



Benjamin Lev

Associate Professor of Applied Physics and of Physics

 Curriculum Vitae available Online

CONTACT INFORMATION

- **Administrative Contact**

Rieko Sasaki

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Bio

BIO

Benjamin Lev received his Bachelors degree Magna Cum Laude from Princeton in 1999 and his Ph.D. from Caltech in 2005, both in Physics. He was an NRC postdoc at JILA (2006-2007), and an Assistant Professor at the University of Illinois at Urbana-Champaign (2008-2011). He is currently an Associate Professor in Physics and Applied Physics. Benjamin has received a Packard Fellowship and a Presidential Early Career Award for Scientists and Engineers (PECASE) as well as NSF CAREER, Air Force Office of Scientific Research, DARPA, Office of Navy Research Young Investigator Program, Terman, and Chambers awards.

His research focuses on exploring the organizing principles of quantum matter through the development of techniques at the interface of ultracold atomic physics, quantum optics, and condensed matter physics.

Major achievements and current projects include:

- Production and study of the first quantum gases of the most magnetic element, dysprosium
- Study of quantum neural networks
- Creation of a dipolar quantum Newton's cradle for investigating quantum thermalization
- Development of the novel SQCRAMscope, a Scanning Quantum CRyogenic Atom Microscope for imaging transport in strongly correlated and topological materials.
- Development of the theory of and experiments with multimode cavity quantum electrodynamical systems.

ACADEMIC APPOINTMENTS

- Associate Professor, Applied Physics
- Associate Professor, Physics
- Member, Bio-X

HONORS AND AWARDS

- Chambers Fellowship, Stanford University (2015)
- Terman Fellowship, Stanford University (2014)
- Young Faculty Award (YFA), DARPA (2012)
- Young Investigator Award (ONR YIP), Office of Naval Research (2012)
- Presidential Early Career Award for Scientists and Engineers (PECASE), NSF (2011)

- Terman Fellowship, Stanford University (2011)
- Packard Fellowship, David and Lucile Packard Foundation (2010)
- NSF CAREER Award, National Science Foundation (NSF) (2008)
- Office of Scientific Research Young Investigator Award (AFOSR YIP), Air Force (2008)
- Everhart Distinguished Graduate Student Lectureship, Caltech (2004)
- Allen Goodrich Schenstone Prize for Outstanding Work in Experimental Physics, Department of Physics, Princeton University (1999)

PROFESSIONAL EDUCATION

- Ph.D., California Institute of Technology , Physics (2005)
- A.B., Princeton University , Physics, Magna Cum Laude (1999)
- Valedictorian, Crystal River High School (1995)

LINKS

- LevLab website: <http://levlab.stanford.edu>

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

Dy Quantum Dipolar Gases: Advances in the quantum manipulation of ultracold atomic gases are opening a new frontier in the quest to better understand strongly correlated and topologically non-trivial matter. Our group created the first Bose and Fermi degenerate gases of the most magnetic atom, dysprosium. Recently, we have used 1D gases of Dy to create a dipolar quantum Newton's cradle, which we used to explore novel aspects of quantum thermalization.

Many-Body Cavity QED: Investigations of many-body physics in an AMO context often employ a static optical lattice to create a periodic potential. Such systems, while capable of exploring, e.g., the Hubbard model, lack the fully emergent crystalline order found in solid state systems whose stiffness is not imposed externally, but arises dynamically. Our multimode cavity QED experiment introduces fully emergent and compliant optical lattices to the ultracold atom toolbox and provides new avenues to explore beyond mean-field physics and quantum soft matter. Quantum liquid crystals, superglasses, and spin glasses may be explored. Quantum neural networks can be engineered in these driven, dissipative spin systems may prove to be powerful for computing solutions to NP-hard combinatorial optimization problems.

The SQCRAMscope: We have created the SQCRAMscope, a novel Scanning Quantum CRyogenic Atom Microscope technique for imaging magnetic and electric fields arising from cryogenically cooled materials. With our SQCRAMscope, we aim to image inhomogeneous transport and domain percolation in technologically relevant materials whose order has evaded elucidation. Our current projects include imaging transport in unconventional superconductors and topologically non-trivial materials.

Teaching

COURSES

2019-20

- Atoms, Fields and Photons: APPPHYS 203 (Aut)
- Quantum Gases: APPPHYS 282, PHYSICS 182, PHYSICS 282 (Win)

2018-19

- Atoms, Fields and Photons: APPPHYS 203 (Aut)
- Introduction to Modern Atomic Physics and Quantum Optics: APPPHYS 282, PHYSICS 182, PHYSICS 282 (Win)

2017-18

- Atoms, Fields and Photons: APPPHYS 203 (Aut)
- Introduction to Modern Atomic Physics and Quantum Optics: PHYSICS 182, PHYSICS 282 (Win)

STANFORD ADVISEES

Doctoral Dissertation Reader (AC)

David Berryrieser, Omer Hazon

Doctoral Dissertation Advisor (AC)

Brandon Freudenstein, Yudan Guo, Ronen Kroeze, Kuan-Yu Li, Kuan-Yu Lin

Doctoral (Program)

Tyler Anderson, Logan Bishop-Van Horn, Aaron Breidenbach, Morgan Brubaker, Sam Carman, Sanyum Channa, Yi-Shiou Duh, Ben Foutty, Brandon Freudenstein, Kuan-Yu Lin, Denzal Martin, John Peterson, Linsey Rodenbach, Ben Safvati, Zhen Su, Steven Tran, Atsushi Yamamura, Xinyang Zhang, Henry Zheng

Publications

PUBLICATIONS

- **Topological pumping of a 1D dipolar gas into strongly correlated prethermal states.** *Science (New York, N.Y.)*
Kao, W. n., Li, K. Y., Lin, K. Y., Gopalakrishnan, S. n., Lev, B. L.
2021; 371 (6526): 296–300
- **Photon-Mediated Peierls Transition of a 1D Gas in a Multimode Optical Cavity** *PHYSICAL REVIEW LETTERS*
Rylands, C., Guo, Y., Lev, B. L., Keeling, J., Galitski, V.
2020; 125 (1)
- **Nematic transitions in iron pnictide superconductors imaged with a quantum gas** *NATURE PHYSICS*
Yang, F., Taylor, S. F., Edkins, S. D., Palmstrom, J. C., Fisher, I. R., Lev, B. L.
2020
- **Photon-Mediated Peierls Transition of a 1D Gas in a Multimode Optical Cavity.** *Physical review letters*
Rylands, C. n., Guo, Y. n., Lev, B. L., Keeling, J. n., Galitski, V. n.
2020; 125 (1): 010404
- **Dynamical Spin-Orbit Coupling of a Quantum Gas** *PHYSICAL REVIEW LETTERS*
Kroeze, R. M., Guo, Y., Lev, B. L.
2019; 123 (16)
- **Sign-Changing Photon-Mediated Atom Interactions in Multimode Cavity Quantum Electrodynamics** *PHYSICAL REVIEW LETTERS*
Guo, Y., Kroeze, R. M., Vaidya, V. D., Keeling, J., Lev, B. L.
2019; 122 (19): 193601
- **Emergent and broken symmetries of atomic self-organization arising from Gouy phase shifts in multimode cavity QED** *PHYSICAL REVIEW A*
Guo, Y., Vaidya, V. D., Kroeze, R. M., Lunney, R. A., Lev, B. L., Keeling, J.
2019; 99 (5)
- **Spinor Self-Ordering of a Quantum Gas in a Cavity** *PHYSICAL REVIEW LETTERS*
Kroeze, R. M., Guo, Y., Vaidya, V. D., Keeling, J., Lev, B. L.
2018; 121 (16)
- **Tuning the Dipole-Dipole Interaction in a Quantum Gas with a Rotating Magnetic Field** *PHYSICAL REVIEW LETTERS*
Tang, Y., Kao, W., Li, K., Lev, B. L.
2018; 120 (23): 230401
- **Thermalization near Integrability in a Dipolar Quantum Newton's Cradle** *PHYSICAL REVIEW X*

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- Tang, Y., Kao, W., Li, K., Seo, S., Mallayya, K., Rigol, M., Gopalakrishnan, S., Lev, B. L.
2018; 8 (2)
- **Tunable-Range, Photon-Mediated Atomic Interactions in Multimode Cavity QED** *PHYSICAL REVIEW X*
Vaidya, V. D., Guo, Y., Kroeze, R. M., Ballantine, K. E., Kollar, A. J., Keeling, J., Lev, B. L.
2018; 8 (1)
 - **Spinor Self-Ordering of a Quantum Gas in a Cavity.** *Physical review letters*
Kroeze, R. M., Guo, Y. n., Vaidya, V. D., Keeling, J. n., Lev, B. L.
2018; 121 (16): 163601
 - **Scanning Quantum Cryogenic Atom Microscope** *PHYSICAL REVIEW APPLIED*
Yang, F., Kollar, A. J., Taylor, S. F., Turner, R. W., Lev, B. L.
2017; 7 (3)
 - **Anisotropic dependence of tune-out wavelength near Dy 741-nm transition** *OPTICS EXPRESS*
Kao, W., Tang, Y., Burdick, N. Q., Lev, B. L.
2017; 25 (4): 3411-3419
 - **Supermode-density-wave-polariton condensation with a Bose-Einstein condensate in a multimode cavity.** *Nature communications*
Kollár, A. J., Papageorge, A. T., Vaidya, V. D., Guo, Y., Keeling, J., Lev, B. L.
2017; 8: 14386-?
 - **Meissner-like Effect for a Synthetic Gauge Field in Multimode Cavity QED** *PHYSICAL REVIEW LETTERS*
Ballantine, K. E., Lev, B. L., Keeling, J.
2017; 118 (4)
 - **Anisotropic collisions of dipolar Bose-Einstein condensates in the universal regime** *NEW JOURNAL OF PHYSICS*
Burdick, N. Q., Sykes, A. G., Tang, Y., Lev, B. L.
2016; 18
 - **Anisotropic Expansion of a Thermal Dipolar Bose Gas** *PHYSICAL REVIEW LETTERS*
Tang, Y., SYKES, A. G., Burdick, N. Q., DiSciaccia, J. M., Petrov, D. S., Lev, B. L.
2016; 117 (15)
 - **Long-Lived Spin-Orbit-Coupled Degenerate Dipolar Fermi Gas** *PHYSICAL REVIEW X*
Burdick, N. Q., Tang, Y., Lev, B. L.
2016; 6 (3)
 - **Coupling to modes of a near-confocal optical resonator using a digital light modulator** *OPTICS EXPRESS*
Papageorge, A. T., Kollar, A. J., Lev, B. L.
2016; 24 (11): 1447-1457
 - **Bilayer fractional quantum Hall states with dipoles** *PHYSICAL REVIEW A*
YAO, N. Y., Bennett, S. D., Laumann, C. R., Lev, B. L., Gorshkov, A. V.
2015; 92 (3)
 - **s-wave scattering lengths of the strongly dipolar bosons Dy-162 and Dy-164** *PHYSICAL REVIEW A*
Tang, Y., Sykes, A., Burdick, N. Q., Bohn, J. L., Lev, B. L.
2015; 92 (2)
 - **Bose-Einstein condensation of Dy-162 and Dy-160** *NEW JOURNAL OF PHYSICS*
Tang, Y., Burdick, N. Q., Baumann, K., Lev, B. L.
2015; 17
 - **An adjustable-length cavity and Bose-Einstein condensate apparatus for multimode cavity QED** *NEW JOURNAL OF PHYSICS*
Kollar, A. J., Papageorge, A. T., Baumann, K., Armen, M. A., Lev, B. L.
2015; 17
 - **Fermionic suppression of dipolar relaxation.** *Physical review letters*
Burdick, N. Q., Baumann, K., Tang, Y., Lu, M., Lev, B. L.
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2015; 114 (2): 023201-?

- **Fermionic Suppression of Dipolar Relaxation** *PHYSICAL REVIEW LETTERS*
Burdick, N. Q., Baumann, K., Tang, Y., Lu, M., Lev, B. L.
2015; 114 (2)
- **Observation of low-field Fano-Feshbach resonances in ultracold gases of dysprosium** *PHYSICAL REVIEW A*
Baumann, K., Burdick, N. Q., Lu, M., Lev, B. L.
2014; 89 (2)
- **Trapping ultracold gases near cryogenic materials with rapid reconfigurability** *APPLIED PHYSICS LETTERS*
Naides, M. A., Turner, R. W., Lai, R. A., DiSciaccia, J. M., Lev, B. L.
2013; 103 (25)
- **Synthetic gauge field with highly magnetic lanthanide atoms** *PHYSICAL REVIEW A*
Cui, X., Lian, B., Ho, T., Lev, B. L., Zhai, H.
2013; 88 (1)
- **Imaging topologically protected transport with quantum degenerate gases** *PHYSICAL REVIEW B*
Dellabetta, B., Hughes, T. L., Gilbert, M. J., Lev, B. L.
2012; 85 (20)
- **Quantum Degenerate Dipolar Fermi Gas** *PHYSICAL REVIEW LETTERS*
Lu, M., Burdick, N. Q., Lev, B. L.
2012; 108 (21)
- **Atomic interface between microwave and optical photons** *PHYSICAL REVIEW A*
Hafezi, M., Kim, Z., Rolston, S. L., OROZCO, L. A., Lev, B. L., Taylor, J. M.
2012; 85 (2)
- **Exploring models of associative memory via cavity quantum electrodynamics** *PHILOSOPHICAL MAGAZINE*
Gopalakrishnan, S., Lev, B. L., Goldbart, P. M.
2012; 92 (1-3): 353-361
- **Frustration and Glassiness in Spin Models with Cavity-Mediated Interactions** *PHYSICAL REVIEW LETTERS*
Gopalakrishnan, S., Lev, B. L., Goldbart, P. M.
2011; 107 (27)
- **Strongly Dipolar Bose-Einstein Condensate of Dysprosium** *PHYSICAL REVIEW LETTERS*
Lu, M., Burdick, N. Q., Youn, S. H., Lev, B. L.
2011; 107 (19)
- **Dynamic polarizabilities and magic wavelengths for dysprosium** *PHYSICAL REVIEW A*
Dzuba, V. A., Flambaum, V. V., Lev, B. L.
2011; 83 (3)
- **Spectroscopy of a narrow-line laser-cooling transition in atomic dysprosium** *PHYSICAL REVIEW A*
Lu, M., Youn, S. H., Lev, B. L.
2011; 83 (1)
- **Dysprosium magneto-optical traps** *PHYSICAL REVIEW A*
Youn, S. H., Lu, M., Ray, U., Lev, B. L.
2010; 82 (4)
- **Atom-light crystallization of Bose-Einstein condensates in multimode cavities: Nonequilibrium classical and quantum phase transitions, emergent lattices, supersolidity, and frustration** *PHYSICAL REVIEW A*
Gopalakrishnan, S., Lev, B. L., Goldbart, P. M.
2010; 82 (4)
- **Anisotropic sub-Doppler laser cooling in dysprosium magneto-optical traps** *PHYSICAL REVIEW A*
Youn, S. H., Lu, M., Lev, B. L.

2010; 82 (4)

- **Cavity-Based Single Atom Preparation and High-Fidelity Hyperfine State Readout** *PHYSICAL REVIEW LETTERS*
Gehr, R., Volz, J., Dubois, G., Steinmetz, T., Colombe, Y., Lev, B. L., Long, R., Esteve, J., Reichel, J.
2010; 104 (20)
- **Trapping Ultracold Dysprosium: A Highly Magnetic Gas for Dipolar Physics** *PHYSICAL REVIEW LETTERS*
Lu, M., Youn, S. H., Lev, B. L.
2010; 104 (6)
- **Powerful narrow-line source of blue light for laser cooling Yb/Er and Dysprosium atoms** *Conference on Solid State Lasers XIX - Technology and Devices*
Kobtsev, S., Lev, B., Fortagh, J., Baraulia, V.
SPIE-INT SOC OPTICAL ENGINEERING.2010
- **Emergent crystallinity and frustration with Bose-Einstein condensates in multimode cavities** *NATURE PHYSICS*
Gopalakrishnan, S., Lev, B. L., Goldbart, P. M.
2009; 5 (11): 845-850
- **Biaxial nematic phases in ultracold dipolar Fermi gases** *NEW JOURNAL OF PHYSICS*
Fregoso, B. M., Sun, K., Fradkin, E., Lev, B. L.
2009; 11
- **Optical Interferometers with Reduced Sensitivity to Thermal Noise** *PHYSICAL REVIEW LETTERS*
Kimble, H. J., Lev, B. L., Ye, J.
2008; 101 (26)
- **Loss of molecules in magneto-electrostatic traps due to nonadiabatic transitions** *PHYSICAL REVIEW A*
Lara, M., Lev, B. L., Bohn, J. L.
2008; 78 (3)
- **Mitigation of loss within a molecular Stark decelerator** *EUROPEAN PHYSICAL JOURNAL D*
Sawyer, B. C., Stuhl, B. K., Lev, B. L., Ye, J., Hudson, E. R.
2008; 48 (2): 197-209
- **Prospects for the cavity-assisted laser cooling of molecules** *PHYSICAL REVIEW A*
Lev, B. L., Vukics, A., Hudson, E. R., Sawyer, B. C., Domokos, P., Ritsch, H., Ye, J.
2008; 77 (2)
- **Magneto-electrostatic trapping of ground state OH molecules** *PHYSICAL REVIEW LETTERS*
Sawyer, B. C., Lev, B. L., Hudson, E. R., Stuhl, B. K., Lara, M., Bohn, J. L., Ye, J.
2007; 98 (25)
- **OH hyperfine ground state: From precision measurement to molecular qubits** *PHYSICAL REVIEW A*
Lev, B. L., Meyer, E. R., Hudson, E. R., Sawyer, B. C., Bohn, J. L., Ye, J.
2006; 74 (6)
- **Integration of fiber-coupled high-Q SiNx microdisks with atom chips** *APPLIED PHYSICS LETTERS*
Barclay, P. E., Srinivasan, K., Painter, O., Lev, B., Mabuchi, H.
2006; 89 (13)
- **Quantum information processing in optical lattices and magnetic microtraps** *FORTSCHRITTE DER PHYSIK-PROGRESS OF PHYSICS*
Treutlein, P., Steinmetz, T., Colombe, Y., Lev, B., Hommelhoff, P., Reichel, J., Greiner, M., Mandel, O., Wiedera, A., Rom, T., Bloch, I., Hansch, T. W.
2006; 54 (8-10): 702-718
- **Precision measurement based on ultracold atoms and cold molecules** *20th International Conference on Atomic Physics*
Ye, J., Blatt, S., Boyd, M. M., Foreman, S. M., Hudson, E. R., Ido, T., Lev, B., Ludlow, A. D., Sawyer, B. C., Stuhl, B., Zelevinsky, T.
AMER INST PHYSICS.2006: 80-91
- **Proposed magneto-electrostatic ring trap for neutral atoms** *PHYSICAL REVIEW A*
Hopkins, A., Lev, B., Mabuchi, H.

2004; 70 (5)

- **Feasibility of detecting single atoms using photonic bandgap cavities** *Nanoscale Devices and System Integration Conference (NDSI-2004)*
Lev, B., Srinivasan, K., Barclay, P., Painter, O., Mabuchi, H.
IOP PUBLISHING LTD.2004: S556–S561
- **Fabrication of micro-magnetic traps for cold neutral atoms** *QUANTUM INFORMATION & COMPUTATION*
Lev, B.
2003; 3 (5): 450-464
- **Atom mirror etched from a hard drive** *APPLIED PHYSICS LETTERS*
Lev, B., Lassailly, Y., Lee, C., Scherer, A., Mabuchi, H.
2003; 83 (2): 395-397
- **QUANTUM NETWORKS BASED ON CAVITY QED** *QUANTUM INFORMATION & COMPUTATION*
Mabuchi, H., Armen, M., Lev, B., Loncar, M., Vuckovic, J., Kimble, H. J., Preskill, J., Roukes, M., Scherer, A., van Enk, S. J.
2001; 1: 7-12
- **Radiation hardness evaluation of the Analog Devices AD9042 ADC for use in the CMS electromagnetic calorimeter** *NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT*
Denes, P., Lev, B., Wixted, R.
1998; 417 (2-3): 371-376