

# Heng Guo

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- Current Positions**
- Lecturer in algorithms and complexity, School of Informatics, University of Edinburgh 2017/09 – present
- 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.

## Research Students

- Jiaheng Wang (Ph.D., primary advisor, from 2020/10)
- Giorgos Mousa (Ph.D., primary advisor, from 2018/10)
- Veselin Blagoev (MPhil., second advisor, graduated 2019/02)
- Weiming Feng (Visiting graduate student, 2019/09 – 2019/12)

## Research Articles

- Counting solutions to random CNF formulas  
Andreas Galanis, Leslie Ann Goldberg, Heng Guo, and Kuan Yang  
**SIAM J. Comput.**, accepted  
**ICALP’20**, 53:1-14  
Available at arXiv: 1911.07020
- 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.**, accepted  
Preliminary version: **FOCS’15**, pp. 1259-1276  
Available at arXiv: 1505.02993
- Rapid mixing from spectral independence beyond the Boolean domain  
Weiming Feng, Heng Guo, Yitong Yin, and Chihao Zhang  
**SODA’21**, pp. 1558-1577  
Available at arXiv: 2007.08091
- 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 nonunique-  
ness region  
Jin-Yi Cai, Andreas Galanis, Leslie Ann Goldberg, Heng Guo, Mark Jerrum, Daniel Šte-  
fankovič, 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

- Inapproximability of counting hypergraph colourings  
Andreas Galanis, Heng Guo, and Jiaheng Wang  
arXiv: 2107.05486
- Counting vertices of integer polytopes defined by facets  
Heng Guo and Mark Jerrum  
arXiv: 2105.01469
- Local-to-global contraction in simplicial complexes  
Heng Guo and Giorgos Mousa  
arXiv: 2012.14317
- End-to-end robustness for sensing-reasoning machine learning pipelines  
Zhuolin Yang, Zhikuan Zhao, Hengzhi Pei, Boxin Wang, Bojan Karlas, Ji Liu, Heng Guo, Bo Li, Ce Zhang  
arXiv: 2003.00120
- Perfect sampling from spatial mixing  
Weiming Feng, Heng Guo, and Yitong Yin  
arXiv: 1907.06033

## 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

- 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, Durham probability seminar, Durham, 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

- Program committee: ICALP 2021, CSR 2021, MFCS 2020, NCTCS 2019, FAW 2019, NCTCS 2018, FAW 2018.
- 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 Probability,  
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,  
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: COLT, ESA, FAW, FOCS, ICALP, ISAAC, ISIT, ITCS, MFCS, QIP, RANDOM, SODA, STACS, STOC, TAMC, WAOA.
- Other Reviews: MathSciNet, Handbook of the Tutte Polynomial.