

Heng Guo

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Current Positions

- Reader in algorithms and complexity, School of Informatics, University of Edinburgh 2022/08 – present
- Lecturer in algorithms and complexity, School of Informatics, University of Edinburgh 2017/09 – 2022/07

Past Experience

- Visiting professor, Institute for Theoretical Computer Science, Shanghai University of Finance and Economics 2019/06 – 2019/07
2018/05 – 2018/06
- Visiting scientist, Simons Institute for the Theory of Computing, University of California, Berkeley 2019/03 – 2019/04
- Postdoctoral research assistant, School of Mathematical Sciences, Queen Mary, University of London 2015/10 – 2017/08
- Google research fellow, Simons Institute for the Theory of Computing, University of California, Berkeley 2016/01 – 2016/05
- Visiting graduate student, Department of Computer Science, University of Oxford 2014/01 – 2014/06

Education

- Ph.D. in Computer Science University of Wisconsin-Madison, 2015
Advisor: Jin-Yi Cai
Thesis: Complexity Classification of Exact and Approximate Counting Problems
- M.A. in Mathematics University of Wisconsin-Madison, 2013
- M.S. in Computer Science Peking University, 2010
- B.S. in Mathematics Peking University, 2007

Research Interests

- Algorithms & Complexity, with an emphasis on computational counting and sampling.

Honours & Awards

- Awarded an European Research Council Starting Grant, 2021-2026.
- Best paper award of ICALP 2018 track A, for the paper “A polynomial-time approximation algorithm for all-terminal network reliability” (joint work with Mark Jerrum).
- EATCS distinguished dissertation award. European Association for TCS, 2016.
- Google research fellow. Simons Institute of Computing, UC-Berkeley, 2016 Spring.
- Simons award for graduate students in TCS. The Simons foundation, 2013-2015.
- Kang Zheng fellowship. Peking University, 2008-2009.

Research Grants

- European Research Council Starting Grant “New Approaches to Counting and Sampling”, 1st January 2021 – 30th June 2026 (sole PI). Award value: €1,468,303.
- EPSRC grant “Multilayer Algorithmics to Leverage Graph Structure”, 1st July 2020 – 30th June 2023 (Co-Investigator, 5%). PI: Dr. Kitty Meeks. Award value: £765,537.
- EPSRC grant “Benchmarking Quantum Advantage”, 1st June 2023 – 31st March 2025 (Co-Investigator, 5%). PI: Dr. Raul Garcia-Patron Sanchez. Award value: £498,884.

Advisees

- Giorgos Mousa (Ph.D. student, 2018 – 2022)
- Jiaheng Wang (Ph.D. student, 2020 – 2023; Postdoc, 2023 – 2024)
- Graham Freifeld (Ph.D. student, 2022 –)
- Zhidan Li (Visiting graduate student, 2022)
- Chunyang Wang (Visiting graduate student, 2024)
- Weiming Feng (Visiting graduate student, 2019; Postdoc, 2021 – 2023)
- Shuai Shao (Postdoc, 2021)
- Vishvajeet “Goje” Nagargoje (Postdoc, 2022 – 2024)
- Konrad Anand (Postdoc, 2024 – 2026)
- Alistair Benford (Postdoc, 2026)

Research Articles

- Deterministic counting from coupling independence
Xiaoyu Chen, Weiming Feng, Heng Guo, Xinyuan Zhang, and Zongrui Zou
FOCS’25, to appear
Available at arXiv: 2410.23225
- Sink-free orientations: a local sampler with applications
Konrad Anand, Graham Freifeld, Heng Guo, Chunyang Wang, and Jiaheng Wang
RANDOM’25, 60:1–19
Available at arXiv: 2502.05877
- Towards derandomising Markov chain Monte Carlo
Weiming Feng, Heng Guo, Chunyang Wang, Jiaheng Wang, and Yitong Yin
SIAM J. Comput., 54(3), 775–813, 2025
Preliminary version: **FOCS’23**, pp. 1963–1990
- Rapid mixing of the flip chain over non-crossing spanning trees
Konrad Anand, Weiming Feng, Graham Freifeld, Heng Guo, Mark Jerrum, and Jiaheng Wang
SoCG’25, 8:1–18
Available at arXiv: 2409.07892
- Approximate counting for spin systems in sub-quadratic time
Konrad Anand, Weiming Feng, Graham Freifeld, Heng Guo, and Jiaheng Wang
TheoretCS, 4:3, 2025
Preliminary version: **ICALP’24**, 11:1–20
- Deterministic approximation for the volume of the truncated fractional matching polytope
Heng Guo and Vishvajeet N

ITCS'25, 57:1–14

Available at arXiv: 2409.07283

- Fast sampling of satisfying assignments from random k -SAT with applications to connectivity
Zongchen Chen, Andreas Galanis, Leslie Ann Goldberg, Heng Guo, Andrés Herrera-Poyatos, Nitya Mani, and Ankur Moitra
SIAM J. Discrete Math., 38(4), 2750–2811, 2024
- Near-linear time samplers for matroid independent sets with applications
Xiaoyu Chen, Heng Guo, Xinyuan Zhang, and Zongrui Zou
RANDOM'24, 32:1–12
Available at arxiv: 2308.09683
- An FPRAS for two terminal reliability in directed acyclic graphs
Weiming Feng and Heng Guo
ICALP'24, 62:1-19
Available at arxiv: 2310.00938
- Swendsen-Wang dynamics for the ferromagnetic Ising model with external fields
Weiming Feng, Heng Guo, and Jiaheng Wang
Inf. Comput., 294:105066, 2023
- A simple polynomial-time approximation algorithm for the total variation distance between two product distributions
Weiming Feng, Heng Guo, Mark Jerrum, and Jiaheng Wang
TheoretCS, 2:8, 2023
Preliminary version: **SOSA'23**, pp. 343–347
- Improving Certified Robustness via Statistical Learning with Logical Reasoning
Zhuolin Yang, Zhikuan Zhao, Boxin Wang, Jiawei Zhang, Linyi Li, Hengzhi Pei, Bojan Karlaš, Ji Liu, Heng Guo, Ce Zhang, and Bo Li
NeurIPS'22
Available at arXiv: 2003.00120
- Inapproximability of counting hypergraph colourings
Andreas Galanis, Heng Guo, and Jiaheng Wang
ACM Trans. Comput. Theory, 14(3-4):10, 2022
- Improved bounds for randomly colouring simple hypergraphs
Weiming Feng, Heng Guo, and Jiaheng Wang
RANDOM'22, 25:1-17
Available at arXiv: 2202.05554
- Counting vertices of integer polytopes defined by facets
Heng Guo and Mark Jerrum
Discrete Comput. Geom., 70(3), 975–990, 2023
- Rapid mixing from spectral independence beyond the Boolean domain
Weiming Feng, Heng Guo, Yitong Yin, and Chihao Zhang
ACM Trans. Algorithms, 18(3):28, 2022
Preliminary version: **SODA'21**, pp. 1558–1577
- Perfect sampling from spatial mixing
Weiming Feng, Heng Guo, and Yitong Yin
Random Struct. Algorithms, 61(4), 678–709, 2022

- Counting solutions to random CNF formulas
Andreas Galanis, Leslie Ann Goldberg, Heng Guo, and Kuan Yang
SIAM J. Comput., 50(6), 1701–1738, 2021
Preliminary version: **ICALP’20**, 53:1–14
- Fast sampling and counting k -SAT solutions in the local lemma regime
Weiming Feng, Heng Guo, Yitong Yin, and Chihao Zhang
J. ACM, 68(6):40, 2021
Preliminary version: **STOC’20**, pp. 854–867
- FKT is not universal – A planar Holant dichotomy for symmetric constraints
Jin-Yi Cai, Zhiguo Fu, Heng Guo, and Tyson Williams
Theory Comput. Syst., 66, 143–308, 2022
Preliminary version: **FOCS’15**, pp. 1259–1276
- Zeros of Holant problems: locations and algorithms
Heng Guo, Chao Liao, Pinyan Lu, and Chihao Zhang
ACM Trans. Algorithms, 17(1):4, 2021
Preliminary version: **SODA’19**, pp. 2262–2278
- Modified log-Sobolev inequalities for strongly log-concave distributions
Mary Cryan, Heng Guo, and Giorgos Mousa
Ann. Probab., 49(1), 506–525, 2021
Preliminary version: **FOCS’19**, pp. 1358–1370
- Approximately counting bases of bicircular matroids
Heng Guo and Mark Jerrum
Combin. Probab. Comput., 30(1), 124–135, 2021
- Tight bounds for popping algorithms
Heng Guo and Kun He
Random Struct. Algorithms, 57(2), 371–392, 2020
- Zeros of ferromagnetic 2-spin systems
Heng Guo, Jingcheng Liu, and Pinyan Lu
SODA’20, pp. 181–192
Available at arXiv: 1907.06156
- The complexity of planar Boolean #CSP with complex weights
Heng Guo and Tyson Williams
J. Comput. Syst. Sci., 107, 1–27, 2020
Preliminary version: **ICALP’13**, pp. 516–527
- Perfect simulation of the hard disks model by partial rejection sampling
Heng Guo and Mark Jerrum
Ann. Inst. Henri Poincaré Comb. Phys. Interact., 8(2), 159–177, 2021
Preliminary version: **ICALP’18**, 69:1–10
- Counting hypergraph colorings in the local lemma regime
Heng Guo, Chao Liao, Pinyan Lu, and Chihao Zhang
SIAM J. Comput., 48(4), 1397–1424, 2019
Preliminary version: **STOC’18**, pp. 926–939
- Uniform sampling through the Lovász local lemma
Heng Guo, Mark Jerrum, and Jingcheng Liu

J. ACM, 66(3):18, 2019

Preliminary version: **STOC'17**, pp. 342–355

- A polynomial-time approximation algorithm for all-terminal network reliability
Heng Guo and Mark Jerrum
SIAM J. Comput., 48(3), 964–978, 2019
Preliminary version: **ICALP'18**, 68:1–12 (Best paper award for track A)
- Approximation via correlation decay when strong spatial mixing fails
Ivona Bezáková, Andreas Galanis, Leslie Ann Goldberg, Heng Guo, and Daniel Štefankovič
SIAM J. Comput., 48(2), 279–349, 2019
Preliminary version: **ICALP'16**, 45:1–13
- Uniqueness, spatial mixing, and approximation in ferromagnetic 2-spin systems
Heng Guo and Pinyan Lu
ACM Trans. Comput. Theory, 10(4):17, 2018
Preliminary version: **RANDOM'16**, 31:1–26
- Clifford gates in the Holant framework
Jin-Yi Cai, Heng Guo, and Tyson Williams
Theor. Comput. Sci., 745, 163–171, 2018
- Holographic algorithms beyond matchgates
Jin-Yi Cai, Heng Guo, and Tyson Williams
Inf. Comput., 259(1), 102–129, 2018
Preliminary version: **ICALP'14**, pp. 271–282
- Layerwise systematic scan: deep Boltzmann machines and beyond
Heng Guo, Kaan Kara, and Ce Zhang
AISTATS'18, PMLR 84, 178–187
- Random cluster dynamics for the Ising model is rapidly mixing
Heng Guo and Mark Jerrum
Ann. Appl. Probab., 28(2), 1292–1313, 2018
Preliminary version: **SODA'17**, pp. 1818–1827
- The complexity of approximating complex-valued Ising and Tutte partition functions
Leslie Ann Goldberg and Heng Guo
Comput. Complex., 26(4), 765–833, 2017
- A complete dichotomy arises from the capture of vanishing signatures
Jin-Yi Cai, Heng Guo, and Tyson Williams
SIAM J. Comput., 45(5), 1671–1728, 2016
Preliminary version: **STOC'13**, pp. 635–644
- The complexity of counting edge colorings and a dichotomy for some higher domain Holant problems
Jin-Yi Cai, Heng Guo, and Tyson Williams
Res. Math. Sci., 3:18, 2016
Preliminary version: **FOCS'14**, pp. 601–610
- #BIS-hardness for 2-spin systems on bipartite bounded degree graphs in the tree nonuniqueness region
Jin-Yi Cai, Andreas Galanis, Leslie Ann Goldberg, Heng Guo, Mark Jerrum, Daniel Štefankovič, and Eric Vigoda

J. Comput. Syst. Sci., 82(5), 690–711, 2016
Preliminary version: **RANDOM'14**, pp. 582–595

- The complexity of symmetric Boolean parity Holant problems
Heng Guo, Pinyan Lu, and Leslie G. Valiant
SIAM J. Comput., 42(1), 324–356, 2013
Preliminary version: **ICALP'11**, pp. 712–723
- Inapproximability after uniqueness phase transition in two-spin systems
Jin-Yi Cai, Xi Chen, Heng Guo, and Pinyan Lu
COCOA'12, pp. 336–347
Available at arXiv: 1205.2934
- The complexity of weighted Boolean #CSP modulo k
Heng Guo, Sangxia Huang, Pinyan Lu, and Mingji Xia
STACS'11, pp. 249–260
- On model checking Boolean BI
Heng Guo, Hanpin Wang, Zhongyuan Xu and Yongzhi Cao
CSL'09, pp. 302–316

Preprints

- Simulating Gaussian boson sampling on graphs in polynomial time
Konrad Anand, Zongchen Chen, Mary Cryan, Graham Freifeld, Leslie Ann Goldberg,
Heng Guo and Xinyuan Zhang
arXiv: 2511.16558
- Local-to-global contraction in simplicial complexes
Heng Guo and Giorgos Mousa
arXiv: 2012.14317

Book Chapters, Surveys, Other Writings

- On the complexity of Holant problems
Heng Guo and Pinyan Lu
The Constraint Satisfaction Problem, Dagstuhl Follow-Ups 7, 159–177, 2017
- Mapping the complexity of counting problems
Heng Guo
Bulletin of EATCS, No 120: October 2016
- Holant problems
Jin-Yi Cai, Heng Guo, and Tyson Williams
Encyclopedia of Algorithms 2016: 918–921

Talks

- Counting and sampling from a computational complexity perspective
 - 2025 Jul, Center for Statistics, Edinburgh, UK
- Deterministic counting from coupling independence
 - 2025 Mar, Partition Functions workshop, CWI, Amsterdam, NL
- An FPRAS for two terminal reliability in directed acyclic graphs
 - 2024 Apr, Algorithm & Complexity workshop, University of Cambridge, UK
 - 2023 Dec, Institute of Software, Chinese Academy of Sciences, Beijing, China
 - 2023 Dec, CFCS seminar, Peking University, Beijing, China

- Towards derandomising Markov chain Monte Carlo
 - 2023 Jun, joint Glasgow–Edinburgh algorithm theory workshop, Glasgow, UK
 - 2022 Dec, Warwick Theory Day, Warwick University, UK
 - 2022 Nov, Dagstuhl Seminar 22482: Computational Counting, Germany
- Partial rejection sampling and network reliability
 - 2022 Aug, three hour lectures in the 128th CCF Advanced Disciplines Lectures “Connectivity in graphs, networks, and solution spaces” Nanjing University, Nanjing, China (online)
- Entropy contraction and the random cluster model
 - 2022 Aug, two lectures in the Summer School “New tools for optimal mixing of Markov chains: Spectral independence and entropy decay” University of California - Santa Barbara, CA, US
- Fast sampling and counting k-SAT solutions in the local lemma regime
 - 2021 Jun, mini-Scottish Combinatorics Meeting part of “Round the world relay in combinatorics” (online)
 - 2020 Dec, Combinatorics Study Group, Queen Mary, University of London, UK (online)
 - 2020 Mar, LFCS lab lunch, University of Edinburgh, UK
- Modified log-Sobolev inequalities for strongly log-concave distributions
 - 2021 Oct, Huawei Strategy and Technology Workshop, Shenzhen, China (online)
 - 2021 Oct, Probability seminar, Durham University, UK (online)
 - 2020 Jan, Probability in the North East meeting, ICMS, Edinburgh, UK
 - 2019 Nov, Algorithms seminar, University of Sheffield, UK
 - 2019 Nov, FOCS, Baltimore, MD, US
 - 2019 Jul, TCS seminar, Nanjing University, Nanjing, China
 - 2019 Jun, IIS seminar, Tsinghua University, Beijing, China
 - 2019 Jun, John Hopcroft center lecture series Shanghai Jiao Tong University, Shanghai, China
 - 2019 Jun, Shanghai Theory Day 2019, Institute of Theoretical Computer Science, Shanghai University of Finance and Economics, Shanghai, China
 - 2019 Apr, Geometry of Polynomials program seminar, Simons Institute, University of California - Berkeley, CA, US
- Recent progress on counting and sampling algorithms
 - 2019 Jun, TCS seminar, Peking University, Beijing, China
- Counting hypergraph colorings in the local lemma regime
 - 2019 Mar, “Deterministic Counting” workshop, Simons Institute, University of California - Berkeley, CA, US
 - 2019 Jan, Combinatorics seminar, University of Birmingham, UK
 - 2018 Oct, LFCS lab lunch, University of Edinburgh, UK

- 2017 Dec, Tensor workshop, China Academy of Science, Beijing, China
- A polynomial-time approximation algorithm for all-terminal network reliability
 - 2018 Aug, Partition Functions workshop, Universiteit van Amsterdam, NL
 - 2018 Jul, Queen Mary Algorithms Day, London, UK
 - 2018 Jul, ICALP, Prague, Czech republic
 - 2018 Jun, Applied math seminar, Zhejiang University, Hangzhou, China
 - 2018 Jun, Institute of Theoretical Computer Science seminar
Shanghai University of Finance and Economics, Shanghai, China
 - 2018 May, FATA seminar, University of Glasgow, UK
 - 2018 May, TADS seminar, Alan Turing Institute, London, UK
 - 2018 Apr, Scottish Combinatorics Meeting, Edinburgh, UK
- A simple FPRAS for bi-directed reachability
 - 2017 Dec, TCS seminar, Peking University, Beijing, China
- Uniform sampling through the Lovász Local Lemma
 - 2017 Nov, Probability seminar, Heriot-Watt University, UK
 - 2017 Nov, ACiD seminar, University of Durham, UK
 - 2017 Aug, Dagstuhl Seminar 17341: Computational Counting, Germany
 - 2017 Jun, STOC, Montreal, Canada
 - 2017 Jun, Counting program reunion workshop, Simons Institute,
University of California - Berkeley, CA, US
 - 2017 May, Nanjing Theory Day 2017, Nanjing, China
 - 2016 Dec, TCS seminar, Nanjing University, Nanjing, China
 - 2016 Dec, Institute for Theoretical Computer Science workshop I,
Shanghai University of Finance and Economics, Shanghai, China
- Random cluster dynamics for the Ising model is rapidly mixing
 - 2017 Dec, Probability seminar, Peking University, Beijing, China
 - 2017 Jul, LMS - EPSRC Durham Symposium, Durham, UK
 - 2017 Jan, SODA, Barcelona, Spain
 - 2016 Nov, A&C seminar, University of Oxford, UK
 - 2016 Oct, Combinatorics Study Group,
Queen Mary, University of London, UK
 - 2016 Jun, Institute of Theoretical Computer Science seminar,
Shanghai University of Finance and Economics, Shanghai, China
 - 2016 May, ToC seminar, Harvard University, Cambridge, MA, US
 - 2016 Apr, Counting program seminar, Simons Institute,
University of California - Berkeley, CA, US
- Computational counting and sampling
 - 2017 Mar, University of Edinburgh, UK
 - 2017 Mar, CS Colloquium, University of Chicago, IL, US

- Uniqueness, spatial mixing, and approximate counting
 - 2016 Sep, RANDOM, Paris, France
 - 2016 Mar, “Classification of counting complexity” workshop, Simons Institute, University of California - Berkeley, CA, US
 - 2015 Oct, ToC seminar, Columbia University, New York, NY, US
- Approximation via correlation decay when strong spatial mixing fails
 - 2016 Jul, ICALP, Rome, Italy
- Planar dichotomy theorems
 - 2016 Jan, Counting program bootcamp, Simons Institute, University of California - Berkeley, CA, US
 - 2015 Oct, FOCS, Berkeley, CA, US
- The complexity of Ising models with complex weights
 - 2014 Dec, Midwest Theory Day, University of Michigan, Ann Arbor, MI, US
- Dichotomy theorems in computational complexity
 - 2014 Sep, Nanjing University, Nanjing, China
 - 2014 Feb, ACiD seminar, Durham University, UK
- Edge coloring, Siegel’s theorem, and a Holant dichotomy
 - 2014 Sep, China Theory Week, Tsinghua University, Beijing, China
- #BIS-hardness for 2-spin systems on bipartite bounded degree graphs in the tree nonuniqueness region
 - 2014 Sep, RANDOM, Barcelona, Spain
- Holographic algorithms beyond matchgates
 - 2014 Jul, ICALP, Copenhagen, Denmark
- Phase transition and computational transition
 - 2014 May, A&C seminar, University of Oxford, UK
- The complexity of planar Boolean #CSP with complex weights
 - 2013 Jul, ICALP, Riga, Latvia
- A complete dichotomy rises from the capture of vanishing signatures
 - 2013 Jun, STOC, Palo Alto, CA, US
 - 2013 Jan, Dagstuhl Seminar 13031: Computational Counting, Germany

Teaching

In the University of Edinburgh:

- 2021 Spring Backup lecturer, Algorithmic Game Theory and Applications
- 2020 Autumn Computational Complexity
- 2020 Spring Randomness and computation
- 2019 Autumn Computational Complexity
- 2018 Autumn Computational Complexity
- 2018 Spring Computational Complexity

In Queen Mary, University of London:

- 2016 Autumn Advanced Combinatorics

Services & Activities

- Editorial board: Theoretical Computer Science (2025 –)
- Program committee: ICALP 2021, CSR 2021, MFCS 2020, NCTCS 2019, FAW 2019, NCTCS 2018, FAW 2018.
- Co-organiser of NII Shonan meeting No. 186, “MCMC 2.0”, 2023.
- Co-organiser of the STOC 2020 workshop, “New frontiers in approximation counting”.
- LFCS (Edinburgh) seminar organiser, 2018/01 – 2019/11.
- Seminar organiser of the 2016 spring program “Counting Complexity and Phase Transitions” in the Simons institute of UC-Berkeley.
- Journal referee for: ACM Transactions on Algorithms,
ACM Transactions on Computation Theory,
Annals of Applied Probability,
Annals of Probability,
Combinatorics, Probability and Computing,
Communications in Mathematical Physics,
Communications of the ACM,
Computational Complexity,
the Computer Journal,
Information and Computation,
Journal of Combinatorics,
Journal of Computer and System Sciences,
Journal of Discrete Algorithms,
Journal of Statistical Physics,
Journal of the ACM,
Michigan Math Journal,
Proceedings of the National Academy of Sciences of the USA,
Quantum,
Random Structures and Algorithms,
SIAM Journal on Computing,
SIAM Journal on Discrete Mathematics,
Theoretical Computer Science,
TheoretCS,
Theory of Computing,
Theory of Computing Systems.

- Conference Reviews: COCOON, COLT, ESA, FAW, FOCS, ICALP, ISAAC, ISIT, ITCS, JCDCGGG, MFCS, QIP, RANDOM, SODA, STACS, STOC, TAMC, WAOA.
- Other Reviews: MathSciNet, Handbook of the Tutte Polynomial.