

TODD R. GINGRICH

Department of Chemistry
Northwestern University
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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, nonequilibrium self-assembly, and biophysics.

AWARDS AND HONORS

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

TOP 5 CITED PAPERS (Number of citations in parentheses according to Google Scholar, 8/30/23)

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/10.1103/PhysRevLett.116.120601)] (578 citations)

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)] (347 citations)

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)] (239 citations)

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)] (173 citations)

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)] (157 citations)

PREPRINTS

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

Albaugh, A.; Fu, R.-S.; Gu, G.; **Gingrich, T.R.** “Thermodynamic Uncertainty Limits to the Precision of Loosely Coupled Molecular Motors” *arXiv:2306.03182*, **2023**.

Nicholson, S.B.; **Gingrich, T.R.** “Quantifying Rare Events in Stochastic Reaction-Diffusion Dynamics Using Tensor Networks.” *arXiv:2301.03717*, **2023**. (To Appear in *Physical Review X*)

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

29. Albaugh, A.; Gu, G.; **Gingrich, T.R.** “Current Reversal in a Molecular Motor.” *Proc. Natl. Acad. Sci. USA*, **2023**, *120*(33), e2210500120. [DOI:[10.1073/pnas.221050012](https://doi.org/10.1073/pnas.221050012)]

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/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/s41567-019-0702-6567-019-0702-6](https://doi.org/10.1038/s41567-019-0702-6567-019-0702-6)]
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 (TRG as a corresponding author in bold)

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/PhysRevLett.119.170601)]
15. Bisker, G.; Poletti, 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)]

RESERCH SUPPORT

Present

Title: EAGER: ADAPT: Optimizing chemical reaction networks with AI

Source: NSF CHE

Role: PI

Amount: \$300,000

Dates: September 1, 2021–August 31, 2023

Title: Computer Simulation of Molecular Motors Far from Equilibrium

Source: Gordon and Betty Moore Foundation

Role: PI

Amount: \$1,963,820

Dates: December 1, 2021–February 1, 2026

Title: Sloan Research Fellowship

Source: Sloan Foundation

Role: PI

Amount: \$75,000

Dates: February 15, 2023–February 14, 2025

Title: CAREER: Reaction-Diffusion Kinetics with Tensor Networks

Source: NSF CHE

Role: PI

Amount: \$650,000

Proposed Dates: September 1, 2023–August 31, 2028

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

Northwestern/Muenster Symposium on Smart Materials, International Institute of Nanotechnology, Evanston, IL	August 2023
Massachusetts Institute of Technology, 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
Berkeley Statistical Mechanics Meeting, Berkeley, CA (Canceled due to Omicron Variant)	January 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	June 2015

Normale Supérieure, Lyon, France
 Princeton University, Princeton Biophysics Symposium, Princeton
 Workshop on Large deviations in statistical physics, National Institute for Theoretical
 Physics (NITheP), Stellenbosch, South Africa

December 2014

July 2014

TEACHING EXPERIENCE

CHEM 171: Advanced General Inorganic Chemistry (new curriculum development) Fall 2022

- 2022 (175 students): 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 2019-2022

- 2022 (11 students): Average rating for course: 5.40/6.00; average rating for instructor: 6.00/6.00
- 2021 (12 students): Average rating for course: 5.30/6.00; average rating for instructor: 5.90/6.00
- 2020 (11 students): Average rating for course: 5.43/6.00; average rating for instructor: 6.00/6.00
- 2019 (8 students): Average rating for course: 5.63/6.00; average rating for instructor: 5.88/6.00

CHEM 444: Elementary Statistical Mechanics (new curriculum development) Fall 2018-2022

- 2022 (20 students): Average rating for course: 5.27/6.00; average rating for instructor: 5.57/6.00
- 2020 (9 students): Average rating for course: 5.67/6.00; average rating for instructor: 5.67/6.00
- 2019 (14 students): Average rating for course: 5.67/6.00; average rating for instructor: 6.00/6.00
- 2018 (13 students): Average rating for course: 5.50/6.00; average rating for instructor: 5.58/6.00

ADVISING/SUPERVISION

Graduate students

Cathryn (Kate) Murphy	2022–present
Jonah Greenberg	2019–present
Geyao Gu	2019–present
Nils Strand	2018–present
Rueih-Sheng (Ray) Fu	2018–2023

Postdoctoral scholars

Kathleen Krist	2022–present
Emanuele Penocchio	2022–present
Schuyler (Sky) Nicholson	2020–present
Alex Albaugh (current position: Assistant Professor of Chemical Engineering, Wayne State)	2018–2022
Hadrien Vroylandt (current position: postdoctoral researcher, Sorbonne Université)	2018–2020

Undergraduate students

Drew Alvarez (Northwestern '26)	2023–present
Isabelle Goodrow (Cornell '24)	2023
Ashini Shah (Northwestern '23)	2022–2023
Niles Babin (Harvey Mudd '24), IIN REU	2022
Akhil Kalghatgi (Northwestern '23), ISP 398 student	2021
Nikhil Kalghatgi (Northwestern '23)	2021

UNIVERSITY SERVICE

Departmental service

Assistant Professor of Instruction Search Committee Chair	2022–2023
General Chemistry Committee	2021–present
Graduate Admissions Committee	2018–present

University service

Integrated Science Program (ISP) Committee	2022-present
Slivka Residential College Fellow	2023-present

Prestigious postgraduate fellowship advisor 2018-present

- Mock interviews and advising coordinated through the Office of Fellowships for Lois Biggs, Claire Petersen, Paul Ohno, Seth Garwin, Yuanzhao Zhang, Natalie Smith, Lindsay Zimmerman, Andrew Rosen, Austin Evans, Thomas Li, Andrew Laeuger

Qualifying exam committee member

1. Evan Oriel	2023
2. Alex Krotz	2022
3. Baxter Flor	2022
4. Adam Nijhawan	2021
5. Malik Williams	2021
6. Curt Waltmann (MSE)	2021
7. Andrew Salij	2021
8. Fanrui Sha	2021
9. Emmaline Lorenzo	2020
10. Aaron Stone	2020
11. Fangbai Xie	2020
12. Max Meiorow	2020
13. Zhao Li (ChBE)	2020
14. Shelby Cuthriell	2020
15. Haochuan Mao	2019
16. Craig Laing	2019
17. Megan Wasson	2019
18. John Rosenberg	2019
19. Yange Lin	2019
20. Yeonjun Jeong	2019

Dissertation committee member

1. Fangbai Xie	2023
2. Emmaline Lorenzo	2023
3. Yange Lin	2023
4. Shelby Cuthriell	2023
5. Curt Waltmann (MSE)	2023
6. Aaron Stone	2023
7. Craig Laing	2023
8. Yeonjun Jeong	2022
9. Cindy Zhang	2021
10. Darren Hsu	2020
11. Mohamad Kodaimati	2019

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 (~100 students virtual, 2021 + 32 students, 2023)	2021-2023
ACS Junior/Senior Theory Award Committee	2022
APS Oppenheim Award Selection Committee	2020
Book reviewer: “Stochastic Thermodynamics: An Introduction” by Luca Peliti and Simone Pigolotti	2019
<i>Ad hoc</i> reviewer: NSF CAREER	2018
Reviewer: Proc. Natl. Acad. Sci. USA, Phys. Rev. X, Nat. Chem., Nat. Phys., Nat. Nanotechnol., Nat. Comm., Phys. Rev. Lett., J. Am. Chem. Soc., J. Phys. Chem., J. Chem. Phys., Phys. Rev. E, J. Stat. Phys., J. Stat. Mech.:Theory Exp., J. Phys. A, Eur. Phys. Lett., Phys. Rev. B, New J. Phys.	2014-present
District 15 Rhodes Scholar selection committee	2013-2015

PATENTS AND PATENT APPLICATIONS

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.