UNIVERSITY OF COLORADO, BOULDER

DEPARTMENT OF PHYSICS

Boulder, Colorado 80309
http://www.colorado.edu/physics/

General University Information

President: Mark Kennedy
Dean of Graduate School: Scott Adler
University website: http://www.colorado.edu
School Type: Public
Setting: Urban
Total Faculty: 1,703
Total number of Students: 34,510
Total number of Graduate Students: 5,680

Department Information

Department Chair: Prof. Michael Ritzwoller, Chair
Department Contact: Jeanne Nijhowne, Graduate Program Assistant
Total full-time faculty: 75
Total number of full-time equivalent positions: 56
Full-Time Graduate Students: 315
Female Full-Time Graduate Students: 55
First-Year Graduate Students: 51
Female First-Year Students: 8
Total Post Doctorates: 99

Department Address

2000 Colorado Avenue
Boulder, CO 80309
Phone: (303) 735-0519
Fax: (303) 492-3352
E-mail: jeanne.nijhowne@colorado.edu
Website: http://www.colorado.edu/physics/

ADMISSIONS

Admission Contact Information

Address admission inquiries to: Jeanne Nijhowne, Graduate Program Assistant, 390 UCB, University of Colorado, Department of Physics, Boulder, CO 80309
Phone: (303) 735-0519
E-mail: jeanne.nijhowne@colorado.edu
Admissions website: http://www.colorado.edu/physics/admissions/graduate-application-info-and-deadlines

Application deadlines

Fall admission:
U.S. students: December 15 *Int'l. students*: December 15

Application fee

U.S. students: $60 *Int'l. students*: $80

Admissions information

For Fall of 2020:
Number of applicants: 897
Number admitted: 177
Number enrolled: 52

Admission requirements

Bachelor's degree requirements: A 4-year Bachelors degree is required.
Minimum undergraduate GPA: 3.0

GRE requirements

The GRE is not required.
There are no minimum score requirements. GRE scores are being waived for the Fall 2021 cycle due to the pandemic.

GRE Physics requirements

The GRE Physics is not required.
There are no minimum score requirements. GRE scores are being waived for the Fall 2021 cycle due to the pandemic.

TOEFL requirements

The TOEFL exam is required for students from non-English-speaking countries.
Minimum accepted TOEFL scores:
iBT score: 85
TOEFL scores are being waived during the application evaluation. If an international student attends CU, they will need to submit a TOEFL score if applicable.

Other admissions information

Additional requirements: The average GRE scores for admitted (matriculating) students for 2020 from the USA were 162 (162), 165 (164), and 824 (812) for verbal, quantitative, and physics, respectively. The corresponding values for international students were 157 (157), 168 (168), and 949 (953) for verbal, quantitative, and physics, respectively. The lowest scores of students admitted for 2020 were 142, 150, and 430 for verbal, quantitative, and physics, respectively.
Undergraduate preparation assumed: An undergraduate program for students entering graduate study in physics should typically include the following: ; Physics: 3 Semesters Introductory Physics; 1 Semester Advanced Classical Mechanics; 1 Semester Quantum Mechanics; 1 Semester Statistical Mechanics; 2 Semesters Advanced Electricity and Magnetism; 2 Semesters Advanced Laboratory Course/Project Work; 1 Semester Advanced Course in modern Physics such as Condensed Matter, Geophysics,; Atomic, Nuclear, or Particle Physics; Math: 3 Semesters Calculus; 1 Semester Linear Algebra; 1 Semester Differential Equations; Computing: ; General knowledge.

TUITION AND ASSISTANTSHIPS

Teaching Assistants, Research Assistants, and Fellowships

Number of first-year
Teaching Assistants: 44
Research Assistants: 6
Fellowship students: 2
Average stipend per academic year
Teaching Assistant: $23,842
Research Assistant: $23,842
Fellowship student: $23,842
Stipends are for 9 months. RA salaries increase by 3% after admission to candidacy.

Tuition year 2020–21:

Tuition for in-state residents
Full-time students: $5,913 per semester
Tuition for out-of-state residents
Full-time students: $15,642 per semester
Tuition is for 9 credits per semester. Tuition is covered by the department for all students in the Ph.D. program.
Credit hours per semester to be considered full-time: 6
Deferred tuition plan: Yes
Health insurance: Available at the cost of $3,896 per year.
Other academic fees: $1,696 graduate student fees for AY 2020–21 assuming 9 credit hours per semester.

Academic term: Semester
Number of first-year students who received full tuition waivers: 52

FINANCIAL AID

Application deadlines

Fall admission:
U.S. students: December 15 *Int'l. students*: December 15

Loans

Loans are available for U.S. students.
Loans are not available for international students.
GAPSFAS application required: No
FAFSA application required: No

For further information

Address financial aid inquiries to: University of Colorado Boulder, Office of Financial Aid, 556 UCB, Boulder, Colorado 80309-0556.
Phone: (303) 492-5091
E-mail: financialaid@colorado.edu
Financial aid website: https://www.colorado.edu/financialaid/aid-graduate-professional-students

HOUSING

Availability of on-campus housing

Single students: Yes
Married students: Yes
Childcare Assistance: No

For further information

Address housing inquiries to: University of Colorado Housing and Dining Services, 159 UCB, Boulder, CO 80309-0159.
Phone: (303) 492-6384
E-mail: graduatefamilyhousing@colorado.edu
Housing aid website: https://living.colorado.edu/explore-your-options

Table A—Faculty, Enrollments, and Degrees Granted

Research Specialty	Faculty	Enrollment Fall 2020		Number of Degrees Granted 2019–20 (2015–20)		
		Master's	Doctorate	Master's	Terminal Master's	Doctorate
Total	–	–	315	20(124)	–(5)	33(157)
Full-time Grad. Stud.	–	–	315	–	–	–
First-year Grad. Stud.	–	–	52	–	–	–

GRADUATE DEGREE REQUIREMENTS

Master's: We do not generally admit students intending to just pursue a Masters degree. Graduate students are admitted directly into the Ph.D. program and generally obtain a Masters degree en route to the Ph.D.

Doctorate: Students must complete five of the six required Comps I courses with a ″B-″ or better. Five additional graduate courses are needed to complete the 30 hours of required coursework of which at least 27 must be physics courses. Students must maintain a 3.0 GPA. All students are required to take the Comps II examination. When students are ready, they take a Comps III examination and are admitted into candidacy. They then write a doctoral thesis that they must defend. Students have six years to complete their doctorate, although this limit may be extended.

Other Degrees: There are programs in geophysics, applied physics, chemical physics, materials science, and interdisciplinary quantitative biology that have different requirements.

SPECIAL EQUIPMENT, FACILITIES, OR PROGRAMS

Two large centers are led by CU physicists: the Soft Material Research Center (SMRC) and the Center on Read-Time Functional Imaging (STROBE). There are many interdisciplinary programs with physics participation: Geophysics, Materials Science and Engineering (MSE), Chemical Physics, and Integrated Quantitative Biology (IQBio). Professional Research Experience Program (PREP)is a special partnership with the National Institute of Standards and Technology (NIST)that places undergraduates, graduate students and post-doctoral researchers in NIST labs to gain research experience alongside NIST scientists and applicable majors include most engineering departments, biochemistry, chemistry and physics.There are many institutes with a physics presence: JILA, Renewable and Sustainable Energy Institute (RASEI), the Cooperative Institute for Research in Environmental Sciences (CIRES), and the Institute for Modeling Plasma Atmospheres and Cosmic Dust (IMPACT); the last one hosts a unique 3 MV dust accelerator. Other facilities in the physics building include multiple shops, an optical metrology lab, and a micro and nanofabrication lab. Experimental and theoretical research opportunities are also available in Boulder at JILA, the National Institute for Standards & Technology (NIST), the Laboratory for Atmospheric and Space Physics (LASP), the High Altitude Observatory (HAO), the National Center for Atmospheric Research (NCAR), the National Solar Observatory (NSO), and the U.S. Geological Survey (USGS), as well as the National Renewable Energy Laboratory (NREL) in nearby Golden. Groups additionally work at facilities around the world including CERN, JPARC, Fermilab, Brookhaven, Spallation Neutron Source, and Advanced Photon Source.

Table B—Separately Budgeted Research Expenditures by Source of Support

Source of Support	Departmental Research	Physics-related Research Outside Department
Federal government	$29,492,161	$35,461,001
State/local government		$356,297
Non-profit organizations	$2,773,704	$2,257,329
Business and industry	$786,797	$288,674
Other		
Total	$33,052,662	$38,363,301

Table C—Separately Budgeted Research Expenditures by Research Specialty

Research Specialty	No. of Grants	Expenditures ($)
Atomic, Molecular, & Optical Physics	–	$32,459,006
Biophysics	–	$734,009
Condensed Matter Physics	–	$5,599,803
Geophysics	–	$546,301
Nuclear Physics	–	$644,789
Professional Research Experience Program	–	$13,394,816
Particles and Fields	–	$1,871,911
Physics and other Science Education	–	$3,070,223
Plasma and Fusion	–	$13,095,105
Total	–	$71,415,963

FACULTY

Professor

Anderson, Dana Z., Ph.D., University of Arizona, 1981. *Nano Science and Technology, Optics*. Experimental nonlinear optics, atom optics and optical precision measurements. (ORCID: 0000-0002-2891-4547)

Baker, Daniel N., Ph.D., University of Iowa, 1974. Joint appointment with Astrophysical & Planetary Sciences and Laboratory for Atmospheric and Space Physics. *Heliophysics and Space Weather, Solar Physics*.

Beale, Paul D., Ph.D., Cornell University, 1982. *Condensed Matter Physics, Theoretical Physics*. Theoretical Physics, thermodynamics and statistical mechanics of condensed matter systems. (ORCID: 0000-0001-8452-6891)

Becker, Andreas, Ph.D., Beilefeld University, 1997. JILA fellow. *Atomic, Molecular, & Optical Physics, Theoretical Physics*. Analysis and simulation of ultrafast phenomena in atoms, molecules and clusters, in particular attosecond electron dynamics, coherent control and molecular imaging. (ORCID: 0000-0003-0210-7584)

Betterton, Meredith D., Ph.D., Harvard University, 2000. *Biophysics, Chemical Physics*. Theoretical and experimental biophysics; systems biology; bioinformatics; pattern formation. (ORCID: 0000-0002-5430-5518)

Cao, Gang, Ph.D., Temple University, 1993. *Condensed Matter Physics, Crystallography, Materials Science, Metallurgy*. Research program combines a methodical search for novel quantum materials in single-crystal form, and a systematic effort to elucidate the underlying physics of these materials.

Cary, John, Ph.D., University of California, Berkeley, 1979. *Computational Physics, Electromagnetism, Physics of Beams, Plasma and Fusion*. Theoretical and computational physics of plasmas, nonlinear dynamics, and electromagnetics. (ORCID: 0000-0002-5888-5193)

Clark, Noel A., Ph.D., Massachusetts Institute of Technology, 1970. Director of Soft Materials Research Center. *Chemical Physics, Condensed Matter Physics, Crystallography*. Understanding and using the properties of Research on condensed phases, ranging from experiments on the fundamental physics of phase transitions, such as melting, to the development of liquid crystal electro-optic light valves. (ORCID: 0000-0001-9301-5540)

Cumalat, John P., Ph.D., University of California, Santa Barbara, 1977. *High Energy Physics, Particles and Fields*. Experimental particle physics (CMS experiment). (ORCID: 0000-0002-6032-5857)

de Alwis, Senarath P., Ph.D., University of Cambridge, 1969. *High Energy Physics, Particles and Fields, Theoretical Physics*. Theoretical particle physics with interests in string theory, supersymmetry breaking, and cosmology. (ORCID: 0000-0002-6907-947X)

DeGrand, Thomas A., Ph.D., Massachusetts Institute of Technology, 1976. *High Energy Physics, Particles and Fields, Theoretical Physics*. Study of the properties of strongly-interacting systems, most of which appear in the context of elementary particle physics, with a combination of analytic and numerical techniques.

Dessau, Daniel, Ph.D., Stanford University, 1992. *Condensed Matter Physics, Materials Science, Metallurgy*. Experimental condensed matter interests center around using femtosecond optics and electron spectroscopic tools for the study of the electronic structure, magnetic structure, and phase transitions of novel materials systems such as high temperature superconductors (HTSCs or cuprates) and colossal magnetoresistive oxides (CMRs or manganites). (ORCID: 0000-0002-3592-5113)

Finkelstein, Noah, Ph.D., Princeton University, 1998. Director of the Physics Education Research group; Director of the Center for STEM Learning. *Physics and other Science Education*. Physics Education Research that focuses on studying the conditions that support students' interest and ability in physics – developing models of context. These research projects range from the specifics of student learning particular concepts, to the departmental and institutional scales of sustainable educational transformation. (ORCID: 0000-0002-4783-4964)

Glenn, Jason, Ph.D., University of Arizona, 1997. Joint appointment with Astrophysical & Planetary Science. *Astrophysics*.

Goldman, Martin, Ph.D., Harvard University, 1965. *Plasma and Fusion, Solar Physics*. Plasma physics research centered around linear and nonlinear wave phenomena excited in plasmas (ionized gases) by electron and radiation beams.

Gurarie, Victor, Ph.D., Princeton University, 1996. Director of Center for Theory of Quantum Matter (CTQM). *Condensed Matter Physics, Theoretical Physics*. Theoretical condensed matter physics. (ORCID: 0000-0001-5331-4415)

Halverson, Nils, Ph.D., University of California, Berkeley, 2002. Joint appointment with Astrophysical & Planetary Sciences. *Astrophysics*. Observational cosmology.

Hamilton, Andrew J. S., Ph.D., University of Virginia, 1983. Joint appointment with Astrophysical & Planetary Science. *Astrophysics, Relativity & Gravitation*.

Hasenfratz, Anna, Ph.D., Lorand Eotvos University, 1982. *High Energy Physics, Particles and Fields, Theoretical Physics*. Theoretical particle physics (lattice gauge theory). (ORCID: 0000-0003-1813-2645)

Hermele, Michael, Ph.D., University of California, Santa Barbara, 2005. *Condensed Matter Physics, Theoretical Physics*. Theoretical condensed matter physics focused on strongly correlated quantum systems. These are systems, occurring both in solid state materials and ultracold atomic gases, where quantum mechanics and interactions among the constituent particles combine to give rise to striking collective behavior. Study is done using modern techniques of quantum field theory and other tools to study the collective behavior of correlated systems. (ORCID: 0000-0003-2594-1176)

Holland, Murray, Ph.D., University of Oxford, 1994. JILA fellow; Associate Chair for Graduate Studies. *Atomic, Molecular, & Optical Physics, Theoretical Physics*. Theoretical research on properties of quantum gases with a focus on transport in optical lattices and on strongly interacting superfluids. Also, research on superradiant cavity QED with group-II elements to develop a mHz linewidth ″laser.″. (ORCID: 0000-0002-3778-1352)

Horanyi, Mihaly, Ph.D., Lorand Eotvos University, Budapest, 1982. Laboratory for Atmospheric and Space Physics (LASP). *Atmosphere, Space Physics, Cosmic Rays, Plasma and Fusion*. Theoretical and experimental investigations of space and laboratory complex (dusty) plasmas. (ORCID: 0000-0002-5920-9226)

Kapteyn, Henry, Ph.D., University of California, Berkeley, 1989. JILA fellow. *Atomic, Molecular, & Optical Physics, Chemical Physics, Optics*. Ultrafast laser technology, ultrafast dynamics in Molecular and materials systems, and development of tabletop coherent x-ray sources. (ORCID: 0000-0001-8386-6317)

Kinney, Edward R., Ph.D., Massachusetts Institute of Technology, 1988. *Nuclear Physics*. Experimental nuclear physics research focused on the elucidation of how the basic constituents of the nucleon, quarks, are bound in a gluonic field. (ORCID: 0000-0002-4176-5283)

Lewandowski, Heather, Ph.D., University of Colorado, Boulder, 2002. Associate Chair of Engineering Physics; JILA fellow. *Atomic, Molecular, & Optical Physics, Physics and other Science Education*. Experimental study of collisions and reactions of simple cold molecules to understand the quantum mechanical processes involved in making and breaking a chemical bond. We aim to control the reacting molecules external and internal degrees of freedom in the quantum regime. To accomplish this control, we slow down a supersonically cooled molecular beam using time-varying inhomogeneous electric fields (Stark deceleration). The cold (~100 mK) mol-

ecules are then loaded into an electrostatic trap for study. (ORCID: 0000-0002-0995-552X)

Marino, Alysia, Ph.D., University of California, Berkeley, 2004. *High Energy Physics, Particles and Fields*. Experimental particle physics studying the properties of neutrinos with the T2K experiment at JPARC, the NA61/Shine experiment at CERN, and the DUNE experiment at Fermilab/Homestake. (ORCID: 0000-0002-1709-538X)

Munsat, Tobin, Ph.D., Princeton University, 2001. *Atmosphere, Space Physics, Cosmic Rays, Plasma and Fusion*. Experimental plasma physics research follows several lines of study, including fluctuation measurements in plasmas, the relationship of turbulent quantities to cross-field plasma transport, and the microphysics of dust impacts which drive the dusty plasma equilibria. (ORCID: 0000-0002-5746-4063)

Murnane, Margaret, Ph.D., University of California, Berkeley, 1989. JILA fellow. *Atomic, Molecular, & Optical Physics, Chemical Physics, Optics*. Ultrafast laser and x-ray science, ultrafast femtosecond-to-attosecond dynamics in molecular and materials systems, development of tabletop coherent x-ray sources and their application in science and technology. (ORCID: 0000-0001-9689-5432)

Nagle, Jamie, Ph.D., Yale University, 1996. *Nuclear Physics*. Research is in the field of experimental high-energy heavy ion physics; studying the quark-gluon plasma with the PHENIX experiment at RHIC and working on the upgraded detector sPHENIX. (ORCID: 0000-0003-0056-6613)

Parker, Scott, Ph.D., University of California, Berkeley, 1990. *Plasma and Fusion*. Research in the area of the kinetic theory and simulation of plasmas, currently in the area of direct numerical simulation of tokamak plasma turbulence on large massively parallel computers. (ORCID: 0000-0003-0942-630X)

Piestun, Rafael, Ph.D., Israel Institute of Technology, 1998. Joint appointment with Electrical, Computer & Energy Engineering. *Electrical Engineering, Optics*.

Pollock, Steven, Ph.D., Stanford University, 1987. *Physics and other Science Education*. Physics Education Research, including issues of teacher preparation, large-scale classes, and upper-division classes. (ORCID: 0000-0002-2462-8164)

Price, John C., Ph.D., Stanford University, 1986. *Condensed Matter Physics, Low Temperature Physics, Nano Science and Technology*. Experimental condensed matter physics including low temperature physics, molecular electronics, and molecular crystals. (ORCID: 0000-0003-1381-8373)

Radzihovsky, Leo, Ph.D., Harvard University, 1993. *Condensed Matter Physics, Theoretical Physics*. Theoretical physics research that spans a broad spectrum of condensed matter, ranging from liquid crystals, colloids, membranes, rubber and other ″soft″ matter to degenerate atomic gases, superconductors, and quantum Hall systems. The unifying theme is the collective universal behavior that emerges at long scales and low energies, driven by a combination of strong interactions, fluctuations, and/or local heterogeneity. (ORCID: 0000-0002-2281-0835)

Rankin, Patricia, Ph.D., University of London, 1982. *High Energy Physics, Particles and Fields, Other*. Experimental particle physics; investigating leadership and the under representation of women in physics. (ORCID: 0000-0002-4140-6627)

Raschke, Markus B., Ph.D., Technical University of Munich, 1999. *Atomic, Molecular, & Optical Physics, Chemical Physics, Condensed Matter Physics, Nano Science and Technology, Optics*. Experimental nonlinear and ultrafast nano-optics; Spatio-temporal optical control, optical antennas, surface plasmon and phonon polaritons, extreme nonlinear optics, strong light matter interaction; scanning probe near-field optical microscopy and spectroscopy, optical forces, and optothermal phenomena; dynamics and phase behavior of complex oxides, semiconductor nanostructures, and polymer nanocomposites. (ORCID: 0000-0003-2822-851X)

Ritzwoller, Michael H., Ph.D., University of California, San Diego, 1987. Department Chair, Director of Center for Imaging the Earth's Interior (CIEI). *Geophysics*. Observational seismology concentrated on developing methods to focus seismic models derived from surface wave dispersion information to tectonic scales, particularly in the US and China. Recent emphasis has focused on developing methods for exploiting ambient noise and earthquakes in surface wave tomography and combining this information to produce 3-D models of the crust and uppermost mantle. (ORCID: 0000-0002-6517-1981)

Rogers, Charles T., Ph.D., Cornell University, 1987. *Condensed Matter Physics*. Experimental condensed matter physics of thin films and very small systems. Presently, studying the nanoelectromechanical behavior of nanowires and fabricated electromechanical structures, buried interfaces in photovoltaic systems, and surface molecular dipole systems. Nanoscale objects are made with a combination of photolithography, electron-beam lithography, epitaxial thin-film growth. (ORCID: 0000-0002-2278-6863)

Schibli, Thomas, Ph.D., University of Karlsruhe, 2001. JILA adjunct fellow. *Atomic, Molecular, & Optical Physics, Condensed Matter Physics, Materials Science, Metallurgy, Nano Science and Technology, Optics*. Experimental research to advance science and technology in the fields of optics and photonics through advanced functional materials, novel laser systems, and measurement techniques. (ORCID: 0000-0001-7226-8805)

Smalyukh, Ivan, Ph.D., Kent State University, 2003. *Chemical Physics, Condensed Matter Physics, Materials Science, Metallurgy, Nano Science and Technology*. Experimental soft condensed matter physics styding the organizing principles of mesoscale self-assembly phenomena that lead to creation of artificial materials and structures with emergent physical behavior and properties arising from the patterning of molecular order combined with the organization of nano- and microsized particles into precisely controlled configurations. (ORCID: 0000-0003-3444-1966)

Stenson, Kevin, Ph.D., University of Wisconsin, Madison, 1998. *High Energy Physics, Particles and Fields*. Experimental particle physics with the CMS experiment at the CERN LHC searching for physics beyond the standard model (for example supersymmetry) and working on upgrades to the detector. (ORCID: 0000-0003-4888-205X)

Zhong, Shijie, Ph.D., University of Michigan, 1994. *Geophysics*. Geophysics research aimed at understanding the physical processes that control the evolution of terrestrial planets (Earth, Moon, Mars, . . .). (ORCID: 0000-0002-1654-1931)

Zimmerman, Eric, Ph.D., University of Chicago, 1998. *High Energy Physics*. Experimental particle physics studying the properties of neutrinos with the T2K experiment at JPARC, the NA61/Shine experiment at CERN, and the DUNE experiment at Fermilab/Homestake. (ORCID: 0000-0002-6394-6659)

Associate Professor

DeWolfe, Oliver, Ph.D., Massachusetts Institute of Technology, 2000. *High Energy Physics, Particles and Fields, Theoretical Physics*. Theoretical particle physics focusing on string theory and supergravity and their applications to other phenomena via holography, particle physics, cosmology and quantum field theory. (ORCID: 0000-0003-0591-2941)

Gopinath, Juliet, Ph.D., Massachusetts Institute of Technology, 2005. Joint appointment with Electrical, Computer & Energy Engineering. *Electrical Engineering, Optics*.

Hough, Loren E., Ph.D., University of Colorado, Boulder, 2007. *Biophysics*. Currently studying intrinsically disordered pro-

teins using solution NMR. Proteins containing disordered domains perform many important cellular functions. The aggregations of this family of proteins is implicated in neuodegenerative diseases such as Alzheimer's and Parkinson's diseases. In-cell nuclear magnetic resonance techniques are used to study the disordered proteins that form the selective barrier of the nuclear pore complex. This is being extended to study similar proteins, especially those involved in transcriptional regulation. (ORCID: 0000-0002-1104-0126)

Kempf, Sascha, Ph.D., Friedrich Schiller University, Jena, 1999. LASP. *Atmosphere, Space Physics, Cosmic Rays, Plasma and Fusion*. Dusty plasmas, specializing in dust detectors and analysis with CCLDAS.

Lee, Minhyea, Ph.D., University of Chicago, 2004. *Condensed Matter Physics*. Experimental condensed matter and materials physics research focusing on understanding collective behavior in condensed matter systems via electrical and thermal transport properties, under the control parameters of high pressure and magnetic field. The systems of interest include anomalous Hall effect materials, itinerant magnetic systems, novel superconductivity in the vicinity of other ground states, and high thermoelectric materials. We also use nanofabrication and microwave measurements to develop novel probes for correlated electron systems based on shot noise. (ORCID: 0000-0002-8559-8544)

Nandkishore, Rahul, Ph.D., Massachusetts Institute of Technology, 2012. *Condensed Matter Physics, Theoretical Physics*. Theoretical condensed matter physics focusing on the search for new emergent phenomena in quantum many body systems with strong interactions and/or strong randomness in systems both in and out of equilibrium. Particular topics of interest include: non-equilibrium quantum statistical mechanics, many body localization and thermalization, field theory of correlated systems, Dirac fermions, unconventional superconductors, and the interplay of disorder and interactions. (ORCID: 0000-0001-5703-6758)

Neil, Ethan T., Ph.D., Yale University, 2011. *High Energy Physics, Particles and Fields, Theoretical Physics*. Theoretical particle physics: Lattice gauge theory, physics beyond the standard model, collider and dark matter phenomenology, strongly-coupled quantum field theory. (ORCID: 0000-0002-4915-3951)

Regal, Cindy, Ph.D., University of Colorado, Boulder, 2006. JILA fellow. *Atomic, Molecular, & Optical Physics*. Engineering and exploring isolated quantum systems for quantum information and quantum optics with a focus on manipulating single and few neutral atoms and the quest to control single phonons in mesoscopic mechanical oscillators. This experimental work relies on low-loss optical interfaces and laser cooling and trapping techniques. (ORCID: 0000-0002-0000-2140)

Reznik, Dmitry, Ph.D., University of Illinois at Urbana-Champaign, 1993. *Condensed Matter Physics, Materials Science, Metallurgy*. Experimental condensed matter and materials physics focusing on using neutron, x-ray, and Raman scattering to investigate the physics of correlated electrons and electron-phonon coupling in perovskite oxides (including high Tc supercondcutors, manganites, etc.) and other exotic materials. (ORCID: 0000-0001-5749-8549)

Romatschke, Paul, Ph.D., Technical University of Vienna, 2003. *Nuclear Physics, Theoretical Physics*. Theoretical study of cold dense matter, relativistic viscous hydrodynamics, non-Abelian plasma instabilities, nonlinear gravity, and other topics. (ORCID: 0000-0003-4380-1986)

Uzdensky, Dmitri A., Ph.D., Princeton University, 1998. Director of Center for Integrated Plasma Studies (CIPS). *Astrophysics, Atmosphere, Space Physics, Cosmic Rays, Plasma and Fusion, Solar Physics*. Theoretical plasma physics, including both basic plasma physics and its applications to understand various natural phenomena, usually those involving magnetized plasmas far beyond Earth. Main interests lie in the realm of plasma astrophysics, including high-energy astrophysics, but I am also strongly interested in various topics in space physics and solar physics, as well as certain areas of magnetic fusion. (ORCID: 0000-0001-8792-6698)

Assistant Professor

Calkins, Michael A., Ph.D., University of California, Los Angeles, 2010. *Geophysics*. Geophysical and astrophysical fluid dynamics studying the generation of planetary magnetic fields via the inductive action of turbulent motions, and the physics of fluid motion in planetary atmospheres. (ORCID: 0000-0002-6917-5365)

Figueroa Morales, Nuris, Ph.D., Sorbonne University, 2017. *Biophysics, Condensed Matter Physics, Fluids, Rheology*. Interdisciplinary areas of soft and active matter studying complex interactions between microorganisms and their surroundings, using tools from microscopy, microfluidics and quantitative image analysis. (ORCID: 0000-0003-2385-3260)

Litos, Michael, Ph.D., Boston University, 2010. *Physics of Beams, Plasma and Fusion*. Experimental plasma physics, beam-driven and laser-driven plasma wakefield acceleration and interactions.

Perepelitsa, Dennis, Ph.D., Columbia University, 2014. *Nuclear Physics*. Experimental nuclear physics; study of phenomena of heavy ion collisions using the ATLAS detector at CERN.

Smith, Graeme, Ph.D., California Institute of Techonology, 2006. JILA associate fellow. *Atomic, Molecular, & Optical Physics, Quantum Foundations, Theoretical Physics*. Theory of quantum information and quantum computing; identification of the fundamental limits that physics places on communication, information processing, and sensing and understand the implications of these limits both in terms of practical technologies and fundamental physics. This involves finding new ways to think about information and computation, and new ideas for analyzing them. Past work includes error correction, quantum channel capacities, additivity questions, characterization of quantum annealers, and mathematical properties of entropy. (ORCID: 0000-0001-8440-3963)

Sun, Shuo, Ph.D., University of Maryland, College Park, 2016. *Nano Science and Technology, Optics, Quantum Foundations*. Quantum optics, nanophotonics, and experimental quantum information science. (ORCID: 0000-0003-4171-0466)

Ulmer, Keith, Ph.D., University of Colorado, Boulder, 2007. *High Energy Physics, Particles and Fields*. Experimental particle physics with the CMS experiment at the CERN LHC searching for physics beyond the standard model (for example supersymmetry) and working on upgrades to the detector. (ORCID: 0000-0001-6875-9177)

Wilcox, Bethany, Ph.D., University of Colorado, 2015. *Physics and other Science Education*.

Research Professor

Bohn, John, Ph.D., University of Chicago, 1995. JILA fellow. *Atomic, Molecular, & Optical Physics, Theoretical Physics*. Theory of cold collisions and few-body physics. (ORCID: 0000-0002-4657-0880)

Research Associate Professor

Jaron-Becker, Agnieszka, Ph.D., Warsaw University Institute of Theoretical Physics, 2000. JILA associate fellow. *Atomic, Molecular, & Optical Physics, Theoretical Physics*. Theoretical atomic physics. (ORCID: 0000-0003-2339-8544)

Research Assistant Professor

D'Incao, Jose P., Ph.D., University of Sao Paulo, Institute of Physics Sao Carlos - Brazil, 2002. *Atomic, Molecular, & Optical Physics, Theoretical Physics*. Theoretical atomic physics.

Adjunct Professor

Nesbitt, David, Ph.D., University of Colorado, Boulder, 1981. JILA fellow. *Biophysics, Chemical Physics*. Chemical physics, including high resolution laser spectroscopy, chemical reaction dynamics, quantum nanostructures and single-molecule biophysics.

Perkins, Thomas T., Ph.D., Stanford University, 1997. JILA fellow. *Biophysics, Chemical Physics, Optics*. Single molecule measurements of biological systems using applying high precision measurements based on optical traps and atomic force microscopes.

Professor Adjoint

Cornell, Eric, Ph.D., Massachusetts Institute of Technology, 1990. JILA fellow. *Atomic, Molecular, & Optical Physics*. Experimental precision measurements and Bose-Einstein condensation and related topics in ultracold atoms. Current projects include an experiment to put an improved limit on the electron electric dipole moment and developing technology for extracting electricity from waste heat.

Diddams, Scott, Ph.D., University of New Mexico, 1996. NIST physicist. *Atomic, Molecular, & Optical Physics, Optics*. Experimental laser physics; femtosecond lasers and ultrafast phenomena; nonlinear optics; precision spectroscopy; optical frequency combs; metrology.

Hall, John, Ph.D., Carnegie Institute of Technology, 1961. JILA fellow. *Atomic, Molecular, & Optical Physics, Optics*. Development of laser stabilization and measurement techniques that lead toward the creation of phase-stable optical frequency sources and their application to precision tests of fundamental principles.

Lehnert, Konrad, Ph.D., University of California, Santa Barbara, 1999. JILA fellow. *Atomic, Molecular, & Optical Physics, Nano Science and Technology*. Studying quantum coherence in macroscopic mechanical oscillators, developing quantum-coherent networks of microwave signals for control and measurement, and implementing quantum-limited measurements in astrophysics and condensed matter experiments.

Levine, Judah, Ph.D., New York University, 1966. JILA fellow; NIST fellow. *Geophysics, Relativity & Gravitation*. Developing statistical methods for estimating the performance of frequency standards and for distributing time and frequency information.

Rey, Ana Maria, Ph.D., University of Maryland, 2004. JILA fellow. *Atomic, Molecular, & Optical Physics, Theoretical Physics*. Theory of optical lattices, quantum degenerate Fermi gases, and ultracold Boson-Fermion mixtures. (ORCID: 0000-0001-7176-9413)

Thompson, James K., Ph.D., Massachusetts Institute of Technology, 2003. JILA fellow. *Atomic, Molecular, & Optical Physics, Low Temperature Physics*. Ultracold atoms, quantum optics, and precision measurements.

Wineland, David, Ph.D., Harvard University, 1970. NIST physicist. *Atomic, Molecular, & Optical Physics*. Laser-cooled trapped ions in the areas of high-resolution spectroscopy, basic plasma physics, and quantum information.

Ye, Jun, Ph.D., University of Colorado, Boulder, 1997. JILA fellow. *Atomic, Molecular, & Optical Physics, Optics*. Atomic and optical physics and precision measurement.

Associate Professor Adjoint

Leibrandt, David, Ph.D., Massachusetts Institute of Technology, 2009. NIST physicist. *Atomic, Molecular, & Optical Physics*.

Assistant Professor Adjoint

Kaufman, Adam, Ph.D., University of Colorado, Boulder, 2015. *Atomic, Molecular, & Optical Physics*.

Professor Attendant Rank

Glaser, Matthew A., Ph.D., University of Colorado, Boulder, 1991. *Biophysics, Computational Physics, Condensed Matter Physics*. Computer simulation techniques for problems in condensed-matter physics and statistical physics. (ORCID: 0000-0002-8366-5598)

Maclennan, Joseph, Ph.D., University of Colorado, Boulder, 1988. *Condensed Matter Physics*. Ferroelectric liquid crystals; freely suspended liquid crystal films; instrumentation. (ORCID: 0000-0002-3587-554X)

Perkins, Katherine, Ph.D., Harvard University, 2000. Director of PhET Interactive Simulations Project and CU's Science Education Initiative. *Physics and other Science Education*. Physics education research with a focus on the use of interactive simulations for teaching and learning physics, students' beliefs about physics (and chemistry), and sustainable course reform. (ORCID: 0000-0002-6464-6586)

Wagner, Stephen, Ph.D., Johns Hopkins University, 1983. *High Energy Physics, Particles and Fields*. Experimental particle physics (CMS experiment). (ORCID: 0000-0002-9269-5772)

Instructor

Bolton, Daniel R., Ph.D., University of Washington, 2011. *Nuclear Physics, Theoretical Physics*. Nuclear theory and lattice QCD.

Dubson, Michael, Ph.D., Cornell University, 1984. Associate Chair of Arts and Sciences Undergraduate Physics. *Physics and other Science Education*. Physics education research. (ORCID: 0000-0003-2354-8071)

Hodby, Eleanor, Ph.D., University of Oxford, 2002. *Physics and other Science Education*. AMO, PER.

West, Colin, Ph.D., C.N. Yang Institute for Theoretical Physics, Stony Brook University, 2016. *Physics and other Science Education*. Quantum information theory; physics education research.

Wilkerson, Donald, M.A., University of Colorado, 1990. *Other*. Writing courses for science and engineering students.

Lecturer

Knill, Emanuel, Ph.D., University of Colorado, Boulder, 1991. NIST physicist. *Applied Mathematics, Theoretical Physics*. Quantum information science.

Papp, Scott, Ph.D., University of Colorado, Boulder, 2007. NIST physicist. *Applied Physics, Atomic, Molecular, & Optical Physics*.

Simmonds, Raymond W., Ph.D., University of California, Berkeley, 2002. NIST physicist. *Atomic, Molecular, & Optical Physics, Optics*.

Ullom, Joel, Ph.D., Harvard University, 1997. NIST physicist. *Applied Physics, Electrical Engineering, Low Temperature Physics, Materials Science, Metallurgy*. Experimental condensed-matter physics: superconductivity, low-temperature physics, and radiation detectors and their applications.

Senior Research Scientist

Wieman, Carl E., Ph.D., Stanford University, 1977. Senior advisor to PhET. *Atomic, Molecular, & Optical Physics, Physics and other Science Education*. Bose-Einstein condensation; AMO physics; physics education research.

Courtesy Professor

Hussein, Mahmoud, Ph.D., University of Michigan - Ann Arbor, 2004. *Materials Science, Metallurgy*. Theoretical, computa-

tional and experimental dynamics of materials and structures; vibrations and wave propagation, thermal transport in crystals, fluid-structure interaction; phononics including phononic crystals and acoustic/elastic metamaterials; dispersive, resonant, dissipative and nonlinear dynamics; periodic systems, disordered systems; fast band structure calculations, multiscale methods, design and optimization.

Hussein, Mahmoud, Ph.D., University of Michigan - Ann Arbor, 2004. Joint appointment with Aerospace Engineering. *Materials Science, Metallurgy*. Theoretical, computational, and experimental dynamics of materials and structures; vibrations and wave propagation, thermal transport in crystals, fluid-structure interaction; phononics including phononic crystals and acoustic/elastic metamaterials; dispersive, resonant, dissipative and nonlinear dynamics; periodic systems, disordered systems; fast band structure calculations, multiscale methods, design and optimization.

Li, Baowen, Ph.D., Carl von Ossietzky Universitat, 1992. Joint appointment with Mechanical Engineering. Phononics: Manipulating and Controlling Heat Flow with Electronic Analogs; Probing Techniques/Methods of Phonons/Heat; Acoustical and Thermal Meta-materials; Acoustic Waves in Random/Turbulent Media; Quantum Computation and Quantum Memory by Phonons; Complex Networks; Inverse Scattering problem.

McGeehee, Michael, Ph.D., University of California Santa Barbara, 1999. Joint appointment with Chemical and Biological Engineering. The McGehee group is currently doing research on perovskite solar cells as well as dynamic windows that have adjustable tinting. This research builds on our prior investigations of organic light-emitting diodes and lasers, light extraction from LEDs, light trapping in solar cells, charge transport in organic semiconductors, nanopatterning, organic and dye-sensitized solar cells and semi-transparent electrodes based on meshes of carbon nanotubes or silver nanowires.

Courtesy Associate Professor

Shaheen, Sean E., Ph.D., University of Arizona, 1999. Joint appointment with Electrical, Computer & Energy Engineering. *Biophysics, Electrical Engineering, Energy Sources & Environment, Materials Science, Metallurgy*.

Courtesy Assistant Professor

Yin, Xiaobo, Ph.D., Stanford University, 2008. Joint appointment with Mechanical Engineering. *Materials Science, Metallurgy, Nano Science and Technology*. Nanoscale materials and engineering.

DEPARTMENTAL RESEARCH SPECIALTIES AND STAFF

Theoretical

Astrophysics. Astrophysics is concentrated in the Department of Astrophysical and Planetary Sciences, but many of our Ph.D. students work with faculty at APS, JILA, CASA, and LASP. Hamilton.

Atmosphere, Space Physics, Cosmic Rays. Solar, space, and atmospheric plasma studies and lunar surface environment. Horanyi.

Atomic, Molecular, & Optical Physics. Our AMO physics is concentrated in JILA, one of the leading research institutes in the world in this area. Research at JILA includes high-precision spectroscopy and precision measurement, ultracold cold atoms and molecules, ultrafast and ultra-high-power lasers, and micron- and nanometer-scale optics. Becker, Bohn, D'Incao, Holland, Jaron-Becker, Knill, Rey, Smith.

Biophysics. Molecular motors and motors that can change their track; DNA-protein interactions; self-assembly of cytoskeletal materials; liquid crystalline aggregates. Betterton, Glaser.

Chemical Physics. Theory of ultracold chemical reactions; chemical reaction dynamics. Bohn.

Condensed Matter Physics. Theoretical condensed-matter research on soft materials, strongly interacting quantum systems, fractional quantum Hall effect, exotic quantum states, and statistical mechanics of spin systems. Beale, Glaser, Gurarie, Hermele, Maclennan, Nandkishore, Radzihovsky, Romatschke.

Geophysics. Physics of earth dynamics, including both gravitational and magnetic fields and tectonics and volcanism. Ritzwoller, Zhong.

High Energy Physics. Non-perturbative QCD lattice gauge theories; grand unified theories; supersymmetry; string theory. de Alwis, DeGrand, DeWolfe, Hasenfratz, Neil.

History & Philosophy of Physics/Science. History and philosophy of 20th-century physics, especially high-energy physics.

Nuclear Physics. Theory of highly relativistic ion collisions, relativistic fluids, and the quark-gluon plasma. Bolton, Romatschke.

Optics. Ultrafast and ultra-high-power lasers and interactions. Becker, Jaron-Becker.

Particles and Fields. Non-perturbative QCD lattice gauge theories; grand unified theories; supersymmetry; string theory. de Alwis, DeGrand, DeWolfe, Hasenfratz, Neil.

Physics and other Science Education. Uses of technology in physics education; assessments (conceptual, epistemological, and belief oriented); curricular and classroom materials at the middle- and upper-division levels; theoretical models of students learning physics; social and contextual foundations of student learning; examination of successful educational reforms and replication studies of such reforms; student problem-solving in physics. Finkelstein, Hodby, West, Wilcox, Wilkerson.

Plasma and Fusion. Theory of space and laboratory plasmas; plasma turbulence; magnetic reconnection. The Center for Integrated Plasma Studies is used. Cary, Goldman, Horanyi, Parker, Uzdensky.

Experimental

Applied Physics. Research in materials science; nanomechanical systems; nano-optics; ultrafast, and ultra-high-power lasers. Anderson, Kapteyn, Lehnert, Levine, Murnane, Papp, Price, Rogers, Schibli, Ullom, Yin.

Astrophysics. Astrophysics is concentrated in the Department of Astrophysical and Planetary Science, but many of our Ph.D. students work with faculty at APS, JILA, CASA, and LASP. Glenn, Halverson.

Atmosphere, Space Physics, Cosmic Rays. Solar, space, and atmospheric plasma studies; lunar surface environment. Baker, Goldman, Horanyi, Kempf, Munsat.

Atomic, Molecular, & Optical Physics. Our AMO physics is concentrated in JILA, one of the leading research institutes in the world in this area. Research at JILA includes high-precision spectroscopy and precision measurement, ultracold cold atoms and molecules, ultrafast and ultra-high-power lasers, and micron- and nanometer-scale optics. Anderson, Cornell, Diddams, Gopinath, Hall, Kapteyn, Kaufman, Lehnert, Leibrandt, Levine, Lewandowski, Murnane, Papp, Piestun, Raschke, Regal, Schibli, Simmonds, Thompson, Ullom, Wineland, Ye.

Biophysics. Atomic force spectroscopy of biological molecules; nanoassembly. Betterton, Hough, Thomas Perkins.

Chemical Physics. Laser spectroscopy of molecules; ultracold molecules; state-resolved chemical reactions; nanometer/fem-

tosecond measurements of electrons in molecules. Betterton, Kapteyn, Lewandowski, Murnane, Nesbitt, Thomas Perkins, Raschke, Smalyukh.

Condensed Matter Physics. Soft condensed-matter and liquid crystal physics; femtosecond optical, electron, and neutron spectroscopy on materials; nanoscale electronic structure studies of surfaces; electrical and mechanical properties of nanofabricated materials; low-temperature properties of exotic materials. Cao, Clark, Dessau, Lee, Lehnert, Maclennan, Price, Raschke, Reznik, Rogers, Schibli, Shaheen, Smalyukh, Yin.

Geophysics. Physics of earth dynamics, including both gravitational and magnetic fields and tectonics and volcanism. Calkins.

High Energy Physics. The high-energy physics experimentalists are members of the CMS experiment at CERN, the T2K neutrino experiment at JPARC, the DUNE project at Fermilab/Homestake, and the NA61/Shine experiment at CERN. Cumalat, Marino, Rankin, Stenson, Ulmer, Wagner, Zimmerman.

Low Temperature Physics. Low-temperature properties of exotic materials. Cornell, Lewandowski, Price, Regal, Thompson, Ye.

Materials Science, Metallurgy. Electronic and mechanical properties of nanostructures. Cao, Dessau, Price, Raschke, Reznik, Rogers, Smalyukh, Yin.

Nuclear Physics. Relativistic heavy ion collisions and medium-energy nuclear structure studies. Kinney, Nagle, Perepelitsa.

Optics. Ultrafast and ultra-high-power lasers; femtosecond/nanoscale optics; nonlinear optics; integrated nano-optics. Anderson, Diddams, Gopinath, Hall, Kapteyn, Murnane, Piestun, Raschke, Schibli, Ye.

Particles and Fields. The particle physics experimentalists are members of the CMS experiment at CERN, the T2K neutrino experiment at JPARC, the DUNE project at Fermilab/Homestake, and the NA61/Shine experiment at CERN. Cumalat, Marino, Stenson, Ulmer, Wagner, Zimmerman.

Physics and other Science Education. Uses of technology in physics education; assessments (conceptual, epistemological, and belief oriented); curricular and classroom materials at the middle- and upper-division levels; theoretical models of students learning physics; social and contextual foundations of student learning; examination of successful educational reforms and replication studies of such reforms; student problem-solving in physics. Dubson, Lewandowski, Katherine Perkins, Pollock, Wieman.

Physics of Beams. Theoretical and experimental development of advanced beams, primarily through plasma wakefield acceleration. Cary, Litos.

Plasma and Fusion. Laboratory and space plasmas; measurement and assessment of turbulence and cross-field transport in magnetically confined plasmas; solar plasma observations; dusty plasmas; lunar surface environment. The Center for Integrated Plasma Studies, Colorado Center for Lunar Dust and Atmospheric Studies is used. Baker, Goldman, Horanyi, Kempf, Litos, Munsat.