Badal Joshi | *Professor of Mathematics*

California State University San Marcos

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Academic Positions

California State University San Marcos — **Department of Mathematics**
Professor — *Aug 2023–present*

California State University San Marcos — **Department of Mathematics**
Graduate Program Coordinator — *Spring 2022–Spring 2025*

California State University San Marcos — **Department of Mathematics**
Associate Professor — *Aug 2018–Aug 2023*

University of Copenhagen (Fa 2018); University of Wisconsin–Madison (Sp 2019)
Sabbatical Visits — *2018–2019*

California State University San Marcos — **Department of Mathematics**
Assistant Professor — *Aug 2013–Aug 2018*

San Diego State University — **Computational Science Research Center**
Adjunct Faculty — *Mar 2014–Jun 2020*

University of Minnesota — **School of Mathematics**
Postdoctoral Fellow — *Aug 2012–Aug 2013*

Duke University — **Department of Mathematics**
Assistant Research Professor — *Aug 2009–Jul 2012*

Education

The Ohio State University
Ph.D., Mathematics — *2009*

The Ohio State University
M.S., Mathematics — *2008*

The Ohio State University
M.S., Physics — *2004*

St. Xavier's College, Gujarat University, India
B.Sc., Physics (Minor: Mathematics)

External Funding

2025–2028: **AMS–Simons Research Enhancement Grant** for Primarily Undergraduate Institution (PUI) Faculty. American Mathematical Society & Simons Foundation.

2022–2024: **NSF Research Opportunity Award (ROA)**, supplement to Prof. David Anderson (UW–Madison) NSF DMS Mathematical Biology grant, "Reaction Networks: Theory, Computation, and Applications." [$79,183]

Publications

All articles available at arxiv.org or badaljoshi.net.

34. David F. Anderson and Badal Joshi. *Instantaneous arithmetic computation via ratio-encoding in chemical reaction networks*. arXiv preprint (2026). [arXiv]

33. Badal Joshi, Tung D. Nguyen, and Matthew D. Johnston. *Bistability, Absolute Concentration Robustness, and Hysteresis in Dual-Site Futile Cycles with Bifunctional Enzymes*. arXiv preprint (2026). [arXiv]

32. David F. Anderson, Badal Joshi, and Tung D. Nguyen. *Computing with reaction networks at input-independent speed: exponential and logarithmic functions*. To appear in *Natural Computing* (2026). [arXiv]

31. Badal Joshi and Tung D. Nguyen. *Bifunctional enzyme action as a source of robustness in biochemical reaction networks: a novel hypergraph approach*. *Journal of the Royal Society Interface*, Vol. 23, 20250252 (2026). [doi] [arXiv]

30. David F. Anderson and Badal Joshi. *Chemical mass-action systems as analog computers: implementing arithmetic computations at specified speed*. *Theoretical Computer Science*, Vol. 1025, 114983 (2025). [doi] [arXiv]

29. Badal Joshi and Tung D. Nguyen. *Bifunctional enzyme provides absolute concentration robustness in multisite covalent modification networks*. *Journal of Mathematical Biology*, Vol. 88, 36 (2024). [doi] [arXiv]

28. Mainak Patel and Badal Joshi. *Development of the sleep-wake switch in rats during the P2–P21 early infancy period*. *Frontiers in Network Physiology*, Vol. 3 (2023). [doi]

27. Badal Joshi and Gheorghe Craciun. *Power-engine-load form for dynamic absolute concentration robustness*. *SIAM Journal on Applied Mathematics*, Vol. 83, Iss. 6 (2023). [doi] [arXiv]

26. Badal Joshi, Nidhi Kaihnsa, Tung D. Nguyen, and Anne Shiu. *Prevalence of multistationarity and absolute concentration robustness in reaction networks*. *SIAM Journal on Applied Mathematics*, Vol. 83, Iss. 6 (2023). [doi] [arXiv]

25. Badal Joshi and Gheorghe Craciun. *Reaction network motifs for static and dynamic absolute concentration robustness*. *SIAM Journal on Applied Dynamical Systems*, Vol. 22, No. 2, pp. 501–526 (2023). [doi] [arXiv]

24. Badal Joshi and Gheorghe Craciun. *Foundations of static and dynamic absolute concentration robustness*. *Journal of Mathematical Biology*, Vol. 85, 53 (2022). [doi] [arXiv]

23. Daniele Cappelletti and Badal Joshi. *Transition graph decomposition for complex balanced reaction networks with non-mass-action kinetics*. *Mathematical Biosciences and Engineering*, Vol. 19, Iss. 8, pp. 7649–7668 (2022). [doi] [arXiv]

22. Gheorghe Craciun, Badal Joshi, Casian Pantea, and Ike Tan. *Multistationarity in cyclic sequestration-transmutation networks*. *Bulletin of Mathematical Biology*, Vol. 84, 65 (2022). [doi] [arXiv]

21. Gheorghe Craciun, Abhishek Deshpande, Badal Joshi, and Polly Y. Yu. *Autocatalytic recombination systems: a reaction network perspective*. *Mathematical Biosciences*, Vol. 345, 108784 (2022). [doi] [arXiv]

20. David F. Anderson, Badal Joshi, and Abhishek Deshpande. *On reaction network implementations of neural networks*. *Journal of the Royal Society Interface*, Vol. 18, Iss. 177 (2021). [doi] [arXiv]

19. Badal Joshi and Gheorghe Craciun. *Autocatalytic networks: an intimate relation between network topology and dynamics*. *SIAM Journal on Applied Mathematics*, Vol. 81, Iss. 4, pp. 1623–1644 (2021). [doi] [arXiv]

18. Stefan Müller and Badal Joshi. *Detailed balance = complex balance + cycle balance: a graph-theoretic proof for reaction networks and Markov chains*. *Bulletin of Mathematical Biology*, Vol. 82, Art. 116 (2020). [doi] [arXiv]

17. Daniele Cappelletti and Badal Joshi. *Graphically balanced equilibria and stationary measures of reaction networks*. *SIAM Journal on Applied Dynamical Systems*, Vol. 17, No. 3, pp. 2146–2175 (2018). [doi] [arXiv]

16. Mainak Patel and Badal Joshi. *Deterministic stability regimes and noise-induced quasistable behavior in a pair of reciprocally inhibitory neurons*. *Journal of Theoretical Biology*, Vol. 441, pp. 68–83 (2018). [doi]

15. Badal Joshi and Anne Shiu. *Which small reaction networks are multistationary?*. *SIAM Journal on Applied Dynamical Systems*, Vol. 16, pp. 802–833 (2017). [doi] [arXiv]

14. Mainak Patel and Badal Joshi. *Modeling the evolving oscillatory dynamics of the rat locus coeruleus through early infancy*. *Brain Research*, Vol. 1618, pp. 181–193 (2015). [doi]

13. Badal Joshi and Anne Shiu. *A survey of methods for deciding whether a reaction network is multistationary*. *Mathematical Modelling of Natural Phenomena*, Vol. 10, No. 5, pp. 47–67 (2015). [doi] [arXiv]

12. Badal Joshi. *A detailed balanced reaction network is sufficient but not necessary for its Markov chain to be detailed balanced*. *Discrete and Continuous Dynamical Systems – Series B*, Vol. 20, pp. 1077–1105 (2015). [doi] [arXiv]

11. Runjing Liu, Mainak Patel, and Badal Joshi. *Encoding whisker deflection velocity within the rodent barrel cortex using phase-delayed inhibition*. *Journal of Computational Neuroscience*, Vol. 37, pp. 387–401 (2014). [doi]

10. Mainak Patel and Badal Joshi. *Switching mechanisms and bout times in a pair of reciprocally inhibitory neurons*. *Journal of Computational Neuroscience*, Vol. 36, pp. 177–191 (2014). [doi]

9. Mainak Patel and Badal Joshi. *Decoding synchronized oscillations within the brain: phase-delayed inhibition provides a robust mechanism for creating a sharp synchrony filter*. *Journal of Theoretical Biology*, Vol. 334, pp. 13–25 (2013). [doi]

8. Badal Joshi and Mainak Patel. *Encoding with synchrony: phase-delayed inhibition allows for reliable and specific stimulus detection*. *Journal of Theoretical Biology*, Vol. 328, pp. 26–32 (2013). [doi]

7. Badal Joshi. *Complete characterization by multistationarity of fully open networks with one non-flow reaction*. *Applied Mathematics and Computation*, Vol. 219, Iss. 12, pp. 6931–6945 (2013). [doi] [arXiv]

6. Badal Joshi and Anne Shiu. *Atoms of multistationarity in chemical reaction networks*. *Journal of Mathematical Chemistry*, Vol. 51, No. 1, pp. 153–178 (2013). [doi] [arXiv]

5. Badal Joshi and Anne Shiu. *Simplifying the Jacobian criterion for precluding multistationarity in chemical reaction networks*. *SIAM Journal on Applied Mathematics*, Vol. 72, No. 3, pp. 857–876 (2012). [doi] [arXiv]

4. Badal Joshi. *Order of magnitude time-reversible Markov chains and characterization of clustering processes*. arXiv preprint (2011). [arXiv]

3. Badal Joshi. *A doubly stochastic Poisson process model for wake-sleep cycling*. Ph.D. Thesis, The Ohio State University (2009).

2. Andrew Gall, Badal Joshi, Janet Best, Virginia R. Florang, Jonathan A. Doorn, and Mark Blumberg. *Developmental emergence of power-law wake behavior depends upon the functional integrity of the locus coeruleus*. *SLEEP*, Vol. 32, No. 7 (2009). [doi]

1. Badal Joshi, Xueying Wang, Sayanti Banerjee, Haiyan Tian, Anastasios Matzavinos, and Mark Chaplain. *On immunotherapies and cancer vaccination protocols: a mathematical modelling approach*. *Journal of Theoretical Biology*, Vol. 259, Iss. 4, pp. 820–827 (2009). [doi]

Selected Talks

2026: *Computing with reaction networks: input-independent speed and rate-constant-independent accuracy.* Chemical Reaction Networks in Hawai'i 2026 (CRNT2026), University of Hawai'i at Mānoa, Honolulu (May). (Invited keynote.)
Computing with reaction networks at input-independent speed. 14th European Conference on Mathematical & Theoretical Biology (ECMTB), University of Graz, Austria (Jul).

2025: *Autonomous computation using chemical reactions.* Southern California Applied Mathematics Symposium, UC Riverside (Apr).

2025: *Bifunctional enzyme action as a source of robustness in biochemical reaction networks: a novel hypergraph approach.* SIAM Conference on Applied Algebraic Geometry, Madison (Jul); NSF–Simons Center for Multiscale Cell Fate Research, UC Irvine (Mar); Formal Reaction Kinetics, online (Mar); Mathematics of Reaction Networks, online (Feb).

2024–25: *Chemical mass-action systems as analog computers.* ICQMB, UC Riverside (Mar 2025); SMB Annual Meeting, Seoul (Jul 2024); Politecnico di Torino (Jun 2024); SPT-CRN Workshop, Sardinia (Jun 2024); SCAMP, UC San Diego (Apr 2024); CSUSM SMIMIC colloquium (Mar 2024).

2023: *Graph-theoretic conditions for absolute concentration robustness.* CSU Mathematical Sciences Conference, Bakersfield (Nov).

2023: *Absolute concentration robustness in reversible covalent modification networks.* SIAM AG, Eindhoven (Jul); SIAM Applications of Dynamical Systems, Portland (May); SCAMP, UC Irvine (Apr).

2022: *Absolute concentration robustness induces dynamic homeostasis in growing systems.* SIAM Annual Meeting, Pittsburgh (Jul).

2021: *Dynamic absolute concentration robustness.* Mathematics of Reaction Networks, online (Sep); SMB Annual Meeting, online (Jul); 2nd International Conference on Reaction Kinetics, Budapest (May).

2019: *Hyperchains: network structure and dynamics.* AMS Central Sectional, UW–Madison (Sep); West Virginia University (Oct); SMB Annual Meeting, Montréal (Jul).

2018: *Graphical symmetries and stationary measures of reaction networks.* SIAM Life Sciences, Minneapolis (Aug); Politecnico di Torino (Nov); BIRS Workshop, Alberta (Jun).

2017: *Multistationarity in interaction networks.* SIAM AG, Georgia Tech (Aug); UCLA Biomathematics Seminar (Nov).

2016: *Identifying multistationary reaction networks.* SIAM Life Sciences, Boston (Jul); AMS Spring Western Sectional, Salt Lake City (Apr).

2015: *Detailed balance and product-form stationary distributions.* Southern California Probability Symposium, UC Irvine (Dec). *Detailed balance in reaction networks.* AMS Central Fall Sectional, Loyola University Chicago (Oct). *Identifying atoms of multistationarity.* Mathematical Trends in Reaction Network Theory, Copenhagen (Jul).

2014: *Atoms of multistationarity.* SIAM Life Sciences, Charlotte (Aug); CSRC Colloquium, SDSU (Mar).

2013: *Switching in biological networks.* AMS Spring Central Sectional, Ames (Apr); Indian Institute of Science, Bangalore (Feb); TIFR, Bangalore (Feb); IISER, Pune (Feb).

2012: *Identifying multistationarity in chemical reaction networks.* NJIT FACM (May); Hawaii Pacific University (May); Young Researchers Meet, Stanford (May); Duke University (Nov).

2010: *A coupled Poisson process model for wake-sleep transitions.* Stochastic Models in Neuroscience, CIRM Marseille (Jan).

Conference & Workshop Organization

2026: **Minisymposia** (3 sessions, 12 speakers) *Mathematical Foundations of Biochemical Computing* and

Molecular Computing: Theory and Implementations, 14th European Conference on Mathematical & Theoretical Biology (ECMTB), University of Graz, Austria, Jul. Co-organized with Jinsu Kim and Tung D. Nguyen.
Research in Teams Workshop "Mathematical foundations of chemical computing," BIRS, Banff, Canada, Mar.

2020: **Minicolloquia** (8 speakers) "Deterministic dynamics of biological interaction networks," SIAM Life Sciences (moved online).
Workshop "Dynamics of Reaction Networks," UC Irvine (cancelled due to COVID-19).

2017: **Minicolloquium** "Recent advances in the analysis of biochemical reaction systems," SMB Annual Meeting, University of Utah. Co-organized with M. Johnston (SJSU).

2016–18: **AIM SQuaRE** "Dynamical properties of deterministic and stochastic models of reaction networks," American Institute of Mathematics (three annual weeklong meetings).

2015: **AMS Special Session** "Recent developments in the theory and applications of reaction network models," AMS Central Fall Sectional, Loyola University Chicago. 2 days, 20 invited speakers. Co-organized with C. Conradi (MPI Magdeburg) and C. Pantea (WVU).

2011: **Minicolloquium** "Stochastic dynamics in biological systems at different scales," SIAM Conference on Dynamical Systems, Snowbird.

External Service

Invited Lecturer: African Mathematical School on Chemical Reaction Networks, Politecnico di Torino & University of Nairobi, Kenya (Jul 2023).

Manuscript Review: *SIAM J. Applied Mathematics*; *SIAM J. Applied Dynamical Systems*; *SIAM J. Applied Algebra & Geometry*; *J. Mathematical Biology*; *Bulletin of Mathematical Biology*; *J. Royal Society Interface*; *Annals of Applied Probability*; *J. Nonlinear Science*; *J. Biological Dynamics*; *J. Applied Probability*; *PLOS ONE*; *PLOS Computational Biology*; *Scientific Reports*; *Mathematical Biosciences*; *Discrete & Continuous Dynamical Systems – B*; *Systems & Control Letters*; *Chemical Engineering Research and Design*; *Chemical Engineering Communications*; *Applied Mathematics and Computation*; *Mathematical Reviews/MathSciNet*.

NSF Panel Review: **Served on NSF grant review panel** (research area and date confidential per NSF policy).

Graduate Student Research

Advisor: Yuan Li (MS thesis, Aug 2018)

Committee: Marvin Pena; Jesse Stevenson (Su 2025); Alireza Pakravan (Fa 2022); Chunxu Ji (Su 2022); Justin Mulvany (Sp 2018); Steven Newberg (Fa 2017); Jason Hultman (Sp 2015)

Undergraduate Research Mentoring

- Chieh-Mi Fiona Lu, CSUSM Summer Scholars Program (2020).
- Jacques Coulombe & Justin Mulvany, CSU-PUMP Program (2015–2016).
- Justin Mulvany, CSU-PUMP Program & ViaSat Summer Research Scholarship (2014–2015).
- Kaveh Danesh, Tiffany Lieu (Duke University)

University Service (CSUSM)

- Graduate Program Coordinator, MS Mathematics (Sp 2022–Sp 2025).
- Chair, Applied Math Task Force for Applied Math option in MS Mathematics (Sp 2023–Sp 2025).

- Chair, Applied Math Task Force for Applied Math option in BS Mathematics (Fa 2021–Sp 2023).
- Mathematics Department representative, Faculty Development Committee (FDC) (2016–2018, 2019–2025); **Committee Chair** 2021–2022.
- Undergraduate advisor, Applied Math option (Fa 2023–present); Math major advisor (Fa 2014–2022).
- Course coordinator: Math 162 Calculus II (Fa 2019–present); Math 160 Calculus I (Fa 2020–Fa 2021).
- New faculty hiring committee, member & diversity advocate (2019, 2020).
- **Chair**, Peer Review Committee for tenure case (2022–2024).
- **Chair**, Curriculum design committee for Math 364 (Intermediate Linear Algebra).
- Academic Senate representative, College of Science and Math (2016–2018).
- CSUSM representative, CSU Quantitative Biology Network Initiative (Fa 2013–present).
- CSTEM Strategic Planning Subcommittee — Partnerships & Interdisciplinary Collaborations (Sp 2025).

Teaching Experience

Enrollment shown in parentheses. Courses marked † are graduate level.

California State University San Marcos

- Mathematical Biology (Math 448): Sp 2014 (14), Sp 2016 (17), Fa 2026 (17).
- Mathematical Methods for Engineering and Physics (Math 346): Sp 2025 (27), Fa 2026 (43, 41).
- † Partial Differential Equations (Math 534): Fa 2021 (10), Sp 2025 (5).
- Calculus with Applications III (Math 260/260A): Fa 2017 (32), Sp 2018 (37), Sp 2020 (37), Fa 2020 (36), Sp 2021 (22), Fa 2024 (35+6).
- Mathematics of Biochemical Reaction Networks (Math 490): Sp 2024 (9).
- Calculus with Applications II (Math 162): Fa 2016 (38), Sp 2017 (38), Sp 2018 (24), Fa 2019 (33), Sp 2020 (18), Fa 2020 (38), Sp 2024 (24).
- † Topology (Math 555): Fa 2023 (10).
- † Calculus of Variations (Math 537): Sp 2023 (9).
- † Ordinary Differential Equations (Math 532): Fa 2019 (5), Fa 2022 (10).
- Pre-calculus (Math 125): Fa 2014 (37, 36), Sp 2015 (33, 36), Fa 2022 (43).
- † Stochastic Processes (Math 570): Sp 2022 (7).
- Introduction to Probability (Math 441): Sp 2021 (36, 23), Fa 2021 (31), Sp 2022 (32).
- Linear Algebra (Math 374): Fa 2015 (42, 40), Fa 2016 (34), Sp 2017 (30), Fa 2017 (34), Fa 2019 (34).
- Basic Discrete Mathematics (Math 270): Fa 2017 (36).
- † Measure Theory (Math 530): Sp 2017 (7).
- Introduction to Optimization (Math 480): Fa 2016 (13).
- † Applicable Analysis / Functional Analysis (Math 538): Fa 2015 (6).
- † Advanced Linear Algebra (Math 528): Fa 2014 (8).
- Introduction to Statistics (Math 242): Fa 2013 (49), Sp 2014 (47).
- Applied Nonlinear Dynamics / Senior Seminar (Math 490): Fa 2013 (14).

University of Minnesota

- Introduction to Stochastic Processes: Fa 2012.

Duke University

- Probability (Sp 2012); Ordinary and Partial Differential Equations (Fa 2011); Nonlinear Dynamical Systems (Sp 2011); Multivariable Calculus (Fa 2009, Fa 2010).

The Ohio State University

- Differential Equations; Multivariable Calculus; recitation sections for calculus, pre-calculus, and introductory physics.

Selected Awards & Grants

2025: Professional Advancement Travel Resource [$1,124].

2024: Professional Advancement Travel Resource [$2,000].

2023–24: Interdisciplinary and Innovative Activities Award [$6,600/course buyout] — modeling ocean ecosystems.

2021–22: Interdisciplinary and Innovative Activities Award [$6,000/course buyout] — reaction network implementations of neural networks.

2020–21: Research, Scholarship & Creative Activity (RSCA) [$1,096].

2019–20: RSCA [$1,500]; Faculty Center Professional Development [$500].

2018–19: RSCA [$1,250].

2017: Intuit Award for Outstanding Faculty–Student Collaboration (joint work with master's student Yuan Li).

2016–17: RSCA [$2,250].

2015: CSU-PUMP Grant [$5,000]; University Professional Development Grant [$2,000].

2014: CSU-PUMP Grant [$2,500]; University Professional Development Grant [$5,250/course buyout].

2008–09: Departmental Graduate Research Associate, OSU (awarded for exceptional performance, Summer 2008 & 2009).

2008: Full scholarship, Advanced Course in Computational Neuroscience, BCCN, Freiburg, Germany.

1999–00: Departmental Fellow, Physics Department, The Ohio State University.

Languages

Fluent: English, Gujarati, Hindi, Marathi

Last updated: September 10, 2026