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, 2021-2025.
- 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 – 31st December 2025 (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.

Advisees

- Giorgos Mousa (Ph.D. student, 2018 – 2022)
- Jiaheng Wang (Ph.D. student, 2020 – 2023; Postdoc, 2023 –)
- Graham Freifeld (Ph.D. student, 2022 –)
- Weiming Feng (Visiting graduate student, 2019; Postdoc, 2021 – 2023)
- Shuai Shao (Postdoc, 2021)
- Vishvajeet Nagargoje (Postdoc, 2022 –)

Research Articles

- Near-linear time samplers for matroid independent sets with applications
  Xiaoyu Chen, Heng Guo, Xinyuan Zhang, and Zongrui Zou
  RANDOM'24
  Available at arxiv: `2308.09683`
- An FPRAS for two terminal reliability in directed acyclic graphs
  Weiming Feng and Heng Guo
  ICALP'24
  Available at arxiv: `2310.00938`
- Approximate counting for spin systems in sub-quadratic time
  Konrad Anand, Weiming Feng, Graham Freifeld, Heng Guo, and Jiaheng Wang
  ICALP'24
  Available at arXiv: `2306.14867`
- Towards derandomising Markov chain Monte Carlo
  Weiming Feng, Heng Guo, Chunyang Wang, Jiaheng Wang, and Yitong Yin
  FOCS'23
  Available at arXiv: `2211.03487`
- 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
  TheoretiCS, 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 rises 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

- Fast sampling of satisfying assignments from random k-SAT
  Andreas Galanis, Leslie Ann Goldberg, Heng Guo, and Andrés Herrera-Poyatos
  arXiv: `2206.15308`
- 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

- 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, IIIS 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

- Program committee: ICALP 2021, CSR 2021, MFCS 2020, NCTCS 2019, FAW 2019, NCTCS 2018, FAW 2018.
- Co-organiser of an NII Shonan workshop, No. 186 "MCMC 2.0", 2023.
- Co-organiser of a 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,
  Communications in Mathematical Physics,
  Communications of the ACM,
  Computational Complexity,
  Information and Computation,
  Journal of Combinatorics,
  Journal of Computer and System Sciences,
  Journal of Discrete Algorithms,
  Journal of Statistical Physics,
  Journal of the ACM,
  Proceedings of the National Academy of Sciences of the USA,
  Random Structures and Algorithms,
  SIAM Journal on Computing,
  Theoretical Computer Science,
  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.