Nikki Sanderson CV

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Research Interests
Topological data analysis, dynamical systems, neuroscience and materials science

Employment

Brown University July 2024 - Present
Division of Applied Mathematics & Carney Institute for Brain Science
Postdoctoral Scholar in the Computational Neuroscience Lab of Carina Curto

The Pennsylvania State University July 2021 - June 2024
Department of Mathematics
Postdoctoral Scholar in the Computational Neuroscience Lab of Carina Curto

The Archer School for Girls January 2021 - June 2021
AP Calculus & Calculus
High School Teacher

Lawrence Berkeley National Laboratory January 2019 - December 2020
Data Science and Technology Department, Computational Research Division
Postdoctoral Scholar in the Data Analytics and Visualization Group
Advisors: Dmitriy Morozov, Kristofer Bouchard

Education

University of Colorado, Boulder
Ph.D. in Mathematics (Topological Data Analysis & Dynamical Systems) December 2018
Advisors: Jim Meiss, Carla Farsi

M.A. in Mathematics May 2015
Advisors: Jim Meiss, Stephen Preston

University of California, Davis
B.A. in Mathematics June 2012

Manuscripts in Progress
- *Threshold-linear networks, attractors, and oriented matroids (with A. Degeratu, C. Curto)*
- *Power law spectra from low rank matrices with monotone nonlinearities (with C. Curto et. al, Women in Computational Topology (WICT), ANU-MSI Research Group)*
- *Topological data analysis of circulant structures in neuroscience (with N. Schonsheck)*
- *Inferring functional geometry of human sensorimotor cortex during speech articulation from topological signatures (with K. Bouchard, data from Cheng Lab)*

Publications
- *Topological analysis of neuronal assemblies reveals low-rank structure with cholinergic modulation.* bioRxiv. Joint with E. Hansen, S. Nourin, V. Candat, G. Sumbre, C. Curto. **(2025)**
- *Topological neuroscience: linking circuits to function.* Annual Reviews of Neuroscience. Joint with C. Curto. **(2025)**
- *Topological regularization via persistence-sensitive optimization.* Computational Geometry Volume 120, Joint with A. Krishnapriyan, A. Nigmetov, D. Morozov **(2024)**

- *Nerve theorems for fixed points of neural networks* Association for Women in Mathematics Series, vol 30. Springer, Cham. Joint with D. Egas Santander, S. Ebli, A. Patania, F. Burtscher, K. Morrison, C. Curto **(2022)**
- *Combinatorial conditions for directed collapsing.* Association for Women in Mathematics Series, vol 30. Springer, Cham. Joint with R. Belton, R. Brooks, S. Ebli, L. Fajstrup, B.T. Fasy, E. Vidaurre **(2022)**
- *Topological network analysis of patient similarity for precision management of acute blood pressure in spinal cord injury* eLife 10:e68015. Joint with Abel et. al **(2021)**
- *Towards directed collapsibility.* Advances in Mathematical Sciences. Association for Women in Mathematics Series, vol 21. Springer, Cham. Joint with R. Belton, R. Brooks, S. Ebli, L. Fajstrup, B.T. Fasy, C. Ray, E. Vidaurre **(2020)**
- *Computational topology techniques for characterizing time-series data,* Advances in Intelligent Data Analysis XVI 16th International Symposium, IDA 2017, London, UK, October 26–28, Proceedings. Joint with E. Shugerman, S. Molnar, J. Meiss E. Bradley **(2017)**
- *Simplicial multivalued maps and the witness complex for dynamical analysis of time series,* SIAM Journal on Applied Dynamical Systems Volume 14, 1278-1307. Joint with Z. Alexander, E. Bradley, J. Meiss **(2015)**
- *Virtual shadow modules and their link invariants,* International Journal of Mathematics Volume 23, 22 pp. Joint with J. Blankstein, S. Kim, C. Lepel, S. Nelson **(2012)**

Talks

- "Topological analysis of assemblies reveals low-rank structure with cholinergic modulation", Math & Machine Learning Seminar, Boston College, Boston, MA; **October 2025**
- "Lightning Talk: Topological analysis of assemblies reveals low-rank structure with cholinergic modulation", Lefschetz Center for Dynamical Systems Seminar, Brown University, Providence, RI; **September 2025**
- "Topological analysis of assemblies reveals low-rank structure with cholinergic modulation", Topology & Neuroscience Workshop, Fields Institute, Toronto, Canada; **August 2025**
- "Persistent homology and zebrafish brain dynamics", SIAM Algebraic Geometry 2025, Madison, WI; **July 2025**
- "Lightining Talk: Neuromodulation in the context of threshold-linear networks" *Janelia Analysis and Modeling of Connectomics Conference*; Washington DC; **June 2025**
- "From correlations to Betti curves: the ABCs of topological data analysis for matrix analysis" Minitutorial, SIAM Annual Meeting, Spokane WA; **July 2024**
- "Spontaneous neural dynamics in an attractor-like network: an experimental and topological approach", AMS Spring Southeastern Sectional Meeting, Florida State University; **March 2024**
- "The ABCs of topological data analysis for matrix analysis" Tutorial, Mathematical Approaches for Connectome Analysis Workshop, IPAM, Los Angeles; **February 2024**
- "Spontaneous neural dynamics in an attractor-like network: an experimental and topological approach", Joint Mathematics Meetings, San Francisco, CA; **January 2024**
- "Spontaneous neural dynamics in an attractor-like network: an experimental and topological approach", Postdoc/Grad Student Seminar, ICERM Math+Neuro: Strengthening the interplay between theory and mathematics, ICERM, Providence; **October 2023**
- "Spontaneous neural dynamics in an attractor-like network: an experimental and topological approach", Lightning Talk Topology and Geometry in Neuroscience Workshop, ICERM; **October 2023**
- "Spontaneous neural dynamics in an attractor-like network: an experimental and topological approach", AMS Fall Central Sectional Meeting, Creighton University; **October 2023**
- "PyCliqueTop_2023: TDA software demo", Software demonstration, Math+Neuro: Strengthening the interplay between theory and mathematics, ICERM, Providence; **September 2023**
- "TDA 101", Tutorial, Math+Neuro: Strengthening the interplay between theory and mathematics, ICERM, Providence; **September 2023**
- "Shape and function?", Lightning Talk, Math+Neuro: Strengthening the interplay between theory and mathematics, ICERM, Providence; **September 2023**
- "Spontaneous neural dynamics in an attractor-like network: an experimental and topological approach", Janelia Computational & Theoretical Zebrafish Neuroscience Workshop, Janelia, Virginia; **April 2023**
- "From correlations to Betti curves: detecting structure in neural assemblies of zebrafish larvae" Tutorial, Janelia Computational & Theoretical Zebrafish Neuroscience Workshop, Janelia, Virginia; **April 2023**
- "Spontaneous neural dynamics in an attractor-like network: an experimental and topological approach", MathBio Seminar, Penn State University, Pennsylvania; **April 2023**
- "Some Betti curve results comparing Euclidean and hyperbolic space" Curto-Itskov Lab Meeting, Penn State University, Pennsylvania; **April 2023**
- "Spontaneous neural dynamics in an attractor-like network: an experimental and topological approach", AMS

Spring Southeastern Sectional Meeting, GA Tech; **March 2023**
- "Spontaneous neural dynamics in an attractor-like network: an experimental and topological approach", École Normale Supérieure, Paris, France; **February 2023**
- "How Neural Network Structure Shapes Dynamics: In Theory & In Vivo", Stochastic Topology and its Applications Seminar, Max Planck Institute, Leipzig, Germany; **February 2023**
- "Topological data analysis for neuroscientific data", Janelia Junior Scientists Neurotheory Workshop, Washington DC; **November 2022**
- "Neuromodulation in threshold-linear networks", Janelia Junior Scientists Neurotheory Workshop, Virginia; **November 2022**
- "Witness complexes for time series analysis", Math Club, Penn State University, Pennsylvania; **September 2022**
- **"**Nerve theorems for threshold linear networks ", Association for Women in Mathematics Research Symposium @ University of Minnesota, Minnesota; **June 2022**
- "Directed Topology Two Ways", *Applied Topology Seminar,* École Polytechnique Fédérale de Lausanne, **January 2020**
- "Computational Topology for Time Series Analysis", *Applied Machine Learning Days @ EPFL*, École Polytechnique Fédérale de Lausanne, **January 2020**
- "Topological Data Analysis of Time Series Using Witness Complexes", *Geometric & Topological Data Analysis Winter School 2020 @ CIMAT*, Centro de Investigacións en Matemática, Guanjuato, Mexico; **January 2020**
- "Inferring Time-Varying Functional Networks from ECoG Data", SIAM AG 2019, University of Bern, **July 2019**
- "Enhancing Witness Complexes Modeling Chaotic Dynamical Systems"*, SIAM: Central States Sectional Meeting,* University of Oklahoma, Oklahoma; **October 2018**
- "Witness Complexes for Time Series Analysis"*, Topology Seminar,* University of Colorado, Boulder; **November 2017**
- "Witness Complexes for Time Series Analysis" *Joining the dots: from data to insight,* University of Southampton; **October 2017**
- "Witness Complexes for Time Series Analysis" *Applied Topology Seminar,* Ecole Polytechnique Federal de Lausanne; **October 2017**
- "Witness Complexes for Time Series Analysis" *Computational & Algorithmic Topology, Sydney,* University of Sydney; **June 2017**
- "Witness Complexes for Time Series Analysis" *Applied Mathematics Seminar,* Australian National University; **June 2017**
- "Witness Complexes for Time Series Analysis" *SIAM: Conference on Applications of Dynamical Systems*, Snowbird, Utah; **May 2017**
- "Topological Data Analysis", "*Meet a Data Scientist" series, CU Data Science Team,* University of Colorado, Boulder; **April 2017**
- "Spectra", *Topology and Geometry Seminar,* University of Colorado, Boulder; **February 2017**
- "Triangulated Categories", *Topology and Geometry Seminar,* University of Colorado, Boulder; **October 2016**
- "Finding the Homology of Submanifolds with High Confidence from Random Samples"*, Differential Equations, Geometry, and Topology Seminar,* University of Colorado, Boulder; **April 2015** (*Masters Defense*, May 2015)
- "Languages and Automata"*, Graduate Algebra Seminar,* University of Colorado, Boulder; **February 2015**
- "Simplicial Multivalued Maps and the Witness Complex"*, Infinite-dimensional Riemannian geometry with application to image processing and shape analysis,* Erwin Schrodinger International Institute for Mathematical Physics, University of Vienna, Austria; **February 2015**

Posters
- "Neuromodulation in the context of threshold-linear networks" *Janelia Analysis and Modeling of Connectomics Conference*; Washington DC; **June 2025**
- "Understanding network dynamics of compact assemblies of neurons in zebrafish larvae optic tectum during spontaneous activation" *Computational and Systems Neuroscience (COSYNE)*; Montreal, Canada; **March 2023**
- "Neuromodulation in threshold-linear networks", *Janelia Junior Scientists Neurotheory Workshop*; Washington DC; **November 2022**
- "Neuromodulation in threshold-linear networks", *Bernstein Conference,* Berlin, Germany; **September 2022**
- "Neuromodulation in threshold-linear networks" *Center for Neural Engineering Retreat,* Penn State University; **August 2022**
- **"**Nerve theorems for dimensional reduction of threshold linear networks ", *Society for Neuroscience, virtual*; **November 2021**

- **"**Global Metrics on Functional ECoG Networks Poor at Distinguishing Dynamic Regimes ", *Women in Computational Topology (WICT) Workshop,* Canberra, Australia; **July 2019**
- "Computational Topology for Dynamical Time Series"*, Dynamics Days Conference,* Denver, Colorado; **January 2018**
- "Virtual Birack Shadow Modules and their Link Invariants"*, Joint Mathematics Meetings,* Boston, Massachusetts; **January 2012**

Conferences & Workshops Attended

SIAM-AG 2025, Madison Wisconsin, July 2025 | Janelia Analysis & Modeling of Connectomics, June 2025 | ICERM Geometry of Materials, April 2025 | SIAM Annual Meeting, Spokane, WA July 2024 | AMS Spring Southeastern Sectionals, Florida State University March 2024 | Mathematical Approaches for Connectome Analysis Workshop, IPAM, Los Angeles, California, February 2024 | Joint Mathematics Meeting, San Francisco, California, January 2024 | AMS Fall Central Sectionals, Creighton, OK, October 2023 | ICERM Math+Neuroscience: Strengthening the Interplay Between Theory and Mathematics, Sept-Dec 2023 |Janelia Computational & Theoretical Zebrafish Neuroscience Workshop, Janelia, April 2023 | AMS Spring Southeastern Sectionals, GA Tech March 2023 | Janelia Junior Scientist Workshop on Theoretical Neuroscience, Janelia, November 2022 | Bernstein Conference, Berlin, Germany September 2022 | AWM Research Symposium, Minneapolis, Minnesota June 2022 | Dynamics Artificial Intelligence and Neuroscience, BIRS, January 2022 | Society for Neuroscience, November 2021 | Applied Machine Learning Days @ EPFL, January 2020 | Geometric and Topological Data Analysis 2020 Winter Workshop @ CIMAT, January 2020 | SIAM Applied Geometry 2019, University of Bern, July 2019 | Women in Computational Topology (WICT) Workshop, MSI-ANU, July 2019 | Society of Industrial and Applied Mathematics (SIAM) Central States Sectional Meeting, University of Oklahoma, Oklahoma October 2018 | Hot Topics: Shape and Structure of Materials Workshop, Mathematical Science Research Institute (MSRI) Berkeley, California October 2018 | Dynamics Days, Denver, Colorado January 2018 | Women in Topology (WIT) Workshop, MSRI Berkeley, California November 2017 | 33rd International Symposium on Computational Geometry (SocG) The University of Queensland, Brisbane, Australia July 2017 | Computational & Algorithmic Topology, Sydney, University of Sydney June 2017 | Conference on Applications of Dynamical Systems, SIAM, Snowbird, Utah May 2017 | Topological and Geometric Data Analysis Conference (TGDA@OSU), Ohio State University May 2016 | Joint Mathematics Meetings, Seattle, Washington January 2016 | Conference on Applications of Dynamical Systems, SIAM, Snowbird, Utah May 2015 | Applied Topology and High-Dimensional Data Analysis, University of Victoria, Canada August 2015 | Joint Mathematics Meetings, Boston, Massachusetts January 2012

Extended Research Visits

ICERM: Math + Neuroscience: Strengthening the Interplay Between Theory and Mathematics, semester-long funded participant; Fall 2023

École Normale Supérieure, IBENS, hosted by the Sumbre Lab; Winter 2022 Winter 2023

École Polytechnique Fédérale de Lausanne & Blue Brain Project, hosted by the Hess Lab; Fall 2017

The Australian National University, hosted by Vanessa Robins; Summer 2017

Research Grants

ORISE NSF-MSGI Project Awarded: Understanding artificial intelligence from topological descriptors, ORISE NSF-MSGI at Lawrence Berkeley National Laboratory, (with E. Jamarillo-Rodriguez) ***June 2020 - August 2020***

PI, Developed project and wrote grant to fund 10 weeks of graduate student summer research. Investigated how topological signatures of neural network activations can improve classification during adversarial attacks.

Other Research Activities

Topological signatures of time-keeping and decision-making in D1 and D2 neurons in mouse striatum, ICERM collaboration, (with R. Curtu, data from Narayanan Lab) November 2023 - April 2024

Analyzing correlations of neural firing rates derived from extracellular electrophysiological recordings of D1, D2 neurons in mouse striatum during interval timing tasks using topology.

Using topology with machine learning to solve problems in chemistry, Lawrence Berkeley National Laboratory, (with

M. El-Khatib) January 2020 - October 2020

Analyzed autoencoder performance on atomic representations of molecules with persistent homology.

Geometry of weighted inextensible strings, University of Colorado, Boulder (with S. Preston, A. Broido) February 2015 - January 2016

Showed that the shape space of inextensible finite length strings with fixed endpoint has positive sectional curvature, and therefore gradient descent upon which is stable up to small error, under a novel metric modeling whips with weights attached.

Teaching Experience

High School AP Calculus Teacher, The Archer School for Girls, January 2021 - June 2021

Taught four classes of AP Calculus and Calculus, prepared students for AP exam

Berkeley Lab Teaching Scholars Program, January 2020 - December 2020

Developed hands-on STEM activities and presentations delivering scientific information and highlighting National Lab research

Undergraduate Research Mentor, University of Colorado, Boulder, *Boulder, CO* May 2016 - December 2019

Led four independent studies for undergraduates in topological data analysis developing code and theory, resulting in publication.

Graduate Instructor, University of Colorado, Boulder, *Boulder, CO* July 2013 - December 2015

Introduction to Statistics (Fall 2015), Calculus I (Fall 2013, Spring 2015), Calculus, Systems, and Modeling (Fall 2014), Spirits and Uses of Mathematics (Spring 2014), Quantitative Reasoning and Mathematical Skills (Summer 2013, Summer 2014)

Graduate Teaching Assistant, University of Colorado, Boulder, *Boulder, CO* August 2012 - May 2013

Calculus I (Fall 2012, Spring 2013)

Teaching Assistantship

Teaching Assistantship for Ph.D. program funding August 2012 - December 2015

Service & Outreach

Co-organized minisymposium “Topology & Geometry in Neuroscience” for SIAM-AG 2025 | Participated in AATRN tutorial-a-thon, Spring 2025 | Co-leader of Journal Club, ICERM Math+Neuro: Strengthening the interplay between theory and mathematics, Fall 2023 | Peer-reviewed journal article for Foundations of Data Science, 2022 | Peer-reviewed journal articles for Computational Geometry: Theory and Applications 2021, 2022 | Volunteered as a judge for Oakland Unified School District Virtual Science Fair Spring 2020 | Peer-reviewed conference articles for LDAV 2019, IEEE 2020 |Volunteered with Oakland City Summer Camp to run a chemistry science lab for K-7 students | Volunteered with Logan School students for semester math project guidance, Denver Colorado May 2018 | Video production for website, “Chromatic Homotopy Theory: Journey to the Frontier Conference” University of Colorado, Boulder May 2018 | Organized minisymposium “Topological Data Analysis of Time Series from Dynamical Systems”, SIAM: Conference on Applications of Dynamical Systems May 2017 | Peer-reviewed journal articles for publication in Chaos, Rocky Mountain Journal of Mathematics, 2017 | STEM Launch Math Project Based Learning Panel Adams 12 Five Star Schools, Denver, Colorado January 2017 | Volunteered at Bridges MoSAIC Festival, University of Colorado, Boulder April 2016 | Helped organize Gone Fishing Poisson Geometry Conference University of Colorado, Boulder March 2016