Alec Kirkley

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EDUCATION

Ph.D. Physics, University of Michigan, 2021
Advisor: Mark Newman
Thesis: "Complex Networks: Structure and Inference"

M.S. Physics, University of Michigan, 2018

B.S. Physics *summa cum laude*, University of Rochester, 2017

B.A. Mathematics *summa cum laude*, University of Rochester, 2017

ACADEMIC APPOINTMENTS

2022– University of Hong Kong
Assistant Professor, School of Computing and Data Science (host), 2025–
Assistant Professor, Department of Urban Planning and Design (co-host), 2022–
Assistant Professor, Musketeers Foundation Institute of Data Science (host), 2022-2025

2022–22 City University of Hong Kong
Assistant Professor, School of Data Science

2017–21 University of Michigan
Graduate Teaching and Research Assistant (NDSEG Fellow)

RESEARCH SUMMARY

Keywords: Network Science, Complex Systems, Statistical Physics, Statistical Inference

My research centers around the design, optimization, and analysis of principled methods for inference and unsupervised learning with network data. The goal of these methods is to enable theoretically meaningful, conceptually consistent summaries and comparisons of complex systems, while ensuring robustness to statistical fluctuations and scalability to large empirical datasets. I strongly subscribe to Occam's Razor, leading me to prefer simple models as well as Bayesian and information theoretic approaches to inference and learning.

My current research falls into three main lines:

1. Developing statistically principled unsupervised learning methods for noisy network data
2. Improving the efficiency and interpretability of network model fitting and evaluation
3. Characterizing heterogeneity and correlations in spatial data with network methods, with an eye towards urban and geographical applications

PUBLICATIONS

Journals

Physics and Network Science: Physical Review X, Physical Review Letters, Communications Physics, Physical Review E, Physical Review Research, Journal of Complex Networks

Multidisciplinary Sciences: Science Advances, Nature Communications, PNAS Nexus, Proceedings of the Royal Society A, Journal of the Royal Society Interface, Scientific Reports

Other Topics: Journal of Open Source Software

Publications as a leading author

†co-first authorship, *corresponding authorship, $^{\#}$student/postdoc under my supervision

26. **A. Kirkley***, Helcio Felippe$^{\#}$, Federico Malizia, and Federico Battiston, Hypergraph backboning. *Preprint arXiv:2606.00893* (2026).

25. J. Wu$^{\#}$, B. He$^{\#}$, and **A. Kirkley***, Networks of amenities reveal universal homophily and heterophily across global cities. *Preprint arXiv:2605.08622* (2026).

24. J. Weng$^{\#}$ and **A. Kirkley***, Scalable inference of spatial regions and temporal signatures from time series. *Preprint arXiv:2605.05008* (2026).

23. H. Felippe$^{\dagger,\#}$, **A. Kirkley**$^{\dagger *}$, and F. Battiston, Information theory for hypergraph similarity. *Science Advances* **12**, eaec5619 (2026).

22. S. Kim$^{\#}$ and **A. Kirkley***, Belief propagation for finite networks using a symmetry-breaking source node. *Physical Review Research* **8**, 013202 (2026).

21. S. Morel-Balbi$^{\#}$ and **A. Kirkley***, Learning when to rank: Estimation of partial rankings from sparse, noisy comparisons. *Communications Physics* **9**, 30 (2026).

20. **A. Kirkley***, H. Felippe$^{\#}$, and F. Battiston, Structural Reducibility of Hypergraphs. *Physical Review Letters* [Editor's Suggestion] **135**, 247401 (2025).

19. **A. Kirkley**, Transfer entropy for finite data. *Physical Review E* [Letter, Editor's Suggestion] **112**, L052304 (2025).

18. **A. Kirkley**, Fast nonparametric inference of network backbones for weighted graph sparsification. *Physical Review X* **15**, 031013 (2025).

17. **A. Kirkley**, Inference of dynamic hypergraph representations in temporal interaction data. *Physical Review E* **109**, 054306 (2024).

16. **A. Kirkley**, Identifying hubs in directed networks. *Physical Review E* [Editor's Suggestion] **109**, 034310 (2024).

15. H. Felippe$^{\#}$, F. Battiston, and **A. Kirkley***, Network mutual information measures for graph similarity. *Communications Physics* **7**, 335 (2024).

14. S. Morel-Balbi[#] and **A. Kirkley**[*], Bayesian regionalization of urban mobility networks. *Physical Review Research* **6**, 033307 (2024).

13. **A. Kirkley**[*] and B. He[#], PANINIpy: Package of Algorithms for Nonparametric Inference with Networks In Python. *Journal of Open Source Software* **9**, 7312 (2024).

12. B. Poudyal, G. Ghoshal, and **A. Kirkley**[*], Characterizing network circuity among heterogeneous urban amenities. *Journal of the Royal Society Interface* **20**, 20230296 (2023).

11. T. P. Peixoto and **A. Kirkley**[*], Implicit models, latent compression, intrinsic biases, and cheap lunches in community detection. *Physical Review E* **108**, 024309 (2023).

10. **A. Kirkley**[*], A. Rojas, M. Rosvall, and J-G. Young, Compressing network populations with modal networks reveals structural diversity. *Communications Physics* **6**, 148 (2023).

9. **A. Kirkley**, Spatial regionalization based on optimal information compression. *Communications Physics* **5**, 249 (2022).

8. **A. Kirkley**[*] and M. E. J. Newman, Representative community divisions of networks. *Communications Physics* **5**, 40 (2022).

7. J-G. Young[†], **A. Kirkley**[†], and M. E. J. Newman, Clustering of heterogeneous populations of networks. *Physical Review E* **105**, 014312 (2022).

6. **A. Kirkley**[†*], G. T. Cantwell[†], and M. E. J. Newman, Belief propagation for networks with loops. *Science Advances* **7**, eabf1211 (2021).

5. S. Feng and **A. Kirkley**[*], Integrating online and offline data for crisis management: Online geolocalized emotion, policy response, and local mobility during the COVID crisis. *Scientific Reports* **11**, 8514 (2021).

4. **A. Kirkley**, Information theoretic network approach to socioeconomic correlations. *Physical Review Research* **2**, 043212 (2020).

3. S. Feng and **A. Kirkley**[*], Mixing patterns in interdisciplinary co-authorship networks at multiple scales. *Scientific Reports* **10**, 7731 (2020).

2. **A. Kirkley**[*], G. T. Cantwell, and M. E. J. Newman, Balance in signed networks. *Physical Review E* **99**, 012320 (2019).

1. **A. Kirkley**, H. Barbosa, M. Barthelemy, and G. Ghoshal, From the betweenness centrality in street networks to structural invariants in random planar graphs. *Nature Communications* **9**, 2501 (2018).

Publications as a co-author

11. S. Feng, B. He, D. Gasevic, and **A. Kirkley**, Heterogeneous Interaction Network Analysis (HINA): A New Learning Analytics Approach for Modelling, Analyzing, and Visualizing Complex Interactions in Learning Processes. *Preprint arXiv:2601.06771* (2026).

10. M. Jerdee, **A. Kirkley**, and M. E. J. Newman, Normalized mutual information is a biased measure for classification and community detection. *Nature Communications* **16**, 11268 (2025).

9. S. Feng, B. He, and **A. Kirkley**, HINA: A Learning Analytics Tool for Heterogenous Interaction Network Analysis in Python. *Journal of Open Source Software* **10**, 8299 (2025).

8. M. Jerdee, **A. Kirkley**, and M. E. J. Newman, Mutual information and the encoding of contingency tables. *Physical Review E* [Editor's Suggestion] **110**, 064306 (2024).

7. L. Hébert-Dufresne, J.G. Young, A. Daniels, **A. Kirkley**, and A. Allard, Network compression with configuration models and the minimum description length. *Physical Review E* **110**, 034305 (2024).

6. M. Jerdee, **A. Kirkley**, and M. E. J. Newman, Improved estimates for the number of non-negative integer matrices with given row and column sums. *Proceedings of the Royal Society A* **480**, 20230470 (2024).

5. G. T. Cantwell, **A. Kirkley**, and F. Radicchi, Heterogeneous message passing for heterogeneous networks. *Physical Review E* **108**, 034310 (2023).

4. S. Mimar, D. Soriano-Paños, **A. Kirkley**, H. Barbosa, A. Sadilek, A. Arenas, J. Gómez-Gardeñes, and G. Ghoshal, Connecting intercity mobility with urban welfare. *PNAS Nexus* **1**, pgac178 (2022).

3. J. Aguilar, A. Bassolas, G. Ghoshal, S. Hazarie, **A. Kirkley**, M. Mazzoli, S. Meloni, S. Mimar, V. Nicosia, J. J. Ramasco, and A. Sadilek, Impact of urban structure on infectious disease spreading. *Scientific Reports* **12**, 3816 (2022).

2. G. T. Cantwell, **A. Kirkley**, and M. E. J. Newman, The friendship paradox in real and model networks. *Journal of Complex Networks* **9**, cnab011 (2021).

1. A. A. Klishin, **A. Kirkley**, D. J. Singer, and G. van Anders, Robust design from systems physics. *Scientific Reports* **10**, 14334 (2020).

GRANTS AND AWARDS

Grants and Fellowships

2026–28 **PI**. General Research Fund (**GRF**) Project No. 17300225, Hong Kong Research Grants Council (496,000 HKD).

2026–27 **Co-I**. General Research Fund (**GRF**) Project No. 17620925, Hong Kong Research Grants Council (570,000 HKD).

2025–27 **PI**. General Research Fund (**GRF**) Project No. 17301024, Hong Kong Research Grants Council (481,834 HKD).

2025-27 **PI**. Young Scientist Fund Project No. 12405044, National Science Foundation of China (327,857 HKD).

2024–26 **PI**. Early Career Scheme (**ECS**) Project No. 27302523, Hong Kong Research Grants Council (538,415 HKD).

2024–26 **PI**. Urban Systems Institute Fellowship Grant, University of Hong Kong (200,000 HKD).

2024–26 **Co-I**. General Research Fund (**GRF**) Project No. 17603323, Hong Kong Research Grants Council (1,168,000 HKD).

2023–25 **Co-PI**. Data Science Research Seed Fund, University of Hong Kong (300,000 HKD).

2022–25 **PI**. HKU-100 Scholars Start Up Grant, University of Hong Kong (3,000,000 HKD).

2019–21 National Defense Science and Engineering Graduate (**NDSEG**) Fellowship, United States Department of Defense (115,200 USD).

2019 National Science Foundation Graduate Research Fellowship (**NSF GRFP**), US National Science Foundation (111,000 USD; declined in order to accept NDSEG fellowship).

2019 Rackham Research Grant, University of Michigan (3,000 USD).

Awards and Honors

2022 HKU-100 Scholar

2017 Summa cum laude, University of Rochester

2016 Phi Beta Kappa, University of Rochester

2016 Physics Honors Prize, University of Rochester

INVITED TALKS

2026 "Defining Balance in Signed Networks" (Keynote). NetSci 2026 (Frameworks, Research, and Applications in Complex Networks with Signed Edges). June 2026.

2026 "Information theory for hypergraph analysis" (Keynote). NetSci 2026 (Higher-Order Hackathon). June 2026.

2026 "Combinatorial transfer entropy for reconstructing networks from discrete dynamics". Department of Mathematics, City University of Hong Kong. March 2026.

2025 "Learning parsimonious hierarchies from pairwise comparisons: From sports teams to universities". IEEE ISI Conference 2025. July 2025.

2025 "Summarizing the structure of higher-order interactions with information theory" (Keynote). NetSci 2025 (TopoNets). June 2025.

2024 "From Hubs to Hypergraphs: Nonparametric Inference for Network Data with the MDL Principle". Network Science Institute, Northeastern University. May 2024.

2024 "Nonparametric Inference for Network Data with the Minimum Description Length Principle". Department of Mathematics and Statistics, University of Vermont. April 2024.

2024 "Principled Identification of Network Hubs". Complex Data Laboratory, Vermont Complex Systems Center, University of Vermont. April 2024.

2023 "Improved algorithms for statistical inference with complex network data: Loopy graphical models and parameter-free regionalization". Department of Physics, Hong Kong University of Science and Technology. February 2023.

2022 "Complex Network Inference: Efficient Algorithms and Insights for Urban Spatial Segregation". Department of Physics and Astronomy, University of Rochester. November 2022.

2022 "Complex Network Inference: Efficient Algorithms and Insights for Urban Spatial Segregation". Institute of Data Science Seminar Series, University of Hong Kong. August 2022.

2022 "Advancing Urban Analytics and Fundamental Data Science with Complex Networks". Institute of Data Science and Department of Urban Planning, University of Hong Kong. February 2022.

2022 "Summarizing Heterogeneous Landscapes of Network Community Divisions". Centre for Complexity and Complex Networks, City University of Hong Kong. February 2022.

2021 "Complex Networks: From Theoretical Modelling to Applications in Urban Data Science". School of Data Science, City University of Hong Kong. February 2021.

2020 "Information Theoretic Network Approach to Socioeconomic Correlations". Network Science Institute, Northeastern University. December 2020.

SERVICE

Editorship

Editorial Board, *Journal of Complex Networks*.

Guest Editor, *Journal of Physics: Complexity*. Focus Issue on Statistical Inference and Machine Learning for Complex Networks

Managing Board, *PCI Network Science*

Academic Peer Review

Physics and Network Science: Physical Review Letters, Communications Physics, Physical Review E, Physical Review Research, Chaos, Journal of Complex Networks, APS Open Science, Journal of Physics: Complexity, Applied Network Science, PCI Network Science, Entropy, Quantum Information Processing Conference (QIP 2025)

Multidisciplinary Sciences: Proceedings of the National Academy of Sciences, Science Advances, Nature Communications, PNAS Nexus, Philosophical Transactions of the Royal

Society A, Journal of the Royal Society Interface, Royal Society Open Science, npj Complexity, PLOS Complex Systems, Scientific Reports, PLOS One, Humanities and Social Sciences Communications, Heliyon

Other Topics: International Journal of Geographical Information Science, Cities, ACM Transactions on Knowledge Discovery from Data, Statistics and Computing, Scientometrics, Knowledge and Information Systems, Geospatial Information Science, Transportmetrica A: Transport Science, IEEE Access

Funding Agency Peer Review

Natural Sciences and Engineering Research Council of Canada (NSERC)

Outreach and Community Collaborations

2022 *Learning Classroom Series for Secondary School Students: Smart Cities*, City University of Hong Kong.

2020–21 *Michigan Data Informed Cities for Everyone (M-DICE)*, University of Michigan and City of Detroit, MI.

2019–20 *Michigan Data Science Team*, University of Michigan.

MEMBERSHIPS AND OTHER AFFILIATIONS

Asian Network of Complexity Scientists

Center for Complexity and Complex Networks, City University of Hong Kong (External Member)

Network Science Society

Society of Young Network Scientists

Urban Systems Institute Fellow, University of Hong Kong

CONFERENCE ACTIVITY

Conference Organization

2026 NetSci 2026, Statistical Inference for Network Models organizing committee and Main Program PC member. Boston, USA. June 2026.

2025 NetSci 2025, Statistical Inference for Network Models organizing committee and Main Program PC member. Maastricht, Netherlands. June 2025.

2024 NetSci 2024, Statistical Inference for Network Models organizing committee and Main Program PC member. Quebec City, Canada. June 2024.

2024 Urban Systems Institute Conference 2024, Urban AI section chair. Hong Kong SAR, China. January 2024.

2023 NetSci 2023, Network Models section chair. Vienna, Austria. July 2023.

2022 NetSci 2022, Spatial Analysis section chair. Shanghai, China. July 2022.

Peer Reviewed Conference Contributions

2026 "Reducing transfer entropy for nonparametric network reconstruction from dynamics" (talk), NetSci 2026 (Boston, USA). June 2026.

2025 "Parameter-free weighted network backboning" (talk), NetSci 2025 (Maastricht, Netherlands). June 2025.

2024 "Constructing hypergraphs from temporal data" (talk), NetSci 2024 (Quebec City, Canada). June 2024.

2023 "Compressing network populations with modal networks reveals structural diversity" (talk), NetSci 2023 (Vienna, Austria). July 2023.

2022 "Regionalization through optimal information compression on spatial networks" (talk). NetSci 2022 (Shanghai, China). July 2022.

2021 "The Paradox of Interdisciplinary Collaboration" (talk, with Shihui Feng), NetSci 2021 (Bloomington, USA). July 2021.

2021 "Multimodal Community Structure in Networks" (talk), NetSci 2021 (Bloomington, USA). July 2021.

2020 "Probabilistic Models on Networks with Loops" (talk), NetSci 2020 (Rome, Italy). September 2020.

2019 "Balance in Signed Networks" (poster), NetSci 2019 (Burlington, USA). May 2019.

ACADEMIC WORKSHOPS AND SCHOOLS

2025 Organizer. *Understanding Complex Networks for Advancing Fundamental Data Science*. University of Hong Kong, Hong Kong SAR, China. August 2025.

2020 Participant. *Network Epidemiology in the Time of Coronavirus (Net-COVID)*. University of Maryland and University of Vermont, Online. April 2020.

2019 Participant. *Complex Networks Winter Workshop*. Laval University, Quebec City, Canada. December 2019.

2019 Participant. *Santa Fe Institute Complex Systems Summer School*. Santa Fe Institute, New Mexico, USA. June 2019.

TEACHING AND MENTORSHIP

Courses Taught at University of Hong Kong

Statistical Inference and Machine Learning for Network Data (Data Science PhD/MPhil)

Transport Network Analysis and Modelling (Urban Design and Transport MSc)

Science of Cities (Urban Analytics MSc)

Introduction to Bayesian Inference and Complex Networks (Data Science Summer Institute)

Data Science for Smart Societies (Data Science Summer Institute)

Courses Taught at University of Michigan

Network Theory (Physics PhD/MS), Teaching Assistant

Mechanics (Undergraduate), Lab Instructor

Courses Taught at University of Rochester

Mechanics (Undergraduate), Teaching Assistant

Introductory General Physics (Undergraduate), Workshop Leader

Tutor for Department of Mathematics

Teaching Awards and Certifications

2022 Professional Certificate in Teaching and Learning in Higher Education, HKU

Graduate Student and Postdoc Supervision

2026– Ethan Lam, PhD Student (Hong Kong PhD Fellowship recipient)

2025– Ya Wen, PhD Student

2025– Yingbang Zang, PhD Student

2024– Baiyue He, PhD Student

2024– Jiayu Weng, PhD Student (Hong Kong PhD Fellowship recipient)

2024– Yanting Zhang, PhD Student

2024– Jianrui Wu, PhD Student

2024–2026 Helcio Felippe, PhD Student (CEU Vienna, with Federico Battiston)

2024–2026 Seongmin Kim, Postdoctoral Fellow

2023–2025 Sebastian Morel-Balbi, Postdoctoral Fellow

Other Doctoral Committee Service

2023– Dining Liu, HKU Department of Urban Planning and Design (PhD co-supervisor)

2025 James Gachanja, HKU Department of Urban Planning and Design (PhD examiner)

2024 Yuebing Liang, HKU Department of Urban Planning and Design (PhD examiner)

2023 Puyuan Zhang, HKU Faculty of Education (PhD examiner)

Undergraduate Supervision

2025 Ethan Lam, University College London, HKU Summer Research Program

2025 Shihe Zhou, Tsinghua University, HKU IDS Summer Research Training Programme

2023 Brian Choy, UCLA, HKU Summer Research Program