

David Barmherzig

Center for Computational Mathematics
Flatiron Institute
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Employment

Research Fellow, 2019-
Center for Computational Mathematics, Flatiron Institute

Education

Doctor of Philosophy, 2019
Stanford University, Institute for Computational and Mathematical Engineering
Dissertation: *The Phase Retrieval Problem: Theory, Algorithms, and Applications*
Dissertation committee: Emmanuel J. Candès (principal advisor), Walter Murray, and Gordon Wetzstein

Master of Science, 2013
University of Toronto, Mathematics
Thesis: *Polyphase representations in mathematical signal processing*
Thesis advisor: George A. Elliott

Bachelor of Applied Science in Engineering Science, 2011
University of Toronto
Thesis: *The Uniqueness theorem for the Cuntz algebras*
Thesis advisor: George A. Elliott

Visiting Appointments

Fellow, 2022
Institute for Pure and Applied Mathematics (IPAM)

Fellow, 2013
Harvard University

Publications

Zhong Zhuang, David Yang, David Barmherzig and Ju Sun. *Practical Phase Retrieval Using Double Deep Image Priors*. Deep Learning and Inverse Problems, Neural Information Processing Systems, 2023.

Zhong Zhuang, David Yang, Felix Hofmann, David Barmherzig and Ju Sun. ***Practical Phase Retrieval Using Double Deep Image Priors***. *Electronic Imaging*, 153, pp. 1-6, 2023.

David A. Barmherzig and Michael Eickenberg. ***Low-Photon Holographic Phase Retrieval with Poisson-Gaussian Denoising***. Proceedings of the Imaging and Applied Optics Congress, CM2A.5, Optica, 2022.

Brian Ward, Bob Carpenter, and David Barmherzig. ***HoloML in Stan: Low-photon Image Reconstruction***. Stan Case Studies, Volume 9, 2022.

David A. Barmherzig and Ju Sun. ***Towards practical holographic coherent diffraction imaging via maximum likelihood estimation***. *Optics Express* 30(5), pp. 6886-6906, 2022.

Hannah Lawrence, David A. Barmherzig, Henry Li, Michael Eickenberg, and Marylou Gabri e. ***Phase Retrieval with Holography and Untrained Priors: Tackling the Challenges of Low-Photon Nanoscale Imaging***. Proceedings of Machine Learning Research 145, pp. 516–567, 2021.

David A. Barmherzig, Alex H. Barnett, Charles L. Epstein, Leslie F. Greengard, Jeremy F. Magland, and Manas Rachh. ***Recovering Missing Data in Coherent Diffraction Imaging***. Proceedings of the Imaging and Applied Optics Congress, CTh7A.3, Optica, 2021.

Hannah Lawrence, David A. Barmherzig, Henry Li, Michael Eickenberg, and Marylou Gabri e. ***Low-Photon Holographic Phase Retrieval via a Deep Decoder Neural Network***. Proceedings of the Imaging and Applied Optics Congress, JTU5A.19, Optica, 2021.

David A. Barmherzig, Alex H. Barnett, Charles L. Epstein, Leslie F. Greengard, Jeremy F. Magland, and Manas Rachh. ***Recovering Missing Data in Coherent Diffraction Imaging***. *SIAM Journal on Imaging Sciences* 14(2), pp. 620-644, 2021.

David A. Barmherzig and Ju Sun. ***Low-Photon Holographic Phase Retrieval***. Proceedings of the Imaging and Applied Optics Congress, JTU4A.6, Optica, 2020.

David A. Barmherzig. ***The Phase Retrieval Problem: Theory, Algorithms, and Applications***. Doctoral Dissertation, Stanford University, 2019.

David A. Barmherzig, Ju Sun, Emmanuel J. Cand es, T.J. Lane, and Po-Nan Li. ***Dual-Reference Design for Holographic Coherent Diffraction Imaging***. 13th International Conference on Sampling Theory and Applications, 2019.

David A. Barmherzig, Ju Sun, Emmanuel J. Cand es, T.J. Lane, and Po-Nan Li. ***Holographic phase retrieval and reference design***. *Inverse Problems* 35(9), pp. 094001, 2019.

David Barmherzig and Ju Sun. ***1D Phase Retrieval and Spectral Factorization***. Proceedings of the Imaging and Applied Optics Congress, JTh1A.4, Optica, 2018.

David Barmherzig, Ju Sun, Po-Nan Li, and T.J. Lane. *On Block-Reference Coherent Diffraction Imaging*. Proceedings of the Imaging and Applied Optics Congress, CTh1B.1, Optica, 2018.

David Barmherzig and Ju Sun. *A Local Analysis of Block Coordinate Descent for Gaussian Phase Retrieval*. Optimization for Machine Learning, Neural Information Processing Systems, 2018.

David Barmherzig and Moshe Praver. *Applications of Principal Component Analysis to Decentralized Consensus for Accreditation*. 2017.

David Barmherzig, Leonidas J. Guibas, and Justin Solomon. *Functional Maps in Computational Geometry*. 2014.

David Barmherzig. *Polyphase Representations in Mathematical Signal Processing*. M.Sc. Thesis, University of Toronto, 2013.

David Barmherzig and George A. Elliott. *Classical Limits of the Feynman Path Integral and Schrodinger Equation*. 2012.

David Barmherzig. *The Uniqueness Theorem for the Cuntz Algebras*. B.A.Sc. Honours Thesis, University of Toronto, Fields Institute, 2012.

Presentations

Single-Photon Lensless Imaging at the Nanoscale

Toronto Computational Imaging Group, University of Toronto. Toronto, ON, Canada. November 30, 2023.

Low-Photon Holographic Phase Retrieval with Poisson-Gaussian Denoising

Computational Optical Sensing and Imaging, Imaging and Applied Optics Congress, Optica. July 11, 2022.

Towards Practical X-ray Microscopy via Optimization and Deep Learning

CCM Colloquium, Flatiron Institute. New York, NY, USA. April 13, 2022.

Recovering Missing Data in Coherent Diffraction Imaging

Computational Optical Sensing and Imaging, Imaging and Applied Optics Congress, Optica. July 22, 2021.

Low-Photon Holographic Phase Retrieval via a Deep Decoder Neural Network

Computational Optical Sensing and Imaging, Imaging and Applied Optics Congress, Optica. July 20, 2021.

New Algorithms for Phase Retrieval with Missing and Noisy Data

SIAM Conference on Imaging Science. July 16, 2020.

Low-Photon Holographic Phase Retrieval

Computational Optical Sensing and Imaging, Imaging and Applied Optics Congress, Optica. June 23, 2020.

Low-Photon Holographic Phase Retrieval

Numerical Analysis Seminar, Flatiron Institute. New York, NY, USA. January 15, 2020.

Holographic Phase Retrieval and Optimal Reference Design

Numerical Analysis Seminar, Flatiron Institute. New York, NY, USA. October 2, 2019.

The Phase Retrieval Problem: Theory, Algorithms, and Applications

Thesis Defense, Stanford University. Stanford, CA, USA. May 23, 2019.

Holographic Phase Retrieval and Dual-Reference Design

Candès group meeting, Department of Statistics, Stanford University. Stanford, CA, USA. March 7, 2019.

Holographic Phase Retrieval and Optimal Reference Design

Candès group meeting, Department of Statistics, Stanford University. Stanford, CA, USA. December 6, 2018.

1D Phase Retrieval and Spectral Factorization

Mathematics in Imaging, Imaging and Applied Optics Congress, Optica. Orlando, FL, USA. June 28, 2018.

On Block-Reference Coherent Diffraction Imaging

Computational Optical Sensing and Imaging, Optica. Orlando, FL, USA. June 28, 2018.

A Local Analysis of Block Coordinate Descent for Gaussian Phase Retrieval

ICME Xpo, Stanford University. Stanford, CA, USA. May 18, 2018.

A Matrix Algebra Approach to the Fourier Phase Retrieval Problem

Operator Algebras Seminar, Fields Institute for Mathematical Research. Toronto, ON, Canada. January 9, 2018.

A Local Analysis of Block Coordinate Descent for Gaussian Phase Retrieval

10th NeurIPS Workshop on Optimization for Machine Learning, Neural Information Processing Systems. Long Beach, CA, USA. December 9, 2017.

ADMM for Phase Retrieval

Candès group meeting, Department of Statistics, Stanford University. Stanford, CA, USA. October 25, 2017.

The Phase Retrieval Problem: Theory and Algorithms

Operator Algebras Seminar, Fields Institute for Mathematical Research. Toronto, ON, Canada. December 29, 2016.

Recent Advances on the Phase Retrieval Problem

Operator Algebras Seminar, Fields Institute for Mathematical Research. Toronto, ON, Canada.
December 15, 2015.

Analyzing Fienup Algorithms for Phase Retrieval

Candès group meeting, Department of Statistics, Stanford University. Stanford, CA, USA.
November 13, 2015.

Functional Map Methods in Computational Geometry

Operator Algebras Seminar, Fields Institute for Mathematical Research. Toronto, ON, Canada.
December 18, 2014.

Functional Maps in Computational Geometry

Guibas group meeting, Department of Computer Science, Stanford University. Stanford
University, Stanford, CA, USA. November 19, 2014.

Mathematical Signal Processing and Operator Algebras

Operator Algebras Seminar, Fields Institute for Mathematical Research. Toronto, ON, Canada.
Series of three talks - August 1, September 3, and September 10, 2013.

Classical Limits of the Feynman Path Integral and Schrodinger Equation

Operator Algebras Seminar, Fields Institute for Mathematical Research. Toronto, ON, Canada.
August 14, 2012.

The Uniqueness Theorem for the Cuntz Algebras

Operator Algebras Seminar, Fields Institute for Mathematical Research. Toronto, ON, Canada.
August 18, 2011.

Awards and Honors

Stanford Teaching Assistantship, 2016

Simons Math+X Fellow, Simons Foundation, 2015-2016

Stanford Research Assistantship, Stanford University, 2014-2015

Stanford Departmental Fellowship, Institute for Computational and Mathematical
Engineering, School of Engineering, Stanford University, 2013

Alexander Graham Bell Canada Graduate Scholarship, Natural Sciences and Engineering
Research Council of Canada, 2013

NSERC Postgraduate Scholarship, Natural Sciences and Engineering Research Council of
Canada, 2013

Ontario Graduate Scholarship, Ontario Ministry of Training, Colleges and Universities, 2012

University of Toronto Tuition Fellowship, University of Toronto, 2012

Graduated with Honours, Bachelor of Applied Science in Engineering Science, Faculty of Applied Science and Engineering, University of Toronto, 2012

Dean's Honour List, Faculty of Applied Science and Engineering (Engineering Science), University of Toronto, 2007 – 2012

Undergraduate Student Research Award, Natural Sciences and Engineering Research Council of Canada, 2010

University of Toronto Excellence Award, University of Toronto, 2007

University of Toronto Scholars Program National Scholarship, University of Toronto, 2006

George Roderick Fraser Scholarship in Mathematics, University of Toronto, 2006

Millennium Excellence Award, Canadian Millennium Scholarship Foundation, 2006

Teaching and Mentorship

Supervisor, Zhong Zhuang, Ph.D. Candidate in Computer Science at the University of Minnesota. Flatiron Institute internship on deep learning methods for Bragg coherent diffraction imaging and computer-generated holography, 2022.

Supervisor, Zhong Zhuang, Ph.D. Candidate in Computer Science at the University of Minnesota. Flatiron Institute internship on deep learning methods for Bragg coherent diffraction imaging, 2021.

Supervisor, Henry Li, Ph.D. Candidate in Computer Science at Yale University. Flatiron Institute internship on deep learning and optimization methods for holographic phase retrieval, 2021.

Course Instructor, ICME Refresher Course – Multivariable Calculus, Stanford University, 2016

Teaching Assistant, CME106/ENGR155C Introduction to Probability and Statistics for Engineers, Stanford University, 2016

Interim Teaching Assistant, MAT137Y1 Calculus!, University of Toronto, 2012

Conferences Attended

Diffraction Imaging with Phase Retrieval, Institute for Pure and Applied Mathematics. October 10-14, 2022.

Imaging and Applied Optics Congress, Optica. July 11-15, 2022.

Flatiron-Wide Algorithms and Mathematics, Flatiron Institute. October 14-15, 2021.

Mathematical and Scientific Machine Learning (MSML), July 19-23, 2021.

Imaging and Applied Optics Congress, Optica. July 19-23, 2021.

SIAM Conference on Imaging Science, Society for Industrial and Applied Mathematics. July 6-17, 2020.

Imaging and Applied Optics Congress, Optica. June 22-26, 2020.

Flatiron-Wide Algorithms and Mathematics, Flatiron Institute. October 30 – November 1, 2019.

13th International Conference on Sampling Theory and Applications (SampTA). University of Bordeaux. July 8-12, 2019.

Imaging and Applied Optics Congress, Optica. Orlando, FL, USA. June 25-29, 2018.

10th NIPS Workshop on Optimization for Machine Learning, Neural Information Processing Systems. Long Beach Convention Center. December 9, 2017.

Neural Information Processing Systems. Long Beach Convention Center. December 4-9, 2017.

Phaseless Imaging in Theory and Practice: Realistic Models, Fast Algorithms, and Recovery Guarantees, Institute for Mathematics and its Applications, University of Minnesota. August 14 - 18, 2017.

Bay Area Vision Meeting. Stanford University. October 3, 2014.

ONR Workshop on Structured Learning for Scene Understanding. Stanford University. October 2, 2014.

Canadian Operator Symposium. University of Toronto. May 27-31, 2013.

Workshop on Applications to Operator Algebras. Fields Institute for Mathematical Research, University of Toronto. September 10-14, 2012.

Canadian Operator Symposium. Queen's University. May 21-25, 2012.

Workshop on Positivity. University of Toronto. August 2-4, 2011.

Professional Services

Organizer: *The Phase Retrieval Problem: Advances from Theory, Computation, and Design*, Minisymposium at the SIAM Conference on Imaging Science. July 16-17, 2020.

Publication Reviewer for:

- Advances in Computational Mathematics
- Applied Physics B: Lasers and Optics
- IEEE International Symposium on Information Theory 2020
- IEEE Transactions on Image Processing
- IEEE Transactions on Information Theory
- IEEE Transactions on Signal Processing
- Information and Inference: A Journal of the IMA
- Scientific Reports, Springer Nature

Technical Consultant, MedX Protocol

Technical Consultant, Breaking Data

Professional Affiliations

Member, Society for Industrial and Applied Mathematics

Member, Institute of Electrical and Electronics Engineers

Member, American Mathematical Society

Member, Canadian Mathematical Society

Member, Optica

Member, Professional Engineers Ontario