Peter T. Brown

Tempe, AZ 85281

ORCiD: 0000-0002-2060-6398
Twitter: @ptbrown1729
Github: ptbrown1729
LinkedIn: ptbrown-phys

Curriculum Vitae

Education

Princeton University, Princeton, NJ, 2013 – 2019
Ph.D. in Physics, Department of Physics
Thesis: Probing Dynamical Quantities in the 2D Fermi-Hubbard Model with Quantum Gas Microscopy
Adviser: Dr. Waseem Bakr

University of Chicago, Chicago, IL, 2009 – 2013
B.A. Physics with honors

Research Interests

quantitative microscopy, super resolution microscopy, structured illumination microscopy, quantitative phase imaging, optical diffraction tomography, digital micromirror devices, bacteria motility, bacteria swimming strategies, fluctuation-dissipation approaches to transport, active matter, colloidal physics

quantum gas microscopy, atomic physics, strongly correlated matter, many-body physics, degenerate Fermi gases, fermions in optical lattices, quantum magnetism, low dimensional quantum systems, dynamical and transport properties of strongly correlated systems, the Fermi-Hubbard model, Rydberg atoms, long-range interactions in quantum gases.

Research Experience

1. **Postdoctoral Scholar** 2019 - present
   Arizona State University, Department of Physics and Center for Biological Physics
   Group of Prof. Douglas Shepherd
   Quantitative microscopy development for biophysics applications. Designed and built multimodal microscope based around a digital micromirror device (DMD) combining three-color structured illumination microscopy (SIM) with optical diffraction tomography (ODT). Developed new numerical and analytic tools to more efficiently simulate multicolor DMD configurations. Achieved 650 frame-per-second volumetric imaging using ODT. Studied the motility of *E. coli* using both oblique plane microscopy and optical diffraction tomography. Developed expertise in quantitative and computational optics including GPU programming, statistics, machine learning, and techniques for solving inverse problems.

2. **Graduate Research Assistant** 2013 - 2019
   Princeton University, Department of Physics
   Group of Prof. Waseem Bakr
   Experimental atomic physics. Participated in design and construction of a state-of-the-art lithium-6 quantum gas microscope. Developed novel experimental techniques for measuring static and dynamical properties of a Fermi-Hubbard system. Measured the conductivity of a 2D Fermi-Hubbard system and observed characteristics of bad- and strange-metallic behavior. First realization of an ARPES like technique in a 2D Fermi-Hubbard system with attractive interactions. Developed expertise with optics, optical system design, diode lasers, ultra-high

vacuum techniques, analog circuit design, radio frequency electronics, and the machine shop fabrication. Performed data analysis and physics simulations using a wide variety of tools including Matlab, Python (NumPy, SciPy, etc.), Mathematica, and Linux environments.

3. **Undergraduate Research Assistant** 2011 - 2013
The University of Chicago, Department of Physics
Group of Prof. David Schuster
Hybrid quantum systems and superconducting microwave devices. Designed, constructed, and characterized high quality factor microwave cavities. Performed feasibility calculations for optomechanical coupling between microwave photons and helium phonons. Performed finite element simulations of microwave cavities using ANSYS HFSS, and of fluid systems using COMSOL Multiphysics. Experience with cryogenic techniques, including fabricating a liquid helium supply line to devices in a dilution refrigerator. Developed expertise with radio frequency electronics and machine shop fabrication including using CAD and CAM software and a CNC mill.

PREPRINTS AND IN SUBMISSION

[1] "The cortical microtubules of Toxoplasma contribute to the helicity, but not the speed or persistence of parasite movement" by I. F. Tengganu, L. F. Arias Padilla, J. Munera Lopez, J. Liu, **P. T. Brown**, K. Hu, bioRxiv

PUBLISHED WORK

See also my Google Scholar page

[1] "Decoding the hydrodynamic properties of microscale helical propellers from Brownian fluctuations" by F. Djutanta*, **P. T. Brown***, B. Nainggolan, A. Coullomb, S. Radhakrishnan, J. Sentosa, B. Yurke, R. F. Hariadi, D. P. Shepherd, *Proceedings of the National Academy of Sciences* **120** 22 (2023). published, arXiv
* denotes equal contribution

[2] "Resolution doubling in light-sheet microscopy via oblique plane structured illumination", by B. Chen,B.-J. Chang, P. Roudot, F. Zhou, E. Sapoznik, M. Marlar-Pavey, J. B. Hayes, **P. T. Brown**, C.-W. Zeng, T. Lambert, J. R. Friedman, C.-L. Zhang, D. T. Burnette, D. P. Shepherd, K. M. Dean, and R. P. Fiolka, *Nature Methods* **19** (2022). published, bioRxiv

[3] "An apical protein, Pcr2, is required for persistent movement by the human parasite Toxoplasma gondii", by J. M. Lopez, I. F. Tengganu, J. Liu, J. M. Murray, L. F. Arias Padilla, Y. Zhang, **P. T. Brown**, L. Florens, and K. Hu, *PLOS Pathogens* **18** 8 (2022). published

[4] "Multicolor structured illumination microscopy and quantitative control of coherent light with a digital mirror device", by **P. T. Brown**, R. Kruithoff, G. J. Seedorf, and D. P. Shepherd, *Biomedical Optics Express* **12** 6 (2021). published, bioRxiv

[5] "Subdiffusion and heat transport in a tilted 2D Fermi-Hubbard system", by E. Guardado-Sanchez, A. Morningstar, B. M. Spar, **P. T. Brown**, D. A. Huse, and W. S. Bakr, *Physical Review X* **10** 011042 (2020). published, arXiv

[6] "Angle-resolved photoemission spectroscopy of a Fermi-Hubbard system", by **P. T. Brown**, E. Guardado-Sanchez, B. M. Spar, E. W. Huang, T. P. Devereaux, and W. S. Bakr, *Nature Physics* **16** 26-31 (2020). published, arXiv

[7] "Bad metallic transport in a cold atom Fermi-Hubbard system", by **P. T. Brown**, D. Mitra, E. Guardado-Sanchez, R. Nourafkan, A. Reymbaut, C.-D. Hebért, S. Bergeron, A.-M. S. Tremblay, J. Kokalj, D. A. Huse, P. Schauß, and W. S. Bakr, *Science* **363** 379 (2019). published, arXiv
Selected for a "Science Perspective". Featured by the Journal Club for Condensed Matter Physics and EurkAlert!

[8] "Probing quench dynamics across a quantum phase transition in a 2D Ising antiferromagnet", by E. Guardado-Sanchez, **P. T. Brown**, D. Mitra, T. Devakul, D. A. Huse, P. Schauß, and W. S. Bakr, *Physical Review X* **8**, 021069 (2018). published, arXiv

[9] "Quantum gas microscopy of an attractive Fermi-Hubbard system", by D. Mitra, **P. T. Brown**, E. Guardado-Sanchez, S. S. Kondov, T. Devakul, D. A. Huse, P. Schauß, and W. S. Bakr, *Nature Physics* **14**, 173 (2017). published, arXiv

[10] "Spin-imbalance in a 2D Fermi-Hubbard system", by **P. T. Brown**, D. Mitra, E. Guardado-Sanchez, P. Schauß, S. S. Kondov, E. Khatami, T. Paiva, N. Trivedi, D. A. Huse, and W. S. Bakr, *Science* **357**, 6358 (2017). published, arXiv

Featured by Princeton University news

[11] "Phase Separation and Pair Condensation in a Spin-Imbalanced 2D Fermi Gas", by D. Mitra, **P. T. Brown**, P. Schauß, S. S. Kondov and W. S. Bakr, *Physical Review Letters* **117**, 093601 (2016). published, arXiv

PRESENTATIONS

[1] Talk, "Fourier Synthesis of Optical Diffraction Tomography Patterns for Kilohertz Frame Rate Volumetric Imaging ", NTu1C.4, Optica Biophotonics Congress: Optics in the Life Sciences, hybrid, April 25, 2023.

[2] Talk (invited), "Microscopic Motility of Isolated *E. Coli* Flagella", Biological Physics and Structural Discovery Seminar, Arizona State University, Tempe, AZ, September 14, 2022.

[3] Poster (video), "High-speed 3D tracking of continuous nanoscale objects in complex environments with optical diffraction tomography and structured illumination microscopy" , IEEE International Conference on Computational Photography, selected as a "poster spotlight", Pasadena, CA, August 2, 2022

[4] Tutorial (video, code), "High quality 2D SIM reconstruction in Python with mcSIM", I2K 2022 From Images to Knowledge, online, May 10, 2022.

[5] Talk, "3D Tracking of Continuous Nanoscale Objects in Complex Environments", Z07.00014, APS March Meeting, Chicago, IL, March 18, 2022.

[6] Talk, "High-speed optical diffraction tomography and structured illumination microscopy using a single binary wavefront modulator", Focus on Microscopy, online, April 11, 2022.

[7] Talk, "A Novel Multicolor Structured Illumination Microscope and Quantitative Control of Polychromatic Coherent Light with a Digital Micromirror Device", Focus on Microscopy, online, March 29, 2021.

[8] Talk, "Probing dynamical properties of Fermi-Hubbard systems with a quantum gas microscope", Emergent phenomena in ultracold atoms: merging topology, interaction, and dynamics, Kavli Center for Theoretical Science, University of the Chinese Academy of Sciences, Beijing, China, June 13, 2019.

[9] Talk, "Photoemission spectroscopy of a Fermi-Hubbard system with a quantum gas microscope", P05.00007. 50th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics, Milwaukee, WI, May 30, 2019.

[10] Talk, "Photoemission spectroscopy of a Fermi-Hubbard system with a quantum gas microscope", F24.00003. APS March Meeting, Boston, MA, March 5, 2019.

[11] Talk, "Probing transport and spectral properties of Fermi-Hubbard systems with a quantum gas microscope", Solvay Workshop on Quantum Simulation, Solvay Institute, Brussels, Belgium, February 19, 2019.

[12] Talk, "Bad Metallic Transport in a Cold Atom Fermi-Hubbard System", D09.00001. 49th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics, Fort Lauderdale, FL, May 29, 2018.

[13] Talk, "Spin-imbalance in a 2D Fermi-Hubbard system", B9.00001. 48th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics, Sacramento, CA, June 6, 2017.

[14] Poster, "Pair condensation in a spin-imbalanced two-dimensional Fermi gas", D1.00168, 47th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics, Providence, RI, May 2016.

[15] Poster, "Towards quantum simulation of the Hubbard model with attractively interacting fermions", K1.00033, 46th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics, Columbus, OH, May 2015.

Honors and Awards

National Defense Science and Engineering Graduate (NDSEG) Fellowship	2015-2018
Hertz Foundation graduate fellowship finalist	2014
John Haeseler Lewis Prize in physics (best graduating seniors in physics), University of Chicago	2013
David W. Grainger Senior Scholarship in physics, University of Chicago	2012
Phi Beta Kappa, Beta of Illinois	2012

Service

Reviewer for *Optics Letters*, *Optics Express*, *Optica*, and *Photonics Research*

Teaching Experience

1. **Laboratory Teaching Assistant** Fall, 2015
   Princeton University, Introductory Physics 101
   Introduced physical concepts, guided students through mechanics labs, and graded lab reports. Participated in a pilot program using the Investigative Science Learning Environment (ISLE) approach. Engaged in weekly discussions with course organizer and other TA's to improve the course.

2. **Grader, Analysis in $\mathbb{R}^n$ I and II** 2011-2013
   University of Chicago, Math 20300 and 20400
   Graded homework assignments for proof-based class following *An Introduction to Analysis* by William R. Wade.

Code

[1] Structured illumination microscopy reconstruction, optical diffraction tomography reconstruction, and microscope control code, https://github.com/QI2lab/mcSIM

[2] Diffraction-limited spot localization and point-spread function fitting code, https://github.com/QI2lab/localize-psf

[3] Optical ray tracing code, https://github.com/QI2lab/ray_trace_pb

[4] Exact diagonalization of Fermi-Hubbard and spin models on a lattice, https://github.com/ptbrown1729/exact_diag