on-solid limited mobility nonequilibrium growth models for kinetic surface roughening. *Phys. Rev. E*, **65**, 0366144 (2002).
40. Z. Toroczkai, T. Tél. Introduction: Active Chaotic Flow. *Chaos*, **12**(#2), 372 (2002)
39. Z. Toroczkai. Topological classification of the Horton-Strahler index on binary trees, *Phys.Rev.E*, **65** 016130 (2002); LA-UR-01-5224.
38. G. Korniss, M.A. Novotny, P.A. Rikvold, H. Guclu and, Z. Toroczkai. Going Through Rough Times: from Non-equilibrium Surface Growth to Algorithmic Scalability. Materials Research Society Symposium Proceedings, Statistical Mechanical Modelling in Materials Research, Series **700**, 297 (2002); LA-UR-01-6631.
37. G. Santoboni, T. Nishikawa, Z. Toroczkai and C. Grebogi. Autocatalytic reactions of phase distributed active particles. *Chaos*, **12**(#2), 408 (2002); LA-UR-01-6099
36. M. Chertkov, I. Gabitov, P. Lushnikov, J. Moeser, and Z. Toroczkai. Pinning method of pulse confinement in optical fiber with random dispersion. *J.Opt.Soc.Am. B*, **19**, 2538 (2002); LA-UR-01-5307.

35. T. Nishikawa, Z. Toroczkai, C. Grebogi and T. Tél. Finite size effects on active chaotic advection, *Phys.Rev.E*, **65** 026216 (2002); LA-UR-00-0613.
34. P. Punyindu, Z. Toroczkai, S. Das Sarma. Epitaxial Mounding in Limited-Mobility Models of Surface Growth, *Phys.Rev.B*, **64**, 205407 (2001); LA-UR-00-0614.
33. Z. Toroczkai, G. Károlyi, Á. Péntek, T. Tél, and I. Scheuring. Autocatalytic Reactions in Systems with Hyperbolic Mixing: Exact Results for the Active Baker Map, *J.Phys.A: Math.Gen.* **34**, 5215 (2001); LA-UR-00-5814.
32. Z. Toroczkai, G. Korniss. Comment on “Extremal-Point densities of interface fluctuations in a quenched random medium”. *Phys.Rev.E*, **64** 048101 (2001); LA-UR-01-1332.
31. T. Nishikawa, Z. Toroczkai, and C. Grebogi. Advective coalescence in chaotic flows *Phys.Rev.Lett* **87** 038301 (2001); LA-UR-00-4319.
30. I. Miklós and Z. Toroczkai, An improved model for statistical alignment. *Lecture Notes In Computer Science* **2149**, pp. 1-10, (2001). LA-UR-01-3270. O.Gascuel, B.M. Moret (Eds.):**Algorithms in Bioinformatics** First International Workshop, WABI 2001, Aarhus, Denmark, Aug. 28-31, 2001.
29. G. Károlyi, Á. Péntek, I. Sheuring, T. Tél, and Z. Toroczkai. Chaotic flow: the physics of species coexistence, *Proc. Natl. Acad. Sci. USA*, **97** 13661 (2000) ; LA-UR-00-3602.
28. I. Sheuring, G. Károlyi, Á. Péntek, T. Tél, Z. Toroczkai. A model for resolving the plankton paradox: coexistence in open flows, *Freshwater Biology*, **45**, 123 (2000); LA-UR-00-4107.
27. Z. Toroczkai, G. Korniss, S. Das Sarma, and R. K. P. Zia. Extremal-Point densities of interface fluctuations, *Phys.Rev.E*, **62**, 276 (2000) .
26. G. Korniss, Z. Toroczkai, M.A. Novotny, and P.A. Rikvold. From massively parallel algorithms and fluctuating time horizons to non-equilibrium surface growth, *Phys.Rev.Lett.* **84** 1351 (2000).
25. S. Das Sarma, P. Punyindu, and Z.Toroczkai. Nonuniversal mound formation in nonequilibrium surface growth, *Surf. Sci. Letters*, **457**, L369, (2000).
24. T. Tél, G. Károlyi, Á. Péntek, I. Sheuring, Z. Toroczkai, C. Grebogi and J. Kadtké. Chaotic advection, diffusion, and reactions in open flows, *Chaos*, **10**, 89 (2000).
23. Z. Toroczkai, and E.D. Williams. Nanoscale fluctuations at solid surfaces, *Physics Today*, **52**, 24 (1999)
22. G. Károlyi, Á. Péntek, I. Sheuring, T. Tél, Z. Toroczkai, C. Grebogi, and J. Kadtké. Fractality, chaos, and reactions in imperfectly mixed open hydrodynamical flows, *Physica A* **274**, 120 (1999); Also to be published in a standalone book by Elsevier, *Applications of Statistical Physics*.

21. Z. Toroczkai, T. J. Newman and S. Das Sarma. Sign-time distributions for interface growth *Phys. Rev. E* **60**, R1115 (1999)
20. G. Károlyi, Á. Péntek, Z. Toroczkai, T. Tél, and C. Grebogi. Chemical or biological activity in open chaotic flows, *Phys. Rev. E* **59**, 5468 (1999)
19. T. J. Newman and Z. Toroczkai. Diffusive persistence and the "sign-time" distribution *Phys. Rev. E* **58**, R2685 (1998)
18. R.K.P. Zia and Z. Toroczkai. Random walk with a hop-over site: a novel approach to tagged diffusion and its applications, *J. Phys. A: Math.Gen.* **31**, 9667 (1998)
17. Z. Toroczkai, G. Károlyi, T. Tél, Á. Péntek, and C.Grebogi. Advection of active particles in open chaotic flows *Phys. Rev. Lett.* **80**, 500 (1998)
16. Z. Toroczkai, G. Korniss, B. Schmittmann, and R.K.P. Zia. Brownian-vacancy mediated disordering dynamics, *Europhys. Lett.* **40**, 281 (1997)
15. Z. Toroczkai. The Brownian vacancy driven walk, *Int. J. Mod. Phys. B* **11**, 3343 (1997)
14. Z. Toroczkai, and R.K.P. Zia. Periodic one-dimensional hopping model with one mobile directional impurity, *J. Stat. Phys.* **87**, 545 (1997)
13. Z. Toroczkai, G. Károlyi, Á. Péntek, T. Tél, C. Grebogi, and J.A. Yorke. Wada dye boundaries in open hydrodynamical flows, *Physica* **A239**, 235 (1997)
12. Á. Péntek, T. Tél, and Z. Toroczkai. Transient chaotic mixing in open hydrodynamical flows, *Int. J. Bif. Chaos.* **6**, 2619 (1996)
11. Á. Péntek, J.B. Kadtko, and Z. Toroczkai. Stabilizing chaotic vortex trajectories: an example of high dimensional control, *Phys. Lett.* **A224**, 85 (1996)
10. Z. Toroczkai, and R.K.P. Zia. A model for electrophoresis of polymers with impurities: exact distribution for a steady state, *Phys. Lett.* **A217**, 97 (1996)
9. B. Sass, and Z. Toroczkai. Continuous extension of the geometric control method, *J. Phys. A: Math.Gen.* **29**, 3545 (1996)
8. Á. Péntek, Z. Toroczkai, T. Tél, C. Grebogi, and J.A. Yorke Fractal boundaries in open hydrodynamical flows: signatures of chaotic saddles, *Phys. Rev. E* **51**, 4076 (1995)
7. Á. Péntek, T. Tél, and Z. Toroczkai. Chaotic advection in the velocity field of leapfrogging vortex pairs, *J. Phys. A: Math.Gen.* **28**, 2191 (1995)
6. Á. Péntek, T. Tél, and Z. Toroczkai. Fractal tracer patterns in open hydrodynamical flows: the case of leapfrogging vortex pairs, *Fractals* **3**, 33 (1995)

5. Z. Toroczkai. Geometric method for stabilizing unstable periodic orbits, *Phys. Lett.* **A190**, 71 (1994)
4. Á. Péntek, Z. Toroczkai, D.H. Mayer, and T. Tél. A generalized Kac model as a dynamical system, *Z. Naturforsch.* **49a**, 1212 (1994)
3. Z. Toroczkai and Á. Péntek. Detecting phase transitions in intermittent systems by using the thermodynamical formalism, *Z. Naturforsch.* **49a**, 1235 (1994)
2. Á. Péntek, Z. Toroczkai, D.H. Mayer, and T. Tél. Kac Model from a dynamical system's point of view, *Phys. Rev. E* **49**, 2026 (1994)
1. Z. Toroczkai and Á. Péntek. Classification criterion for dynamical systems in intermittent chaos, *Phys. Rev. E* **48**, 136 (1993)

#### Book chapters:

3. Z. Toroczkai, G. Korniss, M.A. Novotny and H. Guclu. Virtual Time-Horizon Control via Communication Network Design. In **Computational Complexity and Statistical Physics**, eds. A. Percus and G. Istrate, in press (Oxford University Press, 2003).
2. Z. Toroczkai, M. Anghel, G. Korniss, K.E. Bassler. Effects of Inter-agent Communications on the Collective. In: **Collectives and the Design of Complex Systems**, eds.: K. Tumer and D.H. Wolpert, (Springer, 2004, in press) LA-UR-03-0611.
1. G. Károlyi, Á. Péntek, T. Tél, and Z. Toroczkai. Chaotic tracer dynamics in open hydrodynamical flows, in **Nonlinear Dynamics, Chaotic and Complex Systems**, eds. E. Infeld, R. Zelazny, and A. Galkowski, (Cambridge University Press, Cambridge, 1997, pp. 24)

#### Proceedings:

3. G. Korniss, M.A. Novotny, Z. Toroczkai, and P.A. Rikvold. Non-equilibrium Surface Growth and Scalability of Parallel Algorithms for Large Asynchronous Systems, **Computer Simulation Studies in Condensed Matter Physics XIII**, eds. D.P. Landau, S.P. Lewis, and H.-B. Schuttler, **86** 183 (2001)
2. G. Károlyi, Á. Péntek, T. Tél, and Z. Toroczkai. Hydrodynamically driven chemical or biological activity in open flows, *Proceedings of the: British-Finnish-Hungarian Workshop on Refined Flow and Transport Modeling in Shallow Water Environment*, Budapest, Hungary, April, (1999).
1. Á. Péntek, J.B. Kadtko, and Z. Toroczkai. Controlling symmetric vortex configurations, *Proceedings of ANDM'97, AIP Conference*, No. 411, pp. 109 (American Institute of Physics Publishing, 1997)

### Other publications:

4. Á. Péntek, and Z. Toroczkai, Éltető káosz a planktonok világában, (in Hungarian), *Korunk, in press*
3. Z. Toroczkai. Analytic results for hopping models with excluded volume constraint, *Ph.D. Dissertation* Virginia Tech, 1997
2. Z. Toroczkai. Haosul intermittent. Tranziții de fază (in romanian), *Diploma Thesis* Babeş-Bolyai University, Cluj, Romania, 1992.
1. Z. Toroczkai. Asymptotic behavior of discrete dynamical systems in chaos, *Studia Universitatis Babeş-Bolyai, PHYSICA* 1, 73 (1990)

### PRESENTATIONS AT CONFERENCES AND INVITED TALKS:

- The University of Arizona, Tucson, AZ, March 2004 (invited colloquium)
- Conference on Growing Networks and Graphs in Statistical Physics, Finance, Biology and Social Systems, Midterm conference, COSIN, Rome, Italy, 1-5 September 2003, (invited speaker).
- Workshop on Collectives and the Design of Complex Systems August 25-28, 2003, Stanford University, Palo Alto, CA, USA (invited lecture)
- APS March Meeting, 2003, Austin, TX (lecture)
- Eötvös University Physics Department Colloquium, Budapest, Hungary, December 2002, (invited colloquium)
- NASA workshop on Collectives and the Design of Complex Systems, NASA, Ames, August 2002 (invited lecture)
- UCLA conference on Agent-based modeling in the social sciences, Lake Arrowhead, CA, May, 2002 (invited lecture)
- EGS XXVII assembly meeting, Nice, France, April 2002 (invited lecture)
- Northwestern University, Chemical Engineering Colloquium, February 2002



- Santa Fe Institute Workshop on Mathematical Foundations of Distributed Intelligence, Santa Fe, January 2002 (invited lecture)
- CNLS Statistical Physics Working Seminar Series, Fall, 2001 (3 lectures)
- Workshop on Computational complexity and Stat. Physics, Santa Fe, Sept. 2001 (invited lecture)
- P/T Colloquium, May 10, LANL, 2001 (invited colloquium)
- SIAM-DS01 Dynamical Systems meeting, Snowbird, Utah, 2001 (invited lecture)
- Eötvös University, Budapest, Hungary, 2000 (invited colloquium)
- Rensselaer Polytechnic Institute, Troy, NY, 2000 (invited colloquium)
- Duke University, CNLS-CNCS Workshop Durham, NC, 2000 (invited lecture)
- University of Virginia, Charlottesville, VA, 1999 (invited lecture)
- APS Centennial Meeting, Atlanta, GA, 1999 (lecture)
- University of Maryland at College Park, 1998 (2 lectures)
- Center for Nonlinear Studies, Los Alamos National Laboratory, 1998 (invited lecture)
- Rutgers University, New Jersey, 1995, 1996, 1998 (short talks)
- XIIth International Congress of Mathematical Physics, Brisbane, Australia, 1997 (invited lecture)
- Statistical Physics at the 45th Parallel, University of Rochester, NY, 1996 (lecture)
- CPIP'96, London, Ontario, Canada, 1996 (lecture)
- Virginia Tech, Blacksburg, VA, 1995 (2 lectures)
- The Statistical Description of Non-equilibrium Steady States, Eötvös University, Budapest, Hungary, 1995 (lecture)
- Dynamics Days, Fifteenth Annual Informal Workshop, Budapest, Hungary, 1994 (poster)
- Dynamics Days, Fourteenth Annual Informal Workshop, Poznań, Poland, 1993 (2 posters)
- Workshop on Complex Systems: Turbulence, Chaos, Neural Networks, Humlabæk, Denmark, 1993 (lecture)

## REFERENCES:

Available upon request.