# Carina Curto · Curriculum Vitae

Department of Mathematics
The Pennsylvania State University
331 McAllister Building
University Park, State College, PA 16802

tel: (814) 863 9119
email: ccurto@psu.edu
website: http://www.personal.psu.edu/cpc16/
CV last updated: December 27, 2015

**Research Interests**
· Mathematics applied to and arising from theoretical and computational neuroscience.
· Neural coding and neural networks: theory and data analysis.
· Applied algebra, geometry, and topology.

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## Education & Employment

**Academic Positions**

**The Pennsylvania State University (PSU)** — State College, PA
Associate Professor of Mathematics — Aug 2014–
Member of the Center for Neural Engineering

**University of Nebraska-Lincoln (UNL)** — Lincoln, NE
Assistant Professor of Mathematics — Aug 2009–Aug 2014

**Courant Institute, New York University (NYU)** — New York, NY
Courant Instructor (Mathematics) — Sep 2008–Aug 2009

**Rutgers, The State University of New Jersey** — Newark, NJ
Center for Molecular and Behavioral Neuroscience — May 2005–Aug 2008
Postdoctoral Associate (Neuroscience)

**Education**

**Duke University** — Durham, NC
Ph.D. in Mathematics (Algebraic Geometry & String Theory) — Aug 2000–May 2005
Advisor: Prof. David R. Morrison

**Harvard University** — Cambridge, MA
A.B. in Physics (Cum Laude) — Sep 1996–Jun 2000

**Iowa City West High School** — Iowa City, IA
Valedictorian (4.0 GPA) — Aug 1992–Jun 1996

**Additional Education**

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|---|---|
| MBL Neuroinformatics Course, Woods Hole, MA | Aug 2006 |
| IAS Prospects in Theoretical Physics (String Theory), Princeton, NJ | Jun 2002 |
| IAS Women's Program in Symplectic Geometry, Princeton, NJ | May 2002 |
| IAS Park City Math Institute, Park City, Utah | Jul 2001 |
| IAS Women's Program in Mathematical Physics, Princeton, NJ | May 2001 |
| Budapest Semesters in Mathematics, Hungary | Spring 1999 |
| University of Iowa Summer French Program in Lyon, France | Summer 1996 |
| University of Iowa coursework (as a high school student, 15 courses) | 1993-1996 |

## Grants & Awards

**Research Funding**

NSF DMS-1516881 (single PI; $150,000) 2015-18
– *Theory of threshold-linear networks and combinatorial neural codes*
Sub-award from NIH R01-EY010542-19 ($33,000) 2014-15
– *Regulation of photoreceptor neurotransmission (PI: Wallace Thoreson)*
NSF DMS-1225666/DMS-1537228 (single PI; $164,999; transfer to PSU) 2012-16
– *Memory encoding in spatially structured networks: dynamics, discrete geometry & topology*
Janelia Visitor Program (co-PI with E. Pastalkova & V. Itskov; $61,976) 2013-15
– *Development of a mathematical tool for rigorous analysis of neural activity sequences*
– *Funded by the HHMI, to support a collaboration at Janelia Research Campus.*
Alfred P. Sloan Research Fellowship ($50,000; 2-year no-cost extension) 2011-15
Career Enhancement Fellowship for Junior Faculty ($31,500) 2012-13
– *Woodrow Wilson National Fellowship Foundation & Andrew W. Mellon Foundation*
Nebraska EPSCoR First Award ($20,000) 2012-13
NSF DMS-0920845 (single PI; $109,635; 1-year no-cost extension) 2009-13
– *Stimulus representation and spontaneous activity in recurrent networks*

**Other Funding & Awards**

Statistical and Applied Mathematical Sciences Institute (SAMSI) Spring 2016
– *Year-long program on Challenges in Computational Neuroscience, long-term visitor*
Institute for Mathematics and its Applications (IMA), long-term visitor Spring 2014
– *Year-long program: Scientific and Engineering Applications of Algebraic Topology*
AMS Travel Award (Mathematical Congress of the Americas in Guanajuato) 2013
Named a UNL "Academic Star" 2012
UNL Visiting Scholars Grant (to support visitors) 2010, 2012
NSF S-STEM-1060322 (co-PI; $599,996; education grant) 2011-16
UNL Research Council Interdisciplinary Grant (co-PI; $5,000) 2010
NSF VIGRE Graduate Fellowship (1 year of full funding) 2004–05
NSF Graduate Research Fellowship (3 years of full funding) 2000–04
Duke Endowment Fellowship, Duke University 2001–04
James B. Duke Fellowship, Duke University 2000–03
University Scholars Program Fellowship, Duke University 2000–01
Mellon Mays Undergraduate Fellowship, Harvard University 1997–2000
American Physical Society Scholarship 1996–98
Detur Prize, Harvard University 1997
Varsity Letter Winner, Harvard Women's Tennis 1996-97

## Publications (for peer-reviewed journals only)

**Preprints/ Submitted**

21. **C. Curto**. What can topology tells us about the neural code? *Preprint available.*

20. **C. Curto**, N. Youngs. Neural ring homomorphisms and maps between neural codes. *Preprint available at arXiv.org.*

19. **C. Curto**, K. Morrison. Pattern completion in symmetric threshold-linear networks. *Submitted. Preprint available at arXiv.org.*

18. **C. Curto**, E. Gross, J. Jeffries, K. Morrison, M. Omar, Z. Rosen, A. Shiu, N. Youngs. What makes a neural code convex? *Submitted. Preprint available at arXiv.org.*

**Published/ Accepted**

17. W.B. Thoreson, M.J. Van Hook, C. Parmelee, **C. Curto**. Modeling and measurement of vesicle pools at the cone ribbon synapse: changes in release probability are solely responsible for voltage-dependent changes in release. **Synapse**, 70:1-14, 2016.

16. C. Giusti, E. Pastalkova, **C. Curto**$^{\dagger}$, V. Itskov$^{\dagger}$ ($^{\dagger}$*equal last authors*). Clique topology reveals intrinsic geometric structure in neural correlations. **PNAS**, 2015.

15. M.J. Van Hook, C. Parmelee, M. Chen, K.M. Cork, **C. Curto**, W.B. Thoreson. Calmodulin enhances ribbon replenishment and shapes filtering of synaptic transmission by cone photoreceptors. **Journal of General Physiology**, 144:357-378, 2014.

14. **C. Curto**, A. Degeratu, V. Itskov. Encoding binary neural codes in networks of threshold-linear neurons. **Neural Computation**, Vol 25, pp. 2858-2903, 2013.

13. **C. Curto**, V. Itskov, A. Veliz-Cuba, N. Youngs. The neural ring: an algebraic tool for analyzing the intrinsic structure of neural codes. **Bulletin of Mathematical Biology**, Volume 75, Issue 9, pp. 1571-1611, 2013.

12. **C. Curto**, V. Itskov, K. Morrison, Z. Roth, J.L. Walker. Combinatorial neural codes from a mathematical coding theory perspective. **Neural Computation**, Vol 25(7), pp. 1891-1925, 2013.

11. **C. Curto**, D.R. Morrison. Threefold flops via matrix factorization. **Journal of Algebraic Geometry**, Vol 22(4), pp. 599-627, 2013.

10. **C. Curto**, A. Degeratu, V. Itskov. Flexible memory networks. **Bulletin of Mathematical Biology**, Vol 74(3):590-614, 2012.

9. V. Itskov$^{*}$, **C. Curto**$^{*}$, E. Pastalkova, G. Buzsaki (*$^{*}$*equal contribution*). Cell assembly sequences arising from spike threshold adaptation keep track of time in the hippocampus. **Journal of Neuroscience**, Vol. 31(8):2828-2834, 2011.

8. K.D. Harris, P. Bartho, P. Chadderton, **C. Curto**, J. de la Rocha, L. Hollender, V. Itskov, A. Luczak, S. Marguet, A. Renart, S. Sakata. How do neurons work together? Lessons from auditory cortex. **Hearing Research**, Vol. 271(1-2), pp. 37-53, 2011.

7. P. Bartho, **C. Curto**, A. Luczak, S. Marguet, K.D. Harris. Population coding of tone stimuli in auditory cortex: dynamic rate vector analysis. **European Journal of Neuroscience**, Vol. 30(9), pp. 1767-1778, 2009.

6. **C. Curto**, S. Sakata, S. Marguet, V. Itskov, K.D. Harris. A simple model of cortical dynamics explains variability and state dependence of sensory responses in urethane-anesthetized auditory cortex. **Journal of Neuroscience**, Vol. 29(34):10600-10612, 2009.

5. **C. Curto**$^{*}$, V. Itskov$^{*}$ ($^{*}$*equal contribution*). Cell groups reveal structure of stimulus space. **PLoS Computational Biology**, Vol. 4(10): e1000205, 2008.

4. V. Itskov, **C. Curto**, K.D. Harris. Valuations for spike train prediction. **Neural Computation**, Vol. 20(3), pp. 644-667, 2008.

3. **C. Curto**. Matrix model superpotentials and ADE singularities. **Advances in Theoretical and Mathematical Physics**, Vol. 12 (2), pp. 357-409, 2008.

2. C. A. Kletzing, J. D. Scudder, E. E. Dors, and **C. Curto**. The auroral source region: plasma properties of the high altitude plasma sheet. **Journal of Geophysical Research**, 108(A10), 1360, 2003.

1. **C. Curto**, S. J. Gates, V. G. J. Rodgers, Superspace geometrical realization of the N-extended super Virasoro algebra and its dual. **Physics Letters B** 480, pp. 337-347, 2000.

**Ph.D. Thesis**

0. **C. Curto**. Matrix Model Superpotentials and Calabi-Yau Spaces: an ADE Classification. Duke University Ph.D. Thesis, 2005. (arxiv.org/math.AG/0505111)
*This work resulted in two publications: #3 and #11 above.*

## Research Presentations & Invitations

**Invited Talks**

| | |
|---|---|
| International Conf. on Mathematical Neuroscience, Juan-les-Pins, France | May 2016 |
| Midwest Math Biology Conference, University of Wisconsin-La Crosse | May —— |
| TGDA @ OSU Conference, Ohio State University | May —— |
| AMS Spring SE Sectional Meeting, Athens, GA | Mar —— |
| Current Events Bulletin, 2016 Joint Math Meetings, Seattle, WA | Jan —— |
| Penn State, Center for Neural Engineering Seminar | Nov 2015 |
| Biology and Mathematics in the Bay Area (BaMBA), San Jose, CA | Oct —— |
| MSRI Theory of Neural Computation Workshop, Berkeley, CA | Oct —— |
| SIAM Conference on Applied Algebraic Geometry, Daejeon, South Korea<br>– *Special Session: Algebraic structures arising in systems biology* | Aug —— |
| DARPA Dynamics, Geometry and Big Data Sets Worskhop, Arlington, VA | May —— |
| Duke University, Mathematical Biology Colloquium | Apr —— |
| Penn State, Dynamics Working Seminar | Mar —— |
| University of South Florida, Mathematics Colloquium | Mar —— |
| AMS Sectional Meeting, Georgetown University<br>– *Special Session: Topology in Biology* | Mar —— |
| Ohio State, Topology Geometry and Data Analysis Seminar | Feb —— |
| Penn State, MASS Colloquium | Oct 2014 |
| Temple University, Mathematics Colloquium | Feb —— |
| Georgia Tech, Mathematics Seminar | Feb —— |
| Penn State University, Mathematics Colloquium | Jan —— |
| University of Oregon, Math/Biology Seminar | Jan —— |
| University of Toronto, Mathematics Colloquium | Jan —— |
| Northeastern University, Applied & Interdisciplinary Mathematics Seminar | Jan —— |
| Institute of Mathematics for Applications (IMA), U. Minnesota<br>– *Workshop: Topological Structures in Computational Biology* | Dec 2013 |

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| UC Davis, Applied Mathematics REU Seminar | Aug —— |
| Mathematical Congress of the Americas, Guanajuato, Mexico<br>– *Special Session: Applied Combinatorics* | Aug —— |
| SIAM Conference on Applied Algebraic Geometry, Colorado State U.<br>– *Minisymposium: Applications to the Life and Physical Sciences* | Aug —— |
| Frontiers in Applied and Computational Mathematics Conference, NJIT | Jun —— |
| Baylor College of Medicine, NRI Colloquium, Houston, TX | May —— |
| University of Houston, Networks Seminar (Math Dept) | May —— |
| Sam Houston State University, Mathematics Colloquium | May —— |
| AMS Regional Meeting, Iowa State University<br>– *Special Session: Discrete Methods and Models in Mathematical Biology* | Apr —— |
| Brown University, Pattern Theory Seminar (Applied Math) | Apr —— |
| Woodrow Wilson Fellowship Fall Retreat, Princeton, NJ | Oct 2012 |
| Mathematical Biosciences Institute (MBI), Ohio State<br>– *Workshop: Mathematical Challenges in Neural Network Dynamics* | Oct —— |
| AIMS Conf. on Dynamical Systems, DEs, & Applications, Orlando, FL<br>– *Special Session: Stochastic Networks with Applications to Neuroscience* | Jul —— |
| SIAM Conference on Discrete Mathematics, Halifax, Nova Scotia<br>– *Minisymposium: Discrete Mathematical Biology* | Jun —— |
| Mathematical Neuroscience Meeting, Edinburgh, UK (plenary) | Mar —— |
| COSYNE Annual Meeting, Salt Lake City, UT (workshop talk) | Feb —— |
| University of Iowa, Physics Colloquium | Dec 2011 |
| CIRM (Luminy), Marseille, France<br>– *Workshop: Spatio-temporal evolution equations and neural fields* | Oct —— |
| AMS Regional Meeting, Lincoln, NE | Oct —— |
| University of Nebraska - Omaha, Neuroscience Colloquium | Apr —— |
| Kavli Institute for Systems Neuroscience, Trondheim, Norway<br>– *Seminar for the Moser group* | Jan —— |
| Center of Mathematics for Applications (CMA), U. of Oslo, Norway<br>– *Workshop: Algebraic geometry in the sciences* | Jan —— |
| AIMS Conference on Dynamical Systems, etc., Dresden, Germany<br>– *Special Session: Dynamical networks and their applications in neuroscience* | May 2010 |
| AMCS Colloquium, University of Iowa | Mar —— |
| Mathematical Biosciences Institute (MBI), Ohio State<br>– *Workshop: Mathematical Developments Arising from Biology* | Nov 2009 |
| Rensselaer Polytechnic Institute, Mathematics Seminar | Jun —— |
| Institute of Advanced Study (IAS), Princeton, NJ<br>– *Workshop on Topology: Identifying Order in Complex Systems* | Apr —— |
| University of Utah, Mathematical Biology Seminar | Mar —— |
| COSYNE Annual Meeting, Salt Lake City, UT (workshop talk) | Mar —— |
| UC Berkeley, Mathematical & Computational Biology Seminar | Feb —— |
| Temple University, Mathematics Colloquium | Feb —— |
| Notre Dame, Mathematics Colloquium | Feb —— |

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| Michigan State University, Mathematics Colloquium | Jan —— |
| Ohio State University, Mathematics Seminar | Jan —— |
| University of Nebraska-Lincoln, Mathematics Colloquium | Jan —— |
| North Carolina State University, Mathematics Colloquium | Jan —— |
| Georgia Tech, Math Biology Seminar | Jan —— |
| New York University, Courant Instructor Day | Sep 2008 |
| Center for Theoretical Neuroscience, Columbia University | Apr —— |
| NJIT Mathematical Biology Seminar | Apr —— |
| IBM Computational Biology Research Group, New York | Feb —— |
| New York University, Mostly Biomathematics Seminar | Feb —— |
| Rutgers University, Mathematical Biology Seminar, New Brunswick | Dec 2007 |
| New York University, Mostly Biomathematics Seminar | Nov —— |
| Applications of Analysis to Mathematical Biology, Duke University | May —— |
| CNS Annual Meeting, Madison, WI (workshop talk) | Jul 2005 |
| Theoretical Physics Session, NSBP/NSHP Joint Meeting | Feb —— |
| University of Iowa, Particle Physics Seminar | Dec 2004 |
| University of Wisconsin, Madison, Topology Seminar | Dec —— |

**Other Research Invitations**

Institute for Mathematics and its Applications (IMA), U. of Minnesota — Spring 2014
– *Invited participant for two one-week workshops: "Topological Systems: Communication, Sensing, and Actuation," and "Topology and Geometry of Networks and Discrete Metric Spaces."*

Physical and Mathematical Principles of Brain Structure and Function — May 2013
– *Invited participant. Sponsored by NSF & the Kavli Foundation. Arlington, VA. The workshop's purpose was to brainstorm ideas for President Obama's BRAIN Initiative.*

**Selected Posters**

**COSYNE (Computational and Systems Neuroscience) Annual Meeting**
Salt Lake City, UT. Abstract selection for posters is peer-reviewed and competitive.
(*indicates a student or postdoc presenter)

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| – *Associative memory encoding in bump attractor networks* | Mar 2013 |
| – *The neural ring: an algebraic tool for analyzing neural codes** | Mar —— |
| – *Perturbative memory encoding in recurrent networks* | Feb 2012 |
| – *Recurrent vs. feedforward networks: differences in neural code topology* | Feb —— |
| – *Sequences and the emergence of bump attractor networks** | Feb —— |
| – *Combinatorial neural codes from a math coding theory perspective** | Feb —— |
| – *Optimal architectures for fast-learning, flexible networks* | Feb 2010 |
| – *Stimulus space topology vs. network topography in the ring model* | Feb 2009 |
| – *Control of single neuron activity by sensory stimuli and global network dynamics in auditory cortex* | Feb —— |
| – *State-dependence of sensory-evoked responses in neocortex* | Feb 2007 |

**SfN (Society for Neuroscience) Annual Meeting**
Washington, DC (2005, 2008); Atlanta, GA (2006); San Diego, CA (2007, 2010, 2013).

– *Associative memory encoding in bump attractor networks* Nov 2013
– *Pairwise correlation graphs of hippocampal population activity have highly non-random, low-dimensional clique topology* Nov ——
– *Flexible networks for memory-encoding* Nov 2010
– *Long-lasting, temporally reliable cell sequences via threshold-adaptation in the hippocampus* Nov ——
– *Control of single neuron activity by sensory stimuli and global network dynamics in auditory cortex* Nov 2008
– *State-dependence of sensory-evoked responses in neocortex* Nov 2007
– *Dynamics of activated and inactivated states in neocortex* Oct 2006
– *Laminar organization of sensory-evoked activity in neocortex* Nov 2005

## Teaching

**Teaching Experience**

**Courses taught @ PSU**

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|---|---|
| Math 597B: Mathematical Neuroscience | Fall 2015 |
| Math 311W: Discrete Mathematics | Fall 2015 |
| Math 405: Advanced Calculus for Engineers and Scientists I (2 sections) | Fall 2014 |

**Courses taught @ UNL**

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|---|---|
| Math 107: Analytic Geometry & Calculus II | Fall 2013 |
| Math 450: Combinatorics | Fall 2013 |
| Math 310: Introduction to Proofs Using Algebra | Spring 2012 |
| Math 496/896: Mathematical Neuroscience | Spring 2011 |
| Math 221: Differential Equations (2 times) | Spring 2010, Fall 2010 |
| Math 314: Linear Algebra (3 times) | Fall 2009, Spring 2011 |

**Courant Instructor** (lecturer), New York University 2008-2009
Math V122: Calculus II (Fall 2008), Review sessions for Calculus I courses (Spring 2009).

**Unofficial Lecturer**, CMBN, Rutgers University 2005-2006
Linear Algebra for Neuroscientists
– *Designed and taught a weekly 2-hour seminar course for graduate students and postdoctoral researchers in neuroscience. Topics included SVD, PCA, MDA and Fourier analysis.*

**Graduate Student Instructor** (lecturer), Duke University 2002-2003
Math 32: Calculus II (Fall 2002), Math 103: Multivariable Calculus (Spring 2003).

**Course Assistant** (recitation, office hours, grading), Harvard University 1997-1998
Math 1b: Calculus II (Fall 1997), Math 21a: Vector Calculus (Spring 1998), and Math 21b: Linear Algebra (Fall 1998).

**Miscellaneous Advising**

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|---|---|
| Dissertation committee for Xiao Gan (PSU Physics) | 2015– |
| Dissertation committee for Meiram Murzabulatov (PSU Computer Science) | 2015– |
| Dissertation committee for Mike Skocik (PSU Physics) | 2015– |
| Dissertation committee for Jacob Turner (PSU Mathematics) | 2015– |
| Supervisory committee for Zachary Roth (UNL; as a Reader) | 2013–2015 |

Supervisory committee for Caitlyn Parmelee (UNL; as Chair, Advisor) 2013–
Supervisory committee for Nora Youngs (UNL; as Chair, Advisor) 2011–2014
Supervisory committee for Sara Reynolds (UNL; as a Reader) 2011–
Study group for Math/Neuro Communication Project May-Aug 2012
*– with Steven Cain, Lucas Miller, Ashley Sullivan, & Prof. Frauke Hachtmann*
Nebraska Math Scholars mentor 2011-2014

## Research Mentoring & Organizing

**Conferences**

Organizing committee: SAMSI program in Computational Neuroscience 2015-2016
– SAMSI Opening Workshop organizer Aug 2015
– SAMSI Working Group leader (with Brent Doiron and Chris Hillar) 2015-2016
Organizer for an AMS Mathematics Research Community 2013-2015
*– Algebraic and Geometric Methods in Applied Discrete Mathematics*
*– 40 junior participants and 5 faculty organizers met for a week-long research-intensive workshop at Snowbird (UT) in June 2014.*

**Seminars**

Co-organizer: Theoretical Biology Seminar & Math Biology Colloquium Aug 2014–
Co-organizer: Applied Algebra and Network Theory Seminar Aug 2014–
Co-organizer: Math Biology Seminar (UNL) 2010–2011

**Math Neuro "Lab"**

Co-organizer of Math/Neuro "Lab" meetings 2010–present

*Primary advisor for:* **Katie Morrison** (postdoc, 2015), **Ramon Vera** (postdoc, 2015–), **Caitlyn Parmelee** (Ph.D. student, 2013–), **Nora Youngs** (Ph.D. student, 2011–2014; now a postdoc at Harvey Mudd), **Alan Veliz-Cuba** (postdoc, 2010-2013; now a postdoc at U. Houston), **Ashley Sullivan** (M.A. student, 2010-2012; now a Ph.D. student in Neuroscience at Emory U.), and **Aubrey Thompson** (undergraduate, 2012–2014; now a Ph.D. student in Theoretical Neuroscience at U. Pittsburgh/Carnegie Mellon; awarded an NSF graduate research fellowship).

*Other students and postdocs mentored:* **Zvi Rosen** (postdoc, 2015), **Zachary Roth** (Ph.D. student, 2012–2015), **Alex Kunin** (Ph.D. student, 2013–), **Camila Tulyaganova** (grad student, 2013–2014; now a graduate student in Neural Engineering at Penn State), **Chad Giusti** (postdoc, 2012–2014; now a postdoc at U. Pennsylvania), and **Keler Marku** (undergrad, 2010–2013, now a Ph.D. student in Economics at U. Minnesota).

IMMERSE mentor for **William Kronholm** (at UNL) June-July 2013
UNL Workshop in Mathematical Neuroscience (2 weeks of daily lectures) June 2012

## Service & Miscellanea

**PSU Service**

CORED affiliate member 2015-

**Internal Service at UNL**

Search committee for the new College of Arts & Sciences dean 2013-2014
Nebraska Conference for Undergraduate Women in Mathematics 2010-2014

– *Member of the conference committee* (2013-2014)
– *Panel moderator*: "Random bits of advice" banquet panel (2010, 2012 & 2013)

All Girls All Math (summer camp for high school girls at UNL) 2010-2013
– *Panel moderator* (2012, 2013), *panelist* (2011), & *minicourse in Neuroscience* (2010)

Search committee: departmental postdoctoral positions 2011-2012
Search committee: math department chair (internal search) Spring 2011
Search committee: faculty position in Math Education 2010–2011
Search committee: faculty position in Interdisciplinary Neurophysiology Fall 2009
Undergraduate Activities Committee (esp. Women's Math Club) 2009–2011

**External Service**

NSF INSPIRE reviewer 2015
NSERC external reviewer 2015
NSF review panelist (3 times) and NSF external reviewer (3 times) 2009–
Reviewer for the annual COSYNE conference Fall 2013
Reviewer for *Neural Computation, Journal of Computational Neuroscience,* 2009–
*Journal of Neuroscience, PLoS ONE, PLoS Computational Biology, PNAS, Neuroscience.*
Mellon Mays Graduate Initiatives Math and Science Mtg., New York, NY Sep 2009
– *SSRC workshop to develop ideas for promoting minorities in math and science*

**Languages**

English (native), Spanish (native), French (fluent), Russian (basic).
Matlab (native), Maple (basic).