

Christoph Börgers

April 2018

Employment

1994–present *Tufts University* (Professor of Mathematics since 1997; Chair of Mathematics 2001–2004; associated faculty, Cognitive Science Ph. D. Program, since 2011)

1987–1996 Department of Mathematics, *University of Michigan* (Assistant Professor 1987–1991, Associate Professor 1991–1996, on leave fall 1989 and 1994–1996)

May–December 1989 Department of Mathematical Sciences, *IBM T. J. Watson Research Center*, Visiting Scientist

1985–1987 Lawrence Berkeley Laboratory and Department of Mathematics, *University of California at Berkeley*, Postdoctoral Researcher (Advisor: Alexandre Chorin) and Visiting Lecturer

Education

1982–1985 *Courant Institute of Mathematical Sciences*, New York University, Ph. D. in Mathematics 1985 (Advisor: Charles S. Peskin)

1976–1982 *University of Bonn* (Germany), Diplom in Mathematics 1982 (Advisor: Ulrich Trottenberg)

Publications

Refereed articles:

- 1) C. Börgers and C. Greengard, Slow convergence in generalized central limit theorems, *Comptes Rendu Mathematiques*, to appear (2018). preprint at arXiv
- 2) C. Börgers, R. Melody Takeuchi, and D. Rosebrock, On rhythms in neuronal networks with recurrent excitation, *Neural Computation* 30, no. 2, pp. 333–377, (2018).

- 3) A. Singer, G. Talei Franzesi, S. Kodandaramaiah, F. Flores, J. Cohen, A. Lee, C. Börgers, C. Forest, N. Kopell, and E. Boyden, Mesoscale-duration activated states gate spiking in response to fast rises in membrane voltage in the awake brain, *J. Neurophysiol.*, jn.00116.2017. PMID [28566460](#) DOI: [10.1152/jn.00116.2017](#) (2017)
- 4) M. Carus-Cadavieco, M. Gorbati, L. Ye, F. Bender, S. van der Veldt, C. Kosse, C. Börgers, S. Y. Lee, C. Ramarishnan, Y. Hu, N. Denisova, F. Ramm, E. Volitaki, D. Burdakov, K. Deisseroth, A. Ponomarenko, and T. Korotkova, Gamma oscillations organize top-down signaling to hypothalamus and enable food seeking, *Nature* 542, 232—236 (2017).
- 5) C. Börgers, J. Li, and N. Kopell, Approximate, not perfect synchrony maximizes the downstream effectiveness of excitatory neuronal ensembles, *J. Math. Neurosci.* 4:10, DOI [10.1186/2190-8567-4-10](#) (2014)
- 6) J. Cannon, M. McCarthy, S. Lee, J. Lee, C. Börgers, M. A. Whittington, and N. Kopell, Rhythms and multiple modes of cognitive processing, *Eur. J. Neurosci.*, doi:[10.1111/ejn.12453](#) (2013)
- 7) T. Dugladze, N. Maziashvili, C. Börgers, S. Gurgenedze, U. Häussler, A. Winkelmann, C. A. Haas, J. C. Meier, I. Vida, N. Kopell, and T. Gloveli, GABA_B autoreceptor-mediated cell-type specific reduction of inhibition in epileptic mice, *Proc. Natl. Acad. Sci. USA* 110, No. 37, 15073—15078 (2013)
- 8) S. Friedhoff, S. MacLachlan, and C. Börgers, Local Fourier analysis of space-time relaxation and multigrid schemes, *SIAM J. Sci. Comp.* 35, No. 5, S250—S276 (2013)
- 9) C. Börgers and A. Nectow, Exponential time differencing for Hodgkin-Huxley-like ODEs, *SIAM J. Sci. Comp.* 35, No. 3, B623—B643 (2013)
- 10) C. Börgers and B. Walker, Toggling between gamma-frequency activity and suppression of cell assemblies, *Frontiers Comp. Neurosci.*, doi: [10.3389/fncom.2013.00033](#) (2013)
- 11) C. Börgers, G. Talei Franzesi, F. LeBeau, E. Boyden, and N. Kopell, Minimal size of cell assemblies coordinated by gamma oscillations, *PLOS Computational Biology* 8(2): e1002362 (2012)
- 12) C. Börgers and S. MacLachlan, An angular multigrid method for computing mono-energetic particle beams in Flatland, *Journal of Computational Physics* 229, Issue 8, 2914—2931 (2010)
- 13) E. Munro and C. Börgers, Mechanisms of very fast oscillations in networks of axons coupled by gap junctions, *Journal of Computational Neuroscience* 28, No. 3, 539—555 (2010)

- 14) C. Börgers, M. Krupa, and S. Gielen, The response of a population of classical Hodgkin-Huxley neurons to an inhibitory input pulse, *Journal of Computational Neuroscience* 28, No. 3, 509—526 (2010)
- 15) C. Börgers, S. Epstein, and N. Kopell, Gamma oscillations mediate stimulus competition and attentional selection in a cortical network model, *Proceedings of the National Academy of Sciences, USA* 105, No. 46, 18023-18028 (2008)
- 16) C. Börgers and N. Kopell, Gamma oscillations and stimulus selection, *Neural Computation* 20, 383–414 (2008)
- 17) E. Munro and C. Börgers, The axonal plexus: a description of the behavior of a network of neurons connected by gap junctions, Abstract, *BMC Neuroscience* 8 (Suppl. 2), 47 (2007)
- 18) C. Börgers, S. Epstein, and N. Kopell, Background gamma rhythmicity and attention in cortical local circuits: A computational study, *Proceedings of the National Academy of Sciences, USA* 102, No. 19, 7002–7007 (2005)
- 19) C. Börgers and N. Kopell, Effects of noise on rhythms in networks of excitatory and inhibitory neurons, *Neural Computation* 17, 557-608 (2005)
- 20) C. Börgers and N. Kopell, Synchronization in networks of excitatory and inhibitory neurons with sparse, random connectivity, *Neural Computation* 15, vol. 3, 509–539 (2003)
- 21) C. Börgers and E. T. Quinto, On the non-uniqueness of optimal radiation treatment plans, *Inverse Problems* 15, 1115–1138 (1999)
- 22) C. Börgers, Complexity of Monte Carlo and deterministic dose-calculation methods, *Phys. Med. Biol.* 43, 517–528 (1998).
- 23) C. Börgers, A fast iterative method for computing particle beams penetrating matter, *J. Comp. Phys.* 133, 323–339 (1997).
- 24) C. Börgers and E. W. Larsen, On the accuracy of the Fokker-Planck and Fermi pencil beam equations for charged particle transport, *Med. Phys.* 23, No. 10, 1–11 (1996)
- 25) C. Börgers and E. W. Larsen, Asymptotic derivation of the Fermi pencil beam equation, *Nucl. Sci. Eng.* 123, No. 3, 343–358 (1996)
- 26) C. Börgers and E. W. Larsen, The transversely integrated scalar flux of a narrowly focused particle beam, *SIAM J. Appl. Math* 55, 1–22 (1995)

- 27) C. Börgers and E. W. Larsen, The Fermi pencil beam approximation, in *Proceedings of International Conference on Mathematics and Computations, Reactor Physics, and Environmental Analysis*, Portland, Oregon, April 30 - May 4, 1995
- 28) C. Börgers and E. W. Larsen, Fokker-Planck approximation of monoenergetic transport processes, *Trans. Am. Nucl. Soc.* 71, 235–236 (1994)
- 29) C. Börgers and E. Thomann, Free molecular flow in thin domains, in “Proceedings of the Eighteenth International Symposium on Rarefied Gas Dynamics”, *Progress in Astronautics and Aeronautics* 160, 523–531 (1994)
- 30) C. Börgers, C. Greengard, and E. Thomann, The diffusion limit of free molecular flow in thin plane channels, *SIAM J. Appl. Math.* 52, No. 4, 1057–1075 (1992)
- 31) C. Börgers, E. W. Larsen, and M. L. Adams, The asymptotic diffusion limit of a linear discontinuous discretization of a two-dimensional linear transport equation, *J. Comp. Phys.* 98, No. 2, 285–300 (1992)
- 32) C. Börgers, Generalized Delaunay triangulations of non-convex domains, *Computers Math. Appl.* 20, No. 7, 45–49 (1990)
- 33) C. Börgers, Domain imbedding methods for the Stokes equations, *Numer. Math.* 57, 435–451 (1990)
- 34) C. Börgers, A triangulation algorithm for fast elliptic solvers based on domain imbedding, *SIAM J. Numer. Anal.* 27, No. 5, 1187–1196 (1990)
- 35) C. Börgers and O. B. Widlund, On finite element domain imbedding methods, *SIAM J. Numer. Anal.* 27, No. 4, 963–978 (1990)
- 36) C. Börgers, On the numerical solution of the regularized Birkhoff equations, *Math. Comp.* 53, No. 187, 141–156 (1989)
- 37) C. Börgers, The Neumann-Dirichlet domain decomposition method with inexact solvers on the subdomains, *Numer. Math.* 55, 123–136 (1989)
- 38) C. Börgers and O. B. Widlund, A domain decomposition Laplace solver for internal combustion engine modeling, *SIAM J. Sci. Stat. Comp.* 10, No. 2, 211–226 (1989)
- 39) C. Börgers and C. S. Peskin, A Lagrangian fractional step method for the incompressible Navier-Stokes equations on a periodic domain, *J. Comp. Phys.* 70, No. 2, 397–438 (1987)
- 40) C. Börgers and C. S. Peskin, A Lagrangian method based on the Voronoi diagram for the incompressible Navier-Stokes equations on a periodic domain, in “The Free

Lagrange Method”, *Lecture Notes in Physics* 238, M. J. Fritts, W. P. Crowley, and H. Trease (eds.), 87–113, Springer-Verlag (1985)

Book chapters:

- 1) N. Kopell, C. Börgers, D. Pervouchine, P. Malerba, and A. B. L. Tort, Gamma and theta rhythms in biophysical models of hippocampal circuits, to appear in “Hippocampal Microcircuits: A Computational Modeler’s Resource Book” (V. Cutsuridis, B. Graham, S. Cobb, and I. Vida, eds.), Springer-Verlag (2010).
- 2) C. Börgers, The radiation therapy planning problem, in “Computational Radiology and Imaging: Therapy and Diagnostics”, *IMA Volumes in Mathematics and its Applications* **110**, C. Börgers and F. Natterer (eds.), 1–15 (1999)

Books authored:

C. Börgers, “Mathematics of Social Choice: Voting, Compensation, and Division,” *Society for Industrial and Applied Mathematics (SIAM)*, 2009.

C. Börgers, “An Introduction to Modeling Neuronal Dynamics,” *Springer* 2017.

Book edited:

C. Börgers and F. Natterer (eds.), “Computational Radiology and Imaging: Therapy and Diagnostics”, *IMA Volumes in Mathematics and its Applications* **110**, Springer-Verlag (1999)

Conference and seminar presentations since 2005

Why instant runoff voting is almost as undemocratic as plurality voting, and what we might do instead, *Southwestern Undergraduate Mathematics Research Conference (SUnMaRC)*, April 2018
[invited talk]

Functional roles of neuronal synchrony, *Department of Physics, Biophysics Group, University of Michigan*, Ann Arbor, April 2018

Rhythms in neuronal networks with recurrent excitation, *Department of Mathematics, University of Michigan*, Ann Arbor, April 2018

Rhythms in neuronal networks with recurrent excitation, *Department of Mathematics, University of Massachusetts at Boston*, March 2018

What is entropy, and why? *Tufts Undergraduate Mathematics Society*, February 2018

Rhythms in neuronal networks with recurrent excitation, *Department of Mathematics, University of Massachusetts at Amherst*, November 2017

Some thoughts on the effects of neuronal synchronization, *Computational Neuroscience 2017*, workshop on oscillations in neuronal systems, Antwerp, Belgium, July 2017 [invited talk]

Effects of recurrent excitation in neuronal network models, poster at Joint Mathematics Meetings 2017, Atlanta, GA (with R. Melody Takeuchi)
[presented by Melody Takeuchi]

Recurrent excitation in rhythmic E-I networks, COSYNE workshops 2017, Snowbird, Utah, February 2017 [invited talk]

Recurrent excitation in reduced neuronal network models (with R. Melody Takeuchi and Daniel Rosebrock), SIAM National Meeting, Boston minisymposium in honor of Charles S. Peskin's 70th birthday, July 2016
[invited talk]

Abrupt transitions from low to high firing frequencies in neurons and neuronal networks, poster at Biology and Medicine through Medicine, Virginia Commonwealth University, May 2016 (with R. Melody Takeuchi)
[presented by Melody Takeuchi]

Oscillatory modulation of action potential firing in hippocampal neurons of awake mice via periodic shunting inhibition, poster at the annual meeting of the Society for Neuroscience, Chicago, October 2015 (with Giovanni Talei-

Franzesi, Annabelle Singer, Suhasa B. Kodandaramaiah, Ian R. Wickersham, Melina Tsitsiklis, Denis Bozic, Sunanda Sharma, Sean Batir, Nikita Pak, Greg Holst, Dmitriy Aronov, David Tank, Nancy Kopell, and Edward S. Boyden) [presented by Annabelle Singer]

Mathematics in Neuroscience, *Tufts University Open House*, October 2015

Gamma-rhythmic signaling between medial prefrontal cortex and lateral septum in behaving mice, poster at CRCNS Program Principal Investigators' Meeting, *Arizona State University*, October 2014 (with Tatiana Korotkova, Natalia Denisova, Alexey Ponomarenko, and Nancy Kopell) [presented by Tatiana Korotkova]

Gamma-rhythmic signaling between medial prefrontal cortex and lateral septum in behaving mice, *Workshop on oscillations in the central nervous system, Computational Neuroscience Annual Meeting, Quebec City*, July 2014 [invited talk]

Is synchrony really good for excitatory neuronal transmission?, *Leibniz Institute for Molecular Pharmacology, Charité, Berlin*, June 2014 [invited talk]

Why neuronal synchrony may not be such a good thing after all, *Carnegie-Mellon University*, May 2014 [invited talk]

What is computational neuroscience, and is it good for anything? *Department of Mathematics, Tufts University*, October 2013

What is computational neuroscience, and is it good for anything? *Department of Mathematics, Dartmouth College*, October 2013 [invited talk]

Toggling between gamma-frequency activity and suppression of cell assemblies, and the type of the fast-spiking inhibitory cells, *Institut National de Recherche en Informatique et Automatique (INRIA), Paris, France*, June 2013 [invited talk]

Modulation of neuronal networks by tonic inhibition, *Workshop on Slow-Fast Dynamics, CRM, Barcelona, Spain*, June 2013 [invited talk]

Toggling between gamma-frequency activity and suppression of cell assemblies, and the type of the fast-spiking inhibitory cells, *Workshop on Rhythms and Oscillations, Mathematical Biosciences Institute, Ohio State University*, March 2013 [invited talk]

Toggling between gamma-frequency activity and suppression in neuronal

networks, *Computational Neuroscience Seminar, Boston University*,
November 2012

GABA_A receptor regulation of pyramidal cells in awake cortex, and a derived neurophysiologically realistic model, poster at the annual meeting of the Society for Neuroscience, New Orleans, October 2012 (with Junchol Park, Jie Li, Corina Bondi, Nancy Kopell, and Bitá Moghaddam) [presented by Junchol Park]

Exponential time differencing for neuronal network simulations, poster at the SIAM National Meeting, Minneapolis, July 2012 (with A. Netcow)

Gamma rhythms, theta rhythms, and baths of inhibition, CRCNS Program Principal Investigators' Meeting, *Washington University*, June 2012 (with Jie Li, Junchol Park, Corina Bondi, Bitá Moghaddam, and Nancy Kopell) [presented by Jie Li]

On the size of cell assemblies and the loss of gamma rhythms, poster at the annual retreat of the Boston-area Cognitive Rhythms Collaborative (CRC), April 2012 (with G. Franzesi, E. Boyden, and N. Kopell)

Brain rhythms and mathematics, *Tufts University, Jumbo Days*, April 2012

On the size of cell assemblies and the loss of gamma rhythms, poster at the annual meeting of the Society for Neuroscience, Washington, D.C., November 2011 (with G. Franzesi, E. Boyden, and N. Kopell) [presented by G. Franzesi]

On the size of cell assemblies and the loss of gamma rhythms, poster at CRCNS Program Principal Investigators' Meeting, *Princeton University*, October 2011 (with G. Franzesi, E. Boyden, and N. Kopell)

Mathematics of social choice, *Tufts University* (Osher Institute for Lifelong Learning), October 2011

Loss of gamma rhythms in networks of excitatory and inhibitory neurons, *Harvard Medical School, VA Boston Healthcare System, Seminar of the Laboratory of Neuroscience*, September 2011 [invited talk]

Angular multigrid methods for model transport problems with strongly forward-peaked scattering, *International Congress for Industrial and Applied Mathematics*, Vancouver, July 2011 [invited talk in a minisymposium]

Minimal size of cell assemblies coordinated by gamma oscillations, *Computational Neuroscience Seminar, Ecole Normale Supérieure, Paris, France*, June 2011 [invited talk]

Brain rhythms and mathematics, *Tufts University, April Open House*, April 2011

Mathematics of social choice, Tufts University, Tisch Library *Author Talk*, February 2011

Gamma rhythms with stochastic drive, *Joint Mathematics Meetings 2011*, New Orleans, January 2011 [invited talk in a minisymposium]

Breakdown of gamma oscillations as the number of driven cells becomes too small, *Computational Neuroscience Seminar, Center for Biodynamics, Boston University*, October 2010

Dynamical properties of gamma-frequency cell assemblies in the hippocampus probed with optical neural control and computational modeling, poster at CRCNS Program Principal Investigators' Meeting, Johns Hopkins University, June 2010 (with G. Franzesi, A. Tort, X. Qian, M. Li, X. Han, N. Kopell, F. Lebeau, M. Whittington, and E. Boyden)

Deterministic radiation dose calculations, *Radiation Physics Seminar, Massachusetts General Hospital*, Boston, May 2010 [invited talk]

Brain rhythms and mathematics, *Tufts University, April Open House*, April 2010

Brain rhythms and mathematics, *Tufts University, CSEMS (Computer Science, Engineering, and Mathematics Scholars) program for minority and first generation college students*, March 2010

Dynamical properties of gamma-frequency cell assemblies in the hippocampus probed with optical neural control and computational modeling, contributed poster at meeting of Society for Neuroscience, October 2009 (with G. Franzesi, X. Qian, M. Li, X. Han, N. Kopell, F. Lebeau, M. Whittington, and E. Boyden) [presented by Nancy Kopell]

An angular multigrid method for monoenergetic particle transport with anisotropic scattering in Flatland, *Workshop on Multigrid Methods for Transport Problems*, Boulder, Colorado, October 2009 [invited talk]

Modeling possible roles of gamma oscillations in attention, *Gabriel Kreiman's Lab Meeting, Harvard Medical School, Boston*, September 2009 [invited talk]

Synchronization of type II neurons by inhibitory pulses, *Workshop on Brain Waves, Lorenz Center, University of Leiden, Netherlands*, June 2009 [invited talk]

The response of a classical Hodgkin-Huxley neuron to a pulse of inhibition, *Sixth Annual Conference on Frontiers in Applied and Computational Mathematics, NJIT*, June 2009 [invited talk in a minisymposium]

Protection of Neuronal Signaling Against Distractors Through Gamma-Frequency Coherence, *SIAM Conference on Applications of Dynamical Systems*, Snowbird, Utah, May 2009 [invited talk in a minisymposium]

The response of a classical Hodgkin-Huxley neuron to a pulse of inhibition, *Computational Neuroscience Seminar, Center for Biodynamics, Boston University*, April 2009

Brain rhythms and mathematics, *Tufts University, April Open House*, April 2009

Probing mechanisms of gamma rhythmogenesis with cell type-specific optical neural control, contributed poster at COSYNE meeting, April 2009 (with G. T. Franzesi, X. Qian, M. Li, X. Han, N. Kopell, F. LeBeau, M. Whittington, and E. Boyden) [presented by Giovanni Franzesi]

Stimulus competition via transition from synchrony to asynchrony, *SIAM Meeting on Life Sciences*, Montreal, August 2008 [invited talk in a minisymposium]

Cortical rhythms, *Institute for Mathematics and its Applications, University of Minneapolis, Workshop on Mathematical Neuroscience*, Minnesota, June 2008 [two invited lectures]

Gamma oscillations and attention, *Colloquium talk in the Department of Electrical Engineering, Mathematics, and Computer Science, Universiteit Twente*, Enschede, Netherlands, November 2007 [invited talk]

Some thoughts on deterministic dose calculation, *Radiation Physics Seminar, Massachusetts General Hospital*, Boston, July 2007 [invited talk]

Gamma oscillations and attention, *Workshop on Mathematical Neuroscience, University of British Columbia*, Vancouver, Canada, June 2007 [invited talk]

Gamma oscillations and attention, *SIAM Conference on Applications of Dynamical Systems*, Snowbird, Utah, May 2007 [invited talk in a minisymposium]

Gamma oscillations and attention, *Applied mathematics seminar, Department of Mathematics, University of Michigan*, Ann Arbor, Michigan, October 2006 [invited talk]

Gamma oscillations and attention, *Conference in honor of the 60th birthday of Charles S. Peskin, Courant Institute, New York University, New York*, October 2006 [invited talk]

Reduced models of networks of electrically coupled neurons, *SIAM Meeting on Life Sciences*, Raleigh, North Carolina, July 2006 [contributed talk]

The role of neuronal coherence in attentional processing, *SIAM National Meeting*, Boston, July 2005 [contributed talk]

Background gamma rhythmicity and attention in a local cortical circuit model, *Computational Neuroscience Meeting*, Madison, Wisconsin, July 2005 [contributed poster presentation]

Persistent gamma oscillations and their possible role in attention, *SIAM Conference on Applications of Dynamical Systems*, Snowbird, Utah, May 2005 [invited talk in a minisymposium]

Computational modeling of gamma oscillations in the brain, *Colloquium, Mathematics Department, University of Hong Kong*, March 2005 [invited talk]

External grants

NIH (CRCNS program), “Interneurons mediating neocortical gamma rhythms and cell assemblies” (PIs: Nancy Kopell, Ed Boyden, Christoph Börgers; institutions: Boston University, MIT, Tufts University), approximately \$95,000 per year over a five-year period to Tufts, 9/1/2009 through 8/31/2015

NSF (Division of Mathematical Sciences, Computational Mathematics program): “Fast Multigrid Solvers for Forward-Peaked Transport” (PI: Scott MacLachlan, co-PI: Christoph Börgers), \$280,000, 9/1/2010 through 8/31/2015

NSF grant DMS-0418832, “Modeling and analysis of persistent gamma rhythms and their role in sustained attention” (PI: Christoph Börgers; institution: Tufts University), 8/1/2004 through 7/31/2008, \$205,000

NSF grant DMS-9626696, “Numerical analysis problems in radiotherapy planning” (PI: Christoph Börgers; institution: Tufts University), 8/15/1996 through 7/31/2000, \$60,000

NSF grant DMS-9204271, “Scientific computation of physical problems” (PIs: Robert Krasny, Eduard Harabetian, Christoph Börgers; institution: University of Michigan), 7/15/1992 through 6/30/1996, \$310,000

NSF grant DMS-9003965, “Scientific computation of physical problems” (PIs: Robert Krasny, Eduard Harabetian, Christoph Börgers; institution: University of Michigan), 7/1/1990 through 6/30/1993, \$210,000

NSF grant DMS-8801991, “Computational and analytic problems in fluid mechanics” (PIs: Robert Krasny, Eduard Harabetian, Christoph Börgers; institution: University of Michigan), 6/15/1988 through 6/30/1990, \$146,600

Internal grants (Tufts University)

The Summer Scholars program provided a stipend for research student Jay Stotsky and \$1,000 in research funds in the summer of 2012.

The Summer Scholars program provided a stipend for research student Bryan Walker and \$1,000 in research funds in the summer of 2011.

Senior Faculty Research Semester Fellowship, fall 2010.

The Summer Scholars program provided a stipend for research student Edward O’Brien and \$1,000 in research funds in the summer of 2009.

Faculty Research Awards Committee, \$1,164.89 for travel to Nijmegen to start collaboration with Stan Gielen and Martin Krupa, June 2008.

Marshall Fund for Biomedical Research, \$2,699 for a laptop, October 2001.

Membership in professional societies

Society for Industrial and Applied Mathematics (SIAM)
(life membership)
Mathematical Association of America (MAA)