

TODD R. GINGRICH

Department of Chemistry
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PROFESSIONAL APPOINTMENTS

Assistant Professor of Chemistry, Northwestern University 2018–present
Physics of Living Systems Fellow, Massachusetts Institute of Technology 2015–2018

EDUCATION

University of California, Berkeley, CA 2010–2015
Ph.D., Chemistry
Thesis title: Two Paths Diverged: Exploring Trajectories, Protocols, and Dynamic Phases
Advisor: Prof. Phillip L. Geissler

University College, Oxford University, Oxford, UK 2008–2010
M.Sc. (By Research), Physical and Theoretical Chemistry
Thesis title: Simulating Surface Charge Effects in Carbon Nanotube Templated Ionic Crystal Growth
Advisor: Prof. Mark Wilson

California Institute of Technology, Pasadena, CA 2004–2008
B.S. with Honors, Chemistry
Advisor: Prof. Nathan S. Lewis

MAJOR RESEARCH INTERESTS

Statistical mechanics, stochastic thermodynamics, chemical kinetics, molecular motors, tensor networks, molecular simulations, and theoretical biophysics.

AWARDS AND HONORS

New Horizons Solvay Lecture in Chemistry 2025
Camille Dreyfus Teacher-Scholar Award 2024
Weinberg College of Arts & Sciences Distinguished Teaching Award, Northwestern University 2023
NSF Faculty Career Development (CAREER) Award 2023
Sloan Research Fellow 2023
Searle Fellows Program, Searle Center for Advancing Learning and Teaching 2019-2020
APS Oppenheim Award 2019
Physics of Living Systems Fellowship, MIT 2015
Outstanding Graduate Student Instructor, UC Berkeley 2013
Dan Lucas Book Prize, UC Berkeley 2011
Richard P. Schuster Chemistry Prize, Caltech 2008
Fannie and John Hertz Foundation Graduate Fellowship 2008
National Science Foundation Graduate Research Fellowship 2008
Rhodes Scholarship 2008
Robert L. Noland Leadership Award, Caltech 2007
Amgen Scholars Summer Research Fellowship, Caltech 2007
Upper Class Merit Award, Caltech 2005-2008
Robert C. Byrd Honors Scholarship 2004-2008

PREPRINTS (TRG as a corresponding author in bold; Gingrich group members underlined)

Strand, N.E.; Nicholson, S.B.; Vroylandt, H.; **Gingrich, T.R.** "From high-dimensional committors to reactive insight." *arXiv:2406.xxxx*, 2024.

Penocchio, E.; Gu, G.; Albaugh, A.; **Gingrich, T.R.** "Power strokes in molecular motors: predictive, irrelevant, or somewhere in between?" *ChemRxiv:10.26434/chemrxiv-2024-rjbdc*, 2024.

Tan, T.H.; Watson, G.A.; Chao, Y.-C.; Li, J.; Gingrich, T.R.; Horowitz, J.M.; Fakhri, N. "Scale-dependent irreversibility in living matter." *arXiv:2107.05701*, 2021.

PUBLICATIONS**Northwestern Faculty Career**

31. Albaugh, A.; Fu, R.-S.; Gu, G.; **Gingrich, T.R.** "Limits on the Precision of Catenane Motors: Insights from Thermodynamics and Molecular Dynamics Simulations." *J. Chem. Theory Comput.*, 2024, 20, 1-6. [DOI:[10.1021/acs.jctc.3c01201](https://doi.org/10.1021/acs.jctc.3c01201)]
30. Nicholson, S.B.; **Gingrich, T.R.** "Quantifying Rare Events in Stochastic Reaction-Diffusion Dynamics Using Tensor Networks." *Phys. Rev. X*, 2023, 13, 041006. [DOI:[10.1103/PhysRevX.13.041006](https://doi.org/10.1103/PhysRevX.13.041006)]
29. Albaugh, A.; Gu, G.; **Gingrich, T.R.** "Sterically driven current reversal in a molecular motor model." *Proc. Natl. Acad. Sci. USA*, 2023, 120(33), e2210500120. [DOI:[10.1073/pnas.2210500120](https://doi.org/10.1073/pnas.2210500120)]
28. Binks, L.; Borsley, S.; Gingrich, T.R.; Leigh, D.A.; Penocchio, E.; Roberts, B.W. "The role of kinetic asymmetry and power strokes in an information ratchet." *Chem*, 2023, 9, 1-16. [DOI:[10.1016/j.chempr.2023.05.035](https://doi.org/10.1016/j.chempr.2023.05.035)]
27. Fu, R.-S.; **Gingrich, T.R.** "Thermodynamic uncertainty relation for Langevin dynamics by scaling time." *Phys. Rev. E*, 2022, 106, 024128. [DOI:[10.1103/PhysRevE.106.024128](https://doi.org/10.1103/PhysRevE.106.024128)]
26. Strand, N.E.; Vroylandt, H.; **Gingrich, T.R.** "Computing time-periodic steady-state currents via the time evolution of tensor network states." *J. Chem. Phys.*, 2022, 157, 054104. [DOI:[10.1063/5.0099741](https://doi.org/10.1063/5.0099741)]
25. **Gingrich, T.R.** "Measuring how effectively light drives a molecular pump." *Nat. Nanotechnol.*, 2022, 17, 675 [DOI:[10.1038/s41565-022-01152-x](https://doi.org/10.1038/s41565-022-01152-x)] (News & Views)
24. Strand, N.E.; Vroylandt, H.; **Gingrich, T.R.** "Using tensor network states for multi-particle Brownian ratchets." *J. Chem. Phys.*, 2022, 156, 221103. [DOI:[10.1063/5.0097332](https://doi.org/10.1063/5.0097332)] (Editor's Pick)
23. Albaugh, A.; **Gingrich, T.R.** "Simulating a Chemically Fueled Molecular Motor with Nonequilibrium Molecular Dynamics." *Nat. Comm.*, 2022, 13, 2204. [DOI:[10.1038/s41467-022-29393-3](https://doi.org/10.1038/s41467-022-29393-3)]
22. Albaugh, A.; **Gingrich, T.R.** "Estimating Reciprocal Partition Functions to Enable Design Space Sampling." *J. Chem. Phys.*, 2020, 153, 204102. [DOI:[10.1063/5.0025358](https://doi.org/10.1063/5.0025358)]
21. Strand, N.E.; Fu, R.-S.; **Gingrich, T.R.** "Current inversion in a periodically driven two-dimensional Brownian ratchet." *Phys. Rev. E*, 2020, 102, 012141. [DOI:[PhysRevE.102.012141](https://doi.org/10.1103/PhysRevE.102.012141)] (Editor's Suggestion)
20. Owen, J.A.; Gingrich, T.R.; Horowitz, J.M. "Universal thermodynamic bounds on nonequilibrium response with biochemical applications." *Phys. Rev. X*, 2020, 10, 011066. [DOI:[10.1103/PhysRevX.10.011066](https://doi.org/10.1103/PhysRevX.10.011066)]
19. Vroylandt, H.; Proesmans, K.; **Gingrich, T.R.** "Isometric Uncertainty Relations." *J. Stat. Phys.*, 2020, 178, 1039-1053. [DOI:[10.1007/s10955-020-02484-5](https://doi.org/10.1007/s10955-020-02484-5)]
18. Horowitz, J.M.; **Gingrich, T.R.** "Thermodynamic uncertainty relations constrain nonequilibrium fluctuations." *Nat. Phys.*, 2020, 15, 1. [DOI:[10.1038/s41567-019-0702-6](https://doi.org/10.1038/s41567-019-0702-6)]
17. Li, J.; Horowitz, J.M.; **Gingrich, T.R.**; Fakhri, N. "Quantifying dissipation using fluctuating currents." *Nat. Comm.*, 2019, 10, 1666. [DOI:[10.1038/s41467-019-09631-x](https://doi.org/10.1038/s41467-019-09631-x)]

Independent Postdoctoral Fellowship

16. **Gingrich, T.R.**; Horowitz, J.M. "Fundamental Bounds on First Passage Time Fluctuations for Currents." *Phys. Rev. Lett.*, 2017, 119, 170601. [DOI:[PhysRevLett.119.170601](https://doi.org/10.1103/PhysRevLett.119.170601)]
15. Bisker, G.; Poletini, M.; Gingrich, T.R.; Horowitz, J.M.; "Hierarchical Bounds on Entropy Production Inferred from Partial Information." *J. Stat. Mech.: Theory Exp.*, 2017, 093210. [DOI:[10.1088/1742-5468/aa8c0d](https://doi.org/10.1088/1742-5468/aa8c0d)]
14. Horowitz, J.M.; **Gingrich, T.R.** "Proof of the Finite-Time Thermodynamic Uncertainty Relation for Steady-State Currents." *Phys. Rev. E*, 2017, 96, 020103(R). [DOI:[10.1103/PhysRevE.96.020103](https://doi.org/10.1103/PhysRevE.96.020103)] (Editor's Suggestion)

13. Zakine, R.; Solon, A.; Gingrich, T.R.; van Wijland, F. "Stochastic Stirling engine operating in contact with active baths." *Entropy*, **2017**, *19*(5), 193. [DOI:[10.3390/e19050193](https://doi.org/10.3390/e19050193)]
12. **Gingrich, T.R.**; Rotskoff, G.M.; Horowitz, J.M. "Inferring dissipation from current fluctuations." *J. Phys. A*, **2017**, *50*, 184004. [DOI:[10.1088/1751-8121/aa672f](https://doi.org/10.1088/1751-8121/aa672f)]
11. **Gingrich, T.R.**; Horowitz, J.M.; Perunov, N.; England, J.L. "Dissipation bounds all steady-state current fluctuations." *Phys. Rev. Lett.*, **2016**, *116*, 120601. [DOI:[PhysRevLett.116.120601](https://doi.org/PhysRevLett.116.120601)]

Mentored Research

10. **Gingrich, T.R.**; Rotskoff, G.M.; Crooks, G.E.; Geissler, P.L. "Near-optimal protocols in complex nonequilibrium transformations." *Proc. Natl. Acad. Sci. USA*, **2016**, *113*(37), 10263. [DOI:[10.1073/pnas.1606273113](https://doi.org/10.1073/pnas.1606273113)]
9. Gingrich, T.R.; Geissler, P.L. "Preserving correlations between trajectories for efficient path sampling." *J. Chem. Phys.*, **2015**, *142*(23), 234104. [DOI:[10.1063/1.4922343](https://doi.org/10.1063/1.4922343)] (**Editor's Choice**)
8. Gingrich, T.R.; Rotskoff, G.M.; Vaikuntanathan, S.; Geissler, P.L. "Efficiency and large deviations in time-asymmetric stochastic heat engines." *New J. Phys.*, **2014**, *16*(10), 102003. [DOI:[10.1088/1367-2630/16/10/102003](https://doi.org/10.1088/1367-2630/16/10/102003)] (**Fast Track Communication**)
7. Gingrich, T.R.; Vaikuntanathan, S.; Geissler, P.L. "Heterogeneity-induced large deviations in activity and (in some cases) entropy production." *Phys. Rev. E*, **2014**, *90*, 042123. [DOI:[10.1103/PhysRevE.90.042123](https://doi.org/10.1103/PhysRevE.90.042123)]
6. Vaikuntanathan, S.; Gingrich, T.R.; Geissler, P.L. "Dynamic phase transitions in simple driven kinetic networks." *Phys. Rev. E*, **2014**, *89*, 062108. [DOI:[10.1103/PhysRevE.89.062108](https://doi.org/10.1103/PhysRevE.89.062108)]
5. Gingrich, T.R.; Wilson, M. "The control of inorganic nanotube morphology using an applied potential." *J. Phys. Condens. Matter*, **2011**, *23*(13), 135306. [DOI:[10.1088/0953-8984/23/13/135306](https://doi.org/10.1088/0953-8984/23/13/135306)]
4. Gingrich, T.R.; Wilson, M. "On the Ewald summation of Gaussian charges for the simulation of metallic surfaces." *Chem. Phys. Lett.*, **2010**, *500*(1), 178. [DOI:[10.1016/j.cplett.2010.10.010](https://doi.org/10.1016/j.cplett.2010.10.010)]
3. Katz, J.E.; Gingrich, T.R.; Santori, E.A.; Lewis, N.S. "Combinatorial synthesis and high-throughput photopotential and photocurrent screening of mixed-metal oxides for photoelectrochemical water splitting." *Energy Environ. Sci.*, **2009**, *2*(1), 103. [DOI:[10.1039/B812177J](https://doi.org/10.1039/B812177J)]
2. Thallapally, P.K.; Dobrzanska, L.; Gingrich, T.R.; Wirsig, T.B.; Barbour, L.J.; Atwood, J.L. "Acetylene absorption and binding in a nonporous crystal lattice." *Angew. Chem.*, **2006**, *45*(39), 6506. [DOI:[10.1002/anie.200601391](https://doi.org/10.1002/anie.200601391)]
1. Gingrich, T.R.; Smith, G.P. "Hydroxyapatite chromatography of phage-display virions." *BioTechniques*, **2005**, *39*(6), 879. [DOI:[10.2144/000112032](https://doi.org/10.2144/000112032)]

PATENTS

N.S. Lewis, J.E. Katz, T.R. Gingrich. "High-throughput screening and device for photocatalysts." Issued 9/8/2015, US Patent No. 9,126,175.

RESEARCH SUPPORT

Present

Title: Computer Simulation of Molecular Motors Far from Equilibrium

Role: PI

Amount: \$1,963,820

Source: Gordon and Betty Moore Foundation

Dates: December 1, 2021–February 1, 2026

Title: Sloan Research Fellowship

Role: PI

Amount: \$75,000

Source: Sloan Foundation

Dates: September 15, 2023–September 14, 2025

Title: CAREER: Reaction-Diffusion Kinetics with Tensor Networks

Role: PI

Amount: \$650,000

Source: NSF CHE

Dates: September 1, 2023–August 31, 2028

Title: From Microscopic Motors to Macroscopic Work

Role: Seed Investigator

Amount: \$100,000

Source: International Institute of Nanotechnology Seed Grant

Dates: September 15, 2023–September 14, 2024

Title: Self-Propellant Nanoparticle@MOF Catalysts for Chemical Warfare Agent Detoxification

Role: Co-PI (with Omar Farha) Source: DTRA
 Amount: \$2,500,000 (\$240,000 for TRG) Dates: March 2024-March 2029

Title: Computational Tools for Stochastic, Far-From-Equilibrium Chemical Kinetics
 Role: PI Source: Camille Dreyfus Teacher-Scholar Award
 Amount: \$100,000 Dates: June 2024-June 2029

Completed

Title: EAGER: ADAPT: Optimizing chemical reaction networks with AI
 Role: PI Source: NSF CHE
 Amount: \$300,000 Dates: September 1, 2021–August 31, 2023

Title: Steering the dynamics of nanomachines
 Role: Seed Investigator Source: International Institute of Nanotechnology Seed Grant
 Amount: \$100,000 Dates: February 1, 2021–July 31, 2022

INVITED LECTURES

New Horizons Solvay Lecture in Chemistry, Belgium	2025
Telluride Workshop on Condensed Phase Dynamics	July 2024
Dissipative Processes in Molecular Systems Workshop, Padova, Italy	June 2024
Nonequilibrium Dynamics, Information Processing, and Aging of Living Cells Workshop, ITS @ The Graduate Center, CUNY, New York, NY	May 2024
University of Michigan, Chemistry, Ann Arbor, MI	April 2024
University of Michigan, Complex Systems, Ann Arbor, MI	April 2024
University of Chicago, Department of Chemistry, Chicago, IL	March 2024
Stanford University, Department of Chemistry, Palo Alto, CA	March 2024
New York University, Department of Chemistry, New York, NY	March 2024
Rice University Center for Theoretical Biophysics, Houston, TX	February 2024
Rutgers University, Department of Chemistry, New Brunswick, NJ	December 2023
Northwestern/Muenster Symposium on Smart Materials, International Institute of Nanotechnology, Evanston, IL	August 2023
MIT, Physics of Living Systems, Cambridge, MA	June 2023
University of North Carolina, Department of Chemistry, Chapel Hill, NC	April 2023
Informal Statistical Physics Seminar, University of Maryland, College Park, MD	April 2023
Rare Events: Analysis, Numerics, and Applications, Brin Mathematics Research Center, University of Maryland, College Park, MD	February 2023
Northwestern University, Department of Physics, Evanston, IL	January 2023
Berkeley Statistical Mechanics Meeting, Berkeley, CA	January 2023
Telluride Workshop on Condensed Phase Dynamics	July 2022
Midwest Theoretical Chemistry Conference, Columbus, OH	June 2022
Workshop on Stochastic Thermodynamics II, Sante Fe Institute, Sante Fe, NM (Virtual)	May 2021
University of Colorado at Boulder, Department of Chemistry, Boulder, CO (Virtual)	March 2021
Oxford University, Theoretical Chemistry Group, Oxford, England (Virtual)	February 2021
Telluride Workshop on Condensed Phase Dynamics (Virtual)	July 2020
Illinois State University, Department of Physics, Normal, IL	February 2020
Oppenheim Prize Talk, APS March Meeting, Boston, MA	March 2019
Lawrence Berkeley National Lab/UC Berkeley Soft Matter Seminar, Berkeley, CA	January 2019
Why Measure Entropy Production?, Princeton Center for Theoretical Science, Princeton, NJ	November 2018
Stochastic Thermodynamics: Experiment and Theory, Max Planck Institute for	

the Physics of Complex Systems, Dresden, Germany	September 2018
Telluride Workshop on Condensed Phase Dynamics	July 2018
CCI Solar Fuels Workshop, Ventura, CA	July 2018
Large deviation theory in statistical physics: Recent advances and future challenges, Indian Center for Theoretical Sciences (ICTS), Bangalore, India	September 2017
Igert Summer Institute, Brandeis University, Waltham, MA	June 2017
Berkeley Statistical Mechanics / Machine Learning Meeting, Berkeley, CA	January 2017
New York University, Department of Chemistry, New York, NY	December 2016
Stanford University, Department of Chemistry, Palo Alto, CA	December 2016
Columbia University, Department of Chemistry, New York, NY	November 2016
University of California at Santa Barbara, Department of Chemistry, Santa Barbara, CA	November 2016
Northwestern University, Department of Chemistry, Evanston, IL	October 2016
Boston University, Condensed Matter Theory / Biophysics, Boston, MA	March 2016
JCP Editor's Choice Session, APS March Meeting, Baltimore, MD	March 2016
Modeling and Inference from Single Molecules to Cells, MBI Workshop, Columbus, OH	February 2016
Large Deviation Theory in Principle and in Practice, Princeton Center for Theoretical Science, Princeton, NJ	November 2015
Chemistry & Physics of Liquids Gordon Research Conference, Poster Prize Short Talk, Holderness, NH	August 2015
Workshop on Statistical mechanics and computation of large deviation rate functions, Ecole Normale Superieure, Lyon, France	June 2015
Princeton University, Princeton Biophysics Symposium, Princeton	December 2014
Workshop on Large deviations in statistical physics, National Institute for Theoretical Physics (NITheP), Stellenbosch, South Africa	July 2014

TEACHING EXPERIENCE (Number of students in [...])

CHEM 171: Advanced General Inorganic Chemistry (new curriculum development)

- Fall 2023 [191 students] and 2022 [175]
- Average rating for course: 4.64/6.00; average rating for instructor: 5.26/6.00

CHEM 348: Physical Chemistry for ISP (new curriculum development)

- Spring 2022 [11], 2021 [12], 2020 [11], 2019 [8]
- Average rating for course: 5.42/6.00; average rating for instructor: 5.95/6.00

CHEM 444: Elementary Statistical Mechanics (new curriculum development)

- Fall 2023 [21], 2022 [20], 2020 [9], 2019 [14], 2018 [13]
- Average rating for course: 5.49/6.00; average rating for instructor: 5.70/6.00

ADVISING/SUPERVISION

Graduate students (2 completed PhDs, 4 in progress):

John Zima (2024-); Cathryn (Kate) Murphy (2022-); Jonah Greenberg (2019-); Geyao Gu (2019-); Nils Strand (2018-2023; PhD); Rueih-Sheng (Ray) Fu (2018-2023; PhD)

Postdoctoral scholars (2 completed, 4 in progress):

John Strahan (2024-); Kathleen Krist (2022-); Emanuele Penocchio (2022-); Schuyler (Sky) Nicholson (2020-); Alex Albaugh (2018-2022; Current position: Asst. Prof. of Chemical Engineering, Wayne State); Hadrien Vroylandt (2018-2020; Current position: Postdoctoral Researcher, Sorbonne Universite)

Undergraduate research students:

Drew Alvarez (2023-); Isabelle Goodrow (Summer 2023); Ashini Shah (2022-2023); Niles Babin (Summer 2022; IIN REU); Akhil Kalghatgi (2021; ISP 398 student)

EXTERNAL SERVICE

<i>Physical Review E</i> Editorial Board Member	2022-2024
Co-organizer and Statistical Mechanics Instructor, Telluride School on Theoretical Chemistry Telluride Science Research Center; 2021 & 2023	2021-2023
ACS Junior/Senior Theory Award Committee	2022
APS Oppenheim Award Selection Committee	2020
District 15 Rhodes Scholar Selection Committee	2013-2015

UNIVERSITY SERVICE

Integrated Science Program (ISP) Associate Director (2023-), Slivka Residential College Fellow (2023-), ISP Committee (2022-)

DEPARTMENTAL SERVICE

Graduate Curriculum Committee (2023-), Asst. Prof. of Instruction Search Committee Chair (2022-23), General Chemistry Committee (2021-), Graduate Admissions Committee (2018-)