Benjamin L. Augenbraun

Contact Information

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Education

Ph.D., Physics, Harvard University, Cambridge, MA, USA — **March 2022 (Anticipated)**

Dissertation Advisor: Prof. John M. Doyle

Dissertation Title: *Molecules and Methods for Direct Laser Cooling*

B.A., Physics, Williams College, Williamstown, MA, USA — **June 2015**

Degree conferred with highest honor, *summa cum laude*.

Senior Thesis Advisor: Prof. Protik K. Majumder

Employment

Teaching Fellow, Harvard University, Cambridge MA, USA — **August–December 2020**

Research Assistant, Williams College, Williamstown MA, USA — **June–August 2014/2015**

Research Assistant, University of Rochester, Rochester NY, USA — **June–August 2013**

Research Interests

Direct laser cooling of molecules. Optical cycling in complex polyatomic species. Precision tests of fundamental physics using polyatomic molecules. Laser spectroscopy of polar radicals. Developing methods for quantum-state control and readout of polyatomic molecules. Quantum chemical calculations of electronic and vibrational structure. Experimental characterization of vibronic coupling and Born-Oppenheimer approximation breakdown. Numerical modeling of laser-molecule interactions.

Honors and Awards

Certificate of Distinction in Teaching, Harvard University — **2020**

Graduate Student Research Fellowship, National Science Foundation — **2016–2019**

LeRoy Apker Award, American Physical Society — **2015**

Howard P. Stabler Prize, Williams College Dept. of Physics — **2015**

Barry M. Goldwater Scholarship — **2014**

Teaching Experience

Teaching Fellow, Harvard University

Phys 143a, Quantum Mechanics I — **Fall 2020**

- Responsible for recitation sections, writing and grading exams, and running weekly "tutorials"
- Tutorials consisted of weekly instruction sessions with three students and one instructor; covered topics in depth, individually tailored for each tutorial group
- Received Harvard University Certificate of Distinction in Teaching (Score: 4.9/5.0)

Teaching Assistant, Williams College

Phys 301, Quantum Theory **Fall 2014**

- This course serves as the “advanced lab" course in the Williams curriculum
- Oversaw a half-dozen modern physics experiments, including Doppler-free spectroscopy of rubidium, electron spin resonance, and Raman spectroscopy of iodine
- Taught laboratory techniques and methods (e.g., diode and pulsed lasers, lock-in amplifiers and boxcar integrators, and electronic circuit design)

Mentoring/ Supervision

Undergraduate students

Alice Zhang, Harvard **Summer 2021–Present**

- Project: Interferometric combination of laser beams with nearly-spaced wavelengths

Maryam Hiradfar, Harvard **Spring 2018–Spring 2020**

- Project: Design and construction of a cryogenic chamber for atomic beam production

Cal Miller, Harvard **Fall 2019–Spring 2020**

- Projects: (1) Simulation of Sisyphus laser cooling of polyatomic molecules. (2) Design and optimization of cryogenic beam sources for low-velocity molecular beams.

Phelan Yu, Harvard **Fall 2018–Spring 2019**

- Project: Theoretical investigation of polyatomic molecules with precision measurements and quantum information processing.

Professional Activities and Service

American Physical Society, member **2012–Present**
Division of Atomic and Molecular Physics

Math/Science Resource Center Coordinator, Williams College **2012–2015**
Responsible for hiring and training of about 60 tutors with a focus on physics and mathematics. Tutored physics and mathematics courses throughout the curriculum (multivariable calculus, introductory mechanics, and introductory modern physics)

Committee on Education Policy, Williams College **2012–2013**
One of six student members

Seminar organizer

Center for Ultracold Atoms “Pizza Talks", Harvard University **Fall 2016–Spring 2017**

Journal referee

Computer Physics Communications, Physical Chemistry Chemical Physics

Outreach

Skype-A-Scientist, Speaker **2019–Present**
Spoke virtually to 6th-8th grade science classes about physical chemistry and working as a scientific researcher

Have presented to 6 classrooms, including in Oregon, Georgia, and Wisconsin

Harvard-MIT CUA Kids Day, Speaker **2017–Present**
Annual event for children, ages 5-12, about the science of temperature

Led a team of three graduate student volunteers to develop demonstrations about low temperature physics

Demonstrations included change of LED color upon cooling in liquid nitrogen, high-temperature superconductors, and phase changes

Center for Astrophysics High School Open House, Speaker **2015**

Public lecture, targeting high school students, about laser cooling and low-temperature physics

Led tours of atomic and molecular physics laboratory for visiting high-schoolers

Computer Skills

Expert in: Mathematica, Matlab, Julia.

Proficient in: Python.

Experience in: Fortran, Bash.

Submitted Publications

18. C. Zhang, **B. L. Augenbraun**, Z. D. Lasner, N. B. Vilas, J. M. Doyle, and L. Cheng, "Accurate prediction and measurement of vibronic branching ratios for laser-coolable linear polyatomic molecules," arXiv:2105.10760, submitted to J. Chem. Phys. (2021).
17. Z. D. Lasner, D. Mitra, M. Hiradfar, **B. L. Augenbraun**, L. Cheuk, E. Lee, S. Prabhu, J. M. Doyle, "Fast and High-Yield Loading of a D2 MOT of Potassium from a Cryogenic Buffer Gas Beam," arXiv:2105.14701, submitted to Phys. Rev. A (2021).

Refereed Publications

16. **B. L. Augenbraun**, Z. D. Lasner, A. Frenett, H. Sawaoka, A. T. Le, J. M. Doyle, and T. C. Steimle, "Observation and laser spectroscopy of ytterbium monomethoxide, $YbOCH_3$," Phys. Rev. A 103, 022814 (2021).
15. C. E. Dickerson, H. Guo, A. J. Shin, **B. L. Augenbraun**, J. R. Caram, W. C. Campbell, A. N. Alexandrova, "Franck-Condon tuning of optical cycling centers by organic functionalization," Phys. Rev. Lett. 126, 123002 (2021).
14. L. Baum, N. Vilas, C. Hallas, **B. L. Augenbraun**, S. Raval, D. Mitra, and J. M. Doyle, "Establishing a highly closed cycling transition in a polyatomic molecule," Phys. Rev. A 103, 043111 (2021).
13. **B. L. Augenbraun**, J. M. Doyle, T. Zelevinsky, and I. Kozyryev, "Molecular Asymmetry and Optical Cycling: Laser Cooling Asymmetric Top Molecules," Phys. Rev. X 10, 031022 (2020).
12. **B. L. Augenbraun**, Z. D. Lasner, D. Mitra, S. Prabhu, S. Raval, H. Sawaoka, and J. M. Doyle, "Assessment and mitigation of aerosol airborne SARS-CoV-2 transmission in laboratory and office environments," J. Occup. Environ. Hyg. 17:10, 447-456 (2020).
11. D. Mitra, N. Vilas, C. Hallas, L. Anderegg, **B. L. Augenbraun**, L. Baum, C. Miller, S. Raval, and J. M. Doyle, "Direct Laser Cooling of a Symmetric Top Molecule," Science 369: 6509, 1366 (2020).
10. E. T. Mengesha, A. T. Le, T. C. Steimle, L. Cheng, C. Zhang, **B. L. Augenbraun**, Z. Lasner, and J. Doyle, "Branching Ratios, Radiative Lifetimes and Transition Dipole Moments for YbOH," J. Phys. Chem. A 124, 16, 3135-3148 (2020).
9. L. Baum, N. B. Vilas, C. Hallas, **B. L. Augenbraun**, S. Raval, D. Mitra, and J. M. Doyle, "1D Magneto-Optical Trap of Polyatomic Molecules," Phys. Rev. Lett. 124, 133201 (2020).
8. **B. L. Augenbraun**, Z. D. Lasner, A. Frenett, H. Sawaoka, C. Miller, T. C. Steimle, and J. M. Doyle, "Laser-Cooled Polyatomic Molecules for Improved Electron Electric Dipole Moment Searches," New J. Phys. (Fast Track Communication) 22 022003 (2020).
7. A. L. Collopy, S. Ding, Y. Wu, I. A. Finneran, L. Anderegg, **B. L. Augenbraun**, J. M. Doyle, and J. Ye, "3D Magneto-Optical Trap of Yttrium Monoxide," Phys. Rev. Lett. 121, 213201 (2018).
6. L. W. Cheuk, L. Anderegg, **B. L. Augenbraun**, Y. Bao, S. Burchesky, W. Ketterle, and J. M. Doyle, "Λ-Enhanced Imaging of Molecules in an Optical Trap," Phys. Rev. Lett. 121, 083201 (2018).
5. L. Anderegg, **B. L. Augenbraun**, Y. Bao, S. Burchesky, L. W. Cheuk, W. Ketterle, and J. M. Doyle, "Laser cooling of optically trapped molecules," Nat. Phys. 14, 890-893 (2018).

4. L. Anderegg, **B. L. Augenbraun**, E. Chae, B. Hemmerling, N. R. Hutzler, A. Ravi, A. Collopy, J. Ye, W. Ketterle, and J. M. Doyle, "Radio Frequency Magneto-Optical Trapping of CaF with High Density," Phys. Rev. Lett. 119, 103201 (2017).
3. I. Kozyryev, L. Baum, K. Matsuda, **B. L. Augenbraun**, L. Anderegg, A. P. Sedlack, and J. M. Doyle, "Sisyphus Laser Cooling of a Polyatomic Molecule," Phys. Rev. Lett. 118, 173201 (2017).
2. E. Chae, L. Anderegg, **B. L. Augenbraun**, A. Ravi, B. Hemmerling, N. R Hutzler, A. L Collopy, J. Ye, W. Ketterle, and J. M Doyle, "One-dimensional magneto-optical compression of a cold CaF molecular beam," New J. Phys. 19 033035 (2017).
1. **B. L. Augenbraun**, A. Carter, P. M. Rupasinghe, and P. K. Majumder, "Measurement of the scalar polarizability of the indium $6p_{1/2}$ state using two-step atomic-beam spectroscopy," Phys. Rev. A 94, 022515 (2016).

Manuscripts in preparation

- W. C. Campbell and **B. L. Augenbraun**, "Photon spin molasses for molecular rotation," in preparation to be submitted to J. Mol. Spec. (2021).
- **B. L. Augenbraun** and J. M. Doyle, "Microwave-Optical Stark-Sisyphus Deceleration," in preparation to be submitted to Phys. Rev. X (2021).
- **B. L. Augenbraun**, T. C. Steimle, C. Zhang, L. Cheng, and J. M. Doyle, "Asymmetric Top Molecules for Direct Laser Cooling and Trapping," in preparation to be submitted to Phys. Rev. Research (2021).

Invited Talks

3. UConn AMO Seminar **Feb. 2019**
   - "Laser-Cooled Molecules for Improved Precisions Measurements"
2. Harvard-MIT Center for Ultracold Atoms Annual Retreat **Jan. 2018**
   - "Laser Cooling and Optical Trapping of Molecules"
1. DAMOP Annual Meeting **June 2016**
   - "Apker Award Talk: Atomic Beam Measurement of the Indium $6p_{1/2}$ Scalar Polarizability"

Contributed Talks (selected)

4. International Symposium on Molecular Spectroscopy **June 2021**
   - "Observation and Laser Spectroscopy of Ytterbium Monomethoxide, $YbOCH_3$"
   - "High-Sensitivity Franck-Condon Factor Measurements Enabled by Optical Cycling"
3. DAMOP Annual Meeting **June 2021**
   - "Toward Ultracold Polyatomic Molecules for Measuring the Electron's Electric Dipole Moment"
2. DAMOP Annual Meeting **June 2020**
   - "Laser-Coolable Asymmetric Top Molecules"
1. International Symposium on Molecular Spectroscopy **June 2020**
   - "Branching Ratios, Radiative Lifetimes, and Transition Dipole Moments for YbOH"
   - "Laser-Coolable Asymmetric Top Molecules"