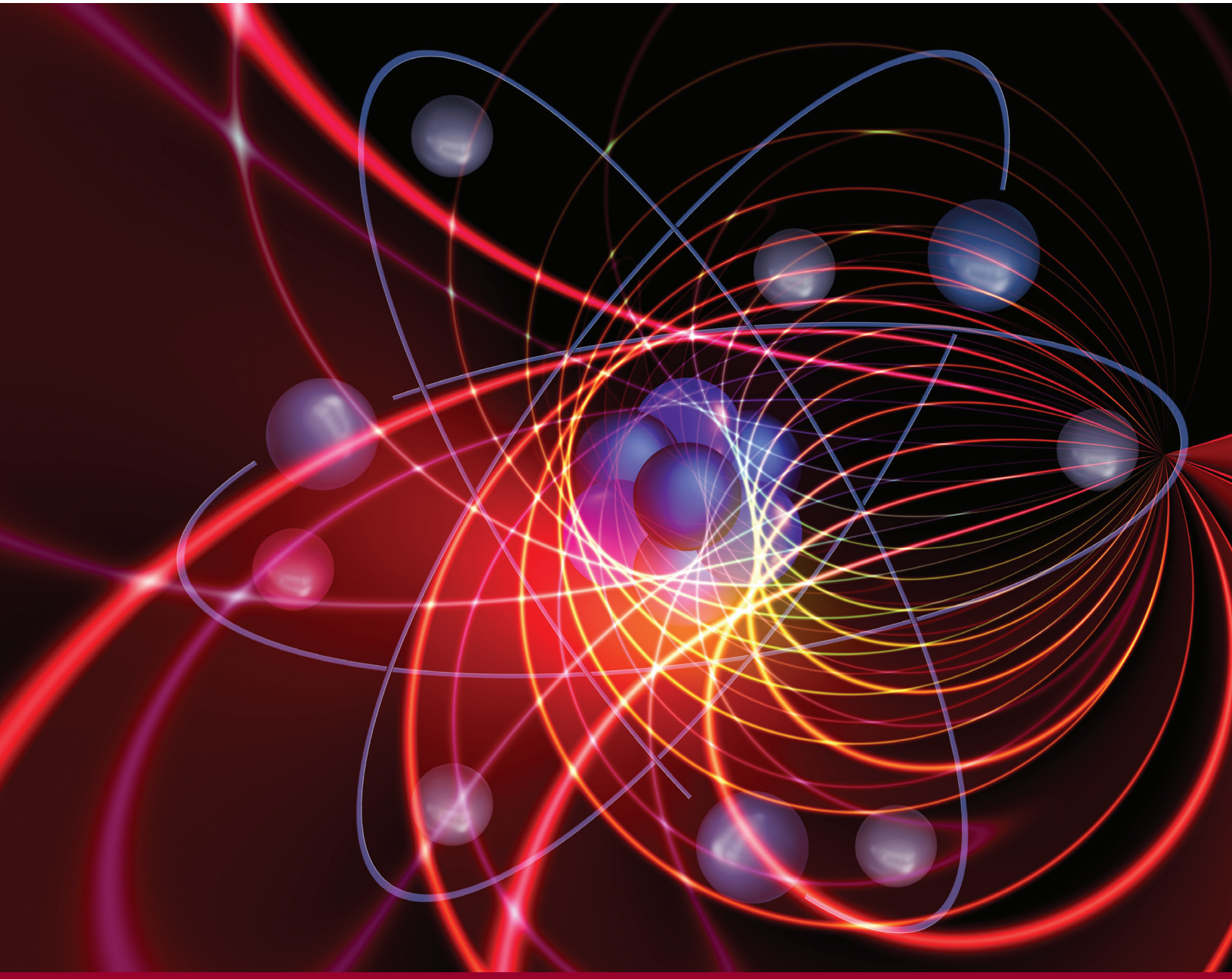
BOSTON COLLEGE

Morrissey College of Arts and Sciences



GRADUATE PROGRAM

Physics

WELCOME FROM THE BOSTON COLLEGE DEPARTMENT OF PHYSICS

Welcome to the Boston College Department of Physics, where our primary focus is cutting-edge research concentrated in experimental and theoretical condensed matter physics. Some specific areas of current interest are superconductivity, photovoltaics, metamaterials, thermoelectrics, nanostructures and nano- materials for biosensing, plasmonics, energy materials, topological insulators, quantum information science, novel electronic materials, and other strongly correlated electron systems.

Graduate students share in this research, gaining the technical and intellectual training needed for future success in the career paths of their choice. The department includes 20 faculty, numerous post-docs, and approximately 50 graduate students, all of whom are supported by teaching assistantships or research assistantships.

Significant research facilities are available to our graduate students. The Department of Physics is continually enhancing and supplementing these and has developed strong ties to many outside facilities, including Los Alamos National Laboratory, Argonne National Laboratory, the Institute for Complex Adaptive Matter (ICAM), Brookhaven National Laboratory, the Naval Research Laboratory, and the National High Magnetic Field Laboratory.

In addition to coursework and research participation, graduate students become members of the worldwide research community. Each week there are colloquia and seminars presented by leading physicists from around the country and world. The department is a close-knit community of scientists as well as part of the thriving Boston intellectual and scientific community, allowing for collaboration among local universities.

Graduates of our doctoral program have gone on to successful careers in many areas, including academic, industrial, and governmental positions. We invite you to learn more about our vibrant scientific environment by visiting bc.edu/physics.

CONTENTS

PROGRAM OVERVIEW

The graduate program in the Department of Physics offers a comprehensive course of study and research leading to the Ph.D. Courses emphasize a broadly based foundation in the fundamental principles of physics, preparing the student to think independently and to undertake advanced research under the supervision of a faculty advisor.

DOCTORAL PROGRAM

Students in the doctoral program may pursue a master's degree and Ph.D. in various theoretical and experimental research programs, including:

- Photonics and Plasmonics
- Strongly Correlated Materials and Unconventional Superconductivity
- Renewable Energy Materials (Thermoelectrics, Photovoltaics, Hydrogen Fuel Cells)
- Topological Materials
- Biological Physics, Neuroscience
- 2D Atomic Crystals and Thin Films
- Quantum Information Science

Graduates of the program have gone on to successful careers in a broad range of fields within as well as outside of physics. Students are prepared for a wide range of careers in a variety of fields, including academic research, teaching, and industry. The department is focused on a highly collaborative approach, with students forming a vital part of the community.

In addition to working with BC faculty in the physics department, students have access to cutting-edge facilities and often work in integrated science teams with faculty from Chemistry, Biology, Neuroscience, or neighboring institutions.

REQUIREMENTS

Master of Science in Physics (M.S.)

Although we do not offer a program culminating in an M.S., students who are accepted into our Ph.D. program have the option to obtain an interim master's degree.

The requirements to obtain an interim M.S.:

- Achieve a master's passing score on the comprehensive exam.
- Pass the following graduate courses: Classical Mechanics, Statistical Physics I, Electromagnetic Theory I, Quantum Mechanics I, Mathematical Physics I, Quantum Mechanics II, and Physics Graduate Seminar.
- Pass three elective graduate courses: Solid State I, Solid State II, Statistical Physics II, Techniques of Experimental Physics, Topics in Physics, or other electives offered periodically by the department, or pass one of the elective courses and prepare a master's thesis to be submitted to and approved by the graduate program director (counts as two courses).

Doctor of Philosophy (Ph.D.)

The requirements to obtain a Ph.D.:

- Achieve a Ph.D. level passing grade on the comprehensive exam before the end of the second year.
- Advance to candidacy by passing the Research Proposal Exam within one year of passing the comprehensive exam.
- Pass the following graduate courses: Classical Mechanics, Statistical Physics I, Electromagnetic Theory I, Quantum Mechanics I, Mathematical Physics I, Quantum Mechanics II, Statistical Physics II, and Physics Graduate Seminar.
- Pass four elective graduate courses: Solid State I, Solid State II, Techniques of Experimental Physics, Topics in Physics, or other electives offered periodically by the department.
- Completion of the thesis research and successful defense.

COMPREHENSIVE EXAMINATION

The comprehensive examination is a written exam that covers all physics that a physics graduate student can be expected to know at the end of one year of formal course work in the curriculum; however, it stresses classical mechanics, electromagnetism, quantum mechanics, and statistical physics. The examination is offered twice each year, the week before the beginning of each semester. Students must pass one of two possible attempts before the end of their second academic year in order to continue in the graduate program. Exceptionally well-prepared

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and qualified students may make the first attempt of the exam either by arriving one week early to take a fall exam or taking a spring exam during their first year.

RESEARCH PROPOSAL EXAMINATION

The purpose of this oral examination is for the student to assimilate work done in an area of research and to define a research project that addresses one or more open important questions in this area. The research proposal examination is a 40-minute, public presentation followed by 20 minutes of questions by the exam committee in private. The proposal should include a detailed explanation for how the student proposes to address the open questions and preferably include preliminary results.

THESIS

Upon the student's passing performance of the research proposal examination, the student and their advisor, in consultation with the chairperson, shall establish a doctoral thesis committee consisting of the student's advisor, who will chair the committee, and at least three additional tenure-track faculty members, with at least two from the Department of Physics.

PH.D. CURRICULUM

A typical sequence of graduate courses during the first two years:

Year I

Fall	Spring	Summer
Quantum Mechanics I	Quantum Mechanics II	Begin Research
Mathematical Physics	Electromagnetic Theory I	Comprehensive Exam
Classical Mechanics	Statistical Physics I	
	Graduate Seminar	

Year II

Fall	Spring	Summer
Statistical Physics II	Elective Elective	Conduct research in preparation for the RPE
Elective		
Graduate Seminar		

FACULTY PROFILES

KEVIN S. BEDELL

John H. Rourke Professor of Physics

Ph.D., SUNY Stony Brook, 1979

Theoretical physics of condensed matter systems. Strongly correlated electron systems, including: weak ferromagnets, unconventional superconductors, and graphene. The theory of local, marginal, and other correlated Fermi liquids. Study of the properties of quantum gases and fluids including: Majorana fermions and the AdS/CFT viscosity bound violation in viscoelastic Fermi liquids.

SELECTED PUBLICATIONS

- "Viscosity Bound Violation in Viscoelastic Fermi Liquids," M. Gochan, H. Li, and K.S. Bedell, *Journal of Physics Communications* 3, 6 (2020).
- "Necessary and Sufficient Conditions for the Validity of Luttinger's Theorem," J.T. Heath and K.S. Bedell, *New Journal of Physics* 22, 063011 (2020).
- "Atypical Behavior of Collective Modes in Two-Dimensional Fermi Liquids," M.P. Gochan, J.T. Heath, and K.S. Bedell, *Journal of Physics: Condensed Matter* 32(34), 345602 (2020).
- "Chebyshev Polynomial Expansion of Two-Dimensional Landau-Fermi liquid Parameters," J.T. Heath, M.P. Gochan, and K.S. Bedell, *Journal of Physics A: Mathematical and Theoretical* 53, 225203 (2020).
- "Unconventional Hund Metal in a Weak Itinerant Ferromagnet," X. Chen et al., *Nature Communications* 11, 3076 (2020).
- "Exotic Quantum Statistics from a Many-body Theory of Majorana Fermions," J.T. Heath and K.S. Bedell, *Journal of Physics A: Mathematical and Theoretical* 52, 315001 (2019).
- "Consequences of the Inherent Density Dependence in Dirac Materials," M. Gochan and K.S. Bedell, *Journal of Physics: Condensed Matter* 30, 445603 (2018).

DAVID A. BROIDO

Professor of Physics

Ph.D., University of California, San Diego, 1985

Theoretical condensed matter physics, computational materials discovery, first principles approaches to phonon and electron transport, thermal properties of crystalline, and disordered bulk and nanostructured materials.

SELECTED PUBLICATIONS

- "The Elphbolt Ab Initio Solver for the Coupled Electron-phonon Boltzmann Transport Equations," N. Protik, C. Li, M. Pruneda, D.A. Broido, and P. Ordejón, *npj Computational Materials* 8, 28 (2022).
- "Phonon-Phonon Interactions in Strongly Bonded Solids: Selection Rules and Higher-Order Processes," N.K. Ravichandran and D.A. Broido, *Physical Review X* 10, 021063 (2020).
- "Ultrahigh Thermal Conductivity in Isotope-enriched Cubic Boron Nitride," K. Chen et al., *Science* 367, 555 (2020).

- "Effect of Thermal Lattice and Magnetic Disorder on Phonons in Bcc Fe: A First-principles Study," M. Heine, O. Hellman, and D. Broido, *Physical Review B* 100, 104304 (2019).
- "Non-monotonic Pressure Dependence of the Thermal Conductivity of Boron Arsenide," N.K. Ravichandran and D.A. Broido, *Nature Communications* 10, 827 (2019).
- "Unusual High Thermal Conductivity in Boron Arsenide Bulk Crystals," F. Tian et al., *Science* 361, 582 (2018).
- "Fermi Surface Nesting and Phonon Frequency Gap Drive Anomalous Thermal Transport," C. Li, N.K. Ravichandran, L. Lindsay, and D.A. Broido, *Physical Review Letters* 121, 175901 (2018).
- "Physically Founded Phonon Dispersions of Few Layer Materials and the Case of Borophene," J. Carrete, W. Li, L. Lindsay, D.A. Broido, L.J. Gallego, and N. Mingo, *Materials Research Letters* 4, 204 (2016).
- "Hydrodynamic Phonon Transport in Suspended Graphene," S. Lee, D.A. Broido, K. Esfarjani, and G. Chen, *Nature Communications* 6, 6920 (2015).

KENNETH S. BURCH

Professor of Physics

Ph.D., University of California, San Diego, 2006

Topological phases, unconventional superconductors, biosensing with 2D materials and magnetic 2d materials. Developing new optical and fabrication techniques to engineer novel-devices and phases.

SELECTED PUBLICATIONS

- "Dielectrophoresis Assisted Rapid, Selective and Single Cell Detection of Antibiotic Resistant Bacteria with G-FETs," N. Kumar et al., *Biosensors and Bioelectronics* 156, 112123 (2020).
- "High Mobility in a Van der Waals Layered Antiferromagnetic metal," S. Lei et al., *Science Advances* 6, eaay6407 (2020).
- "The Range of Non-Kitaev Terms and Fractional Particles in α-RuCl3," Y. Wang et al., *npj Quantum Materials* 5, 14 (2020).
- "Uncovering Eectron-phonon Scattering and Phonon Dynamics in Type-I Weyl Semimetals," J. Coulter et al., *Physical Review B* 100, 220301 (2019).
- "Evidence for Helical Hinge Zero Modes in an Fe-Based Superconductor," J. Coulter et al., *Nano Letters* 19, 4890 (2019).
- "Coulomb Blockade in an Atomically Thin Quantum Dot Coupled to a Tunable Fermi Reservoir," M. Brotons-Gisbert et al., *Nature Nanotechnology* 14, 442 (2019).
- "Colossal Mid-infrared Bulk Photovoltaic Effect in a Type-I Weyl Semimetal," G.B. Osterhoudt, L.K. Diebel, M.J. Gray, X. Yang, J. Stanco, X. Huang, B. Shen, N. Ni, P.J.W. Moll, Y. Ran, and K.S. Burch, *Nature Materials* 18, 471 (2019).
- "Magnetism in Two-dimensional van der Waals Materials," K.S. Burch, D. Mandrus, and J.-G. Park, *Nature* 563, 47 (2018).
- "Andreev Reflection Without Fermi Surface Alignment in High-Tc van der Waals Heterostructure," P. Zareapour, A. Hayat, S.Y.F. Zhao, M. Kreshchuk, Z. Xu, T.S. Liu, G.D. Gu, S. Jia, R.J. Cava, H.-Y. Yang, Y. Ran, and K.S. Burch, *New Journal of Physics* 19, 043026 (2017).
- "When Chiral Photons Meet Chiral Fermions," *Physical Review Letters* 116, 026805 (2016).
- "Magneto-elastic Coupling in a Potential Ferromagnetic 2D Atomic Crystal," Y. Tian, M.J. Gray, H. Ji, R.J. Cava and K.S. Burch, *2D Materials* 3, 025035 (2016).
- "Scattering Continuum and Possible Fractionalized Excitations in RuCl3," L.J. Sandilands, Y. Tian, K.W. Plumb, Y.-J. Kim, and K.S. Burch, *Physical Review Letters* 114, 147201 (2015).
- "Optical Evidence of Surface State Suppression in Bi-Based Topological Insulators," A.A. Reijnders, Y. Tian, L.J. Sandilands, G. Pohl, I.D. Kivlichan, S.Y.F. Zhao, S. Jia, M.E. Charles, R.J. Cava, N. Alidoust, S. Xu, M. Neupane, M.Z. Hasan, X. Wang, S.W. Cheong, and K.S. Burch, *Physical Review B* 89, 075138 (2014).
- "Cooper-pair-Based Photon Entanglement Without Isolated Emitters," A. Hayat, H.-Y. Kee, K.S. Burch, and A.M. Steinberg, *Physical Review B* 89, 094508 (2014).

XIAO CHEN

Assistant Professor of Physics

Ph.D., University of Illinois at Urbana-Champaign, 2016

Non-equilibrium many-body quantum dynamics in closed and open systems, such as transport property and quantum information dynamics. Topological phases of matter, such as topological insulator, topological ordered phase, and topological defect.

SELECTED PUBLICATIONS

- "Measurement-induced Criticality in Z2-symmetric Quantum Automaton Circuits," Y. Han and X. Chen, *Physical Review B* 105, 064306 (2022).
- "Multifractality in Nonunitary Random Dynamics," J. Iaconis and X. Chen, *Physical Review B* 104, 214307 (2021).
- "Emergent Replica Conformal Symmetry in Non-Hermitian SYK Chains," P. Zhang, S.-K. Jian, C. Liu, and X. Chen, *Quantum* 5, 579 (2021).
- "Hybrid Wannier Chern Bands in Magic Angle Twisted Bilayer Graphene and the Quantized Anomalous Hall Effect," K. Hejazi, X. Chen, and L. Balents, *Physical Review Research* 3, 013242 (2021).
- "Measurement-induced Phase Transitions in Quantum Automaton Circuits," J. Iaconis, A. Lucas, and X. Chen, *Physical Review B* 102, 224311 (2020).
- "Operator Lévy Flight: Light Cones in Chaotic Long-Range Interacting Systems," T. Zhou, S. Xu, X. Chen, A. Guo, and B. Swingle, *Physical Review Letters* 124(18), 180601 (2020).
- "Emergent Conformal Symmetry in Nonunitary Random Dynamics of Free Fermions," X. Chen, Y. Li, M.P.A. Fisher, and A. Lucas, *Physical Review Research* 2, 033017 (2020).
- "Measurement-driven Entanglement Ttransition in Hybrid Quantum Circuits," Y. Li, X. Chen, and M.P.A. Fisher, *Physical Review B* 100, 134306 (2019).

FACULTY PROFILES

- "Quantum Chaos Dynamics in Long-range Power Law Interaction Systems," X. Chen and T. Zhou, *Physical Review B* 100, 064305 (2019).
- "Quantum Zeno Effect and the Many-body Entanglement Transition," Y.Li, X. Chen, and M.P.A. Fisher, *Physical Review* 98, 205136 (2018).
- "Entanglement Signatures of Emergent Dirac Fermions: Kagome Spin Lliquid and Quantum Criticality," W. Zhu, X. Chen, Y.-C. He, and W. Witczak-Krempa, *Science Advances* 4, eaat5535 (2018).
- "Measuring the Distance Between Quantum Many-body Wave Functions," X. Chen, T. Zhou, and C. Xu, *Journal of Statistical Mechanics: Theory and Experiment* 073101 (2018).
- "Universal Spectral Correlations in the Chaotic Wave Function, and the Development of Quantum Chaos," X. Chen and A.W.W. Ludwig, *Physical Review B* 98, 064309 (2018).
- "Quantum Entanglement of the Sachdev-Ye-Kitaev Models," C. Liu, X. Chen, and L. Balents, *Physical Review B* 97, 245126 (2018).
- "Gauging (3+1)-dimensional Topological Phases: An Approach from Surface Theories," X. Chen, A. Tiwari, C. Nayak, and S. Ryu, *Physical Review B* 96, 165112 (2017).
- "Twofold Twist Defect Chains at Criticality," X. Yu, X. Chen, A. Roy, and J.C.Y. Teo, *Physical Review B* 96, 205435 (2017).
- "From Obifolding Conformal Field Theories to Gauging Topological Phases," X. Chen, A. Roy, J.C.Y. Teo, and S. Ryu, *Physical Review B* 96, 115447 (2017).
- "Gapless Quantum Spin Chains: Multiple Dynamics and Conformal Wavefunctions," X. Chen, E. Fradkin, and W. Witczak-Krempa, *Journal of Physics A: Mathematical and Theoretical* 50, 464002 (2017).

JAN R. ENGELBRECHT

Professor of Physics

Ph.D., University of Illinois, Urbana, 1993

Current research focuses on collective ordering in time. Using conformal geometric and group-theoretic techniques to study Kuramoto oscillator networks, correspondence between oscillator dynamics on group orbits and geometric flows on the Poincaré disc. Collective behavior in the spiking activity of model and real neural networks, and the dynamics of machine learning.

SELECTED PUBLICATIONS

- "Is the Ott-Antonsen Manifold Attracting?" *Physical Review Research* 2, 023057 (2020).
- "Dynamics of the Kuramoto-Sakaguchi Network with Asymmetric Order Parameter," *Chaos* 29, 013126 (2019).
- "Hyperbolic Geometry of Kuramoto Oscillator Networks," *Journal of Physics A: Mathematical and Theoretical* 50, 355101 (2017).
- "Cluster Synchronization in Networks of Identical Oscillators with Alpha-function Pulse Coupling," *Physical Review E* 95, 022207 (2017).
- "Classification of Attractors for Systems of Identical Coupled Kuramoto Oscillators," *Chaos* 24(1), 013114 (2014).
- "Rhythm-Induced Spike-Timing Patterns Characterized by 1D Firing Maps," *Journal of Computational Neuroscience* 34(1), 59 (2013).
- "Structure of Long-term Average Frequencies for Kuramoto Oscillator Systems," *Physical Review Letters* 109(3), 034103 (2012).

BENEDETTA FLEBUS

Assistant Professor of Physics

Ph.D., Utrecht University, 2017

Condensed matter theory, non-Hermitian topological classifications, twistronics and Floquet engineering in magnetic systems, quantum-impurity relaxometry, and collective spin and heattransport as probes of magnetization dynamics.

SELECTED PUBLICATIONS

- "Quantum Sensing of Spin Transport Properties of an Antiferromagnetic Insulator," H. Wang, S. Zhang, N.J. McLaughlin, B. Flebus, M. Huang, Y. Xiao, E.E. Fullerton, Y. Tserkovnyak, and C.R. Du, *Science Advances* 1, 8 (2022).
- "Non-Hermitian Topology of 1D Spin-torque Oscillator Arrays," B. Flebus, R.A. Duine, and H.M. Hurst, *Physical Review B* 102, 180408(R) (2020).
- "Electronic Structure of Carbon Nanotubes on Graphene Substrates," B. Flebus and A.H. MacDonald, *Physical Review Research* 2, 022041 (2020).
- "Quantum-impurity Relaxometry of Magnetization Dynamics," B. Flebus and Y. Tserkovnyak, *Physical Review Letters* 121, 187204 (2018).
- "Two-Fluid Theory for Spin Superfluidity in Magnetic Insulators," B. Flebus, S.A. Bender, Y. Tserkovnyak, and R.A. Duine, *Physical Review Letters* 116, 117201 (2016).
- "Magnon Polarons in the Spin Seebeck Effect," T. Kikkawa, K. Shen, B. Flebus, R.A. Duine, K. Uchida, Z. Qiu, G.E.W. Bauer, and E. Saitoh, *Physical Review Letters* 117, 207203 (2016).

MICHAEL J. GRAF

Professor of Physics

Ph.D., Brown University, 1987

Experimental condensed matter physics at low temperatures; electronic, magnetic, and thermodynamic properties; NMR and muon spin spectroscopy of novel electronic materials, including magnetically frustrated materials, molecular and single-ion magnets, nanostructured thermoelectrics, and superconductors.

SELECTED PUBLICATIONS

- "First Demonstration of Tuning Between the Kitaev and Ising Limits in a Honeycomb Lattice," *Science Advances* 8, abl5671 (2022).
- "Effect of Structural Disorder on the Kitaev Magnet $Ag_3LiIr_2O_6$," *Physical Review B* 103, 094427 (2021).

- "Absence of Local Moments in the Kagome Metal KV3Sb5 as Determined by Muon Spin Spectroscopy," *Journal of Physics: Condensed Matter* 33, 235801 (2021).
- "Superconductivity in the Z2 Kagome Metal KV3Sb5," *Physical Review Matters* 5, 034801 (2021).
- "Frustrated Heisenberg J1 - J2 Model Within the Stretched Diamond Lattice of LiYbO2," *Physical Review B* 103, 014420 (2021).
- "Monopole-limited Nucleation of Magnetism in Eu2Ir2O7," *Physical Review B* 101, 174435 (2020).
- "Competition Between Static and Dynamic Magnetism in the Kitaev Spin Liquid Material Cu2IrO3," *Physical Review B* 100, 094418 (2019).
- "Suppression of μ+ Depolarization by Fast Magnetic Fluctuations at Avoided Level Crossings for Ho3+ ions in CaWO4," *Physical Review B* 98, 134424 (2018).

ANDRZEJ HERCZYNSKI

Research Professor of Physics

Ph.D., Lehigh University, 1987

Analytical methods in fluid dynamics, perturbation theory for compressible flows, similarity solutions in hydrodynamics, waves. Physics and art, scaling properties and fluid dynamical effects in abstract paintings. Recent and new projects include experiments on viscous thread falling on a rotating surface, granular matter in spinning containers, depictions of fluid dynamics in art, and fractal patterns in music.

SELECTED PUBLICATIONS

- "Towards Spectrally Selective Catastrophic Response," *Physical Review E* 101, 062415 (2020).
- "Form of Spinning Liquids in Diverse Geometries," *American Journal of Physics* 88, 475 (2020).
- "From Depicting to Deploying Fluids in Art," *Bulletin of the APS* 64(13), 356 (2019).
- "Bio-inspired 3D Quasi-fractal Nanostructure for Improved Oxygen Evolution Reaction," *Chemical Communications* 55, 357 (2019).
- "Optimisation of Hierarchical Structures and Nano-Scale-Enabled Plasmonic Refraction for Window Electrodes in Photovoltaics," *Nature Communications* 7, 12825 (2016).
- "Experiments on Standing Waves Over a Corrugated Bottom," *Journal of Fluid Mechanics* 777, 122 (2015).
- "Bio-inspired Networks for Optoelectronic Applications," *Nature Communications* 5, 5674 (2014).

KRZYSZTOF KEMPA

Professor of Physics

Ph.D., University of Wroclaw, 1980

Plasmonic and metamaterial effects in metallic and semiconducting nanostructures, plasmon scattering, superfluorescence and plasmon instability, photovoltaics beyond the Shockley-Queisser limit, bioapplications of nanostructures.

SELECTED PUBLICATIONS

- "Light- and Melanin Nanoparticle-Induced Cytotoxicity in Metastatic Cancer Cells," V.R. Gabriele et al., *Pharmaceutics* 13, 965 (2021).
- "Towards Spectrally Selective Catastrophic Response," V.R. Gabriele et al., *Physical Review E* 101, 062415 (2020).
- "Tailoring the Electron-phonon Interaction with Metallic Pasmonic Structures," X. Wu et al., *Materials Today Physics* 8, 86 (2019).
- "Plasmon-polaron of the Topological Metallic Surface States," A. Shvonski, J. Kong, and K. Kempa, *Physical Review B* 99, 125148 (2019).
- "Topologically Protected Photonic Edge States in the Visible in Plasmo-Gyroelectric Metamaterials," X. Wu et al., *Advanced Optical Materials* 6(15), 1800119 (2018).
- "Nonlocal Response with Local Optics," J. Kong, A. Shvonski, and K. Kempa, *Physical Review B* 97, 165423 (2018).
- "Nature Inspired Metallic Networks for Transparent Electrodes," J. Gao et al., *Advanced Functional Materials* 28(24), 1705023(2017).
- "Anomalous Acoustic Plasmon Mode from Topologically Protected States," X. Jia et al., *Physical Review Letters* 119, 136805 (2017).
- "Physics of Transparent Conductors," J. Gao et al., *Advances in Physics* 65, 553 (2016).
- "Wireless Communication System Via Nanoscale Plasmonic Antennas," J.M. Merlo et al., *Scientific Reports* 6, 31710 (2016).

QIONG MA

Assistant Professor of Physics

Ph.D., Massachusetts Institute of Technology, 2016

Experimental condensed matter physics; topological and correlated materials; 2D materials and devices; nanofabrication; electronic transport, optical, and optoelectronic measurements of quantum materials.

SELECTED PUBLICATIONS

- "Topology and Geometry Under the Nonlinear Electromagnetic Spotlight," Q. Ma, A. Grushin, and K. Burch, *Nature Materials* 20, 1601 (2021).
- "Unconventional Ferroelectricity in Moiré Heterostructures," Z. Zheng and Q. Ma et al., *Nature* 588, 71 (2020).
- "Spontaneous Gyrotropic Electronic Order in a Transition-metal Dichalcogenide," S-Y. Xu and Q. Ma et al., *Nature* 578, 545 (2020).

FACULTY PROFILES

- "Observation of the Nonlinear Hall Effect Under Time Reversal Symmetric Conditions," Q. Ma et al., *Nature* 565, 337 (2019).
- "Van der Waals Heterostructures with Graphene and Hexagonal Boron Nitride," M. Yankowitzl and Q. Ma et al., *Nature Reviews Physics* 1, 112 (2019).
- "Van der Waals Heterostructures with Graphene and Hexagonal Boron Nitride", M. Yankowitzl and Q. Ma et al., *Nature Reviews Physics* 1, 112 (2019).

MICHAEL J. NAUGHTON

Evelyn J. and Robert A. Ferris Professor of Physics

Ph.D., Boston University, 1986

Experimental condensed matter and materials physics, nanoscale integrated science; electrical, magnetic, and photonic studies of low dimensional and nanoscale matter; superconductivity; nanostructures for energy conversion, biosensing, and neurointerface development; physics-based medical device development.

SELECTED PUBLICATIONS

- "Grand Challenges in Nanofabrication: There Remains Plenty of Room at the Bottom," J.T. Fourkas and M.J. Naughton et al., *Frontiers in Nanotechnology* 3, 700849 (2021).
- "All-optical Logic Gates Based on Anomalous Floquet Photonic Topological Insulator Structures," J.M. Merlo and M.J. Naughton et al., *Journal of Optics* 23, 065001 (2021).
- "Light- and Melanin Nanoparticle-induced Cytotoxicity in Metastatic Cancer Cells," V.R. Gabriele and M.J. Naughton et al., *Pharmaceutics* 13, 965 (2021).
- "All-optical Logic Gates Based on Anomalous Floquet Photonic Topological Insulator Structure," J.M. Merlo and M.J. Naughton et al., *Journal of Optics* 23, 065001 (2021).
- "Optical Confinement in the Nanocoax: Coupling to the Fundamental TEM-like Mode," Y.M. Calm and M.J. Naughton et al., *Optics Express* 28, 32152 (2020).
- "Towards Spectrally Selective Catastrophic Response," V.R. Gabriele and M.J. Naughton et al., *Physical Review E* 101, 062415 (2020).
- "Plasmonic Multiple Exciton Generation," J. Kong and M.J. Naughton et al., *Physical Review Materials* 3, 065201 (2019).
- "Facile Fabrication and Formation Mechanism of Aluminum Nanowire Arrays," N.T. Nesbitt, M.J. Burns, and M.J. Naughton, *Nanotechnology* 31, 095301 (2020).
- "An Extended Core Nanocoax Pillar Architecture for Enhanced Molecular Detection Sensitivity," L.A. D'Imperio and M.J. Naughton et al., *Biosensors and Bioelectronics* 134, 83 (2019).
- "All-Solution-Processed Micro/Nanowires with Electroplate Welding as Transparent Conducting Electrodes," C. Yang and M.J. Naughton et al., *Physica Status Solidi (RRL)—Rapid Research Letters* 13(6), 1900010 (2019).
- "On-chip Electrochemical Detection of Cholera Using a Polypyrrole-Functionalized Dendritic Gold Sensor," A.E. Valera and M.J. Naughton et al., *ACS Sensors* 4, 644 (2019).

CYRIL P. OPEIL, S.J.

Associate Professor of Physics

Ph.D., Boston College, 2004

Experimental condensed-matter physics; thermoelectric materials; synthesis and characterization of bulk and thin film samples from 2–1200 K. meteorite/asteroid formation; physical and thermal characterization of meteorites via thermal conductivity, specific heat capacity; Young's modulus and resonant ultrasound spectroscopy from 5–300 K.

SELECTED PUBLICATIONS

- "Heat Capacities of Ordinary Chondrite Falls Below 300 K," R.J. Macke, C.P. Opeil, and G.J. Consolmagno, *Meteoritics & Planetary Science* 54, 2729 (2019).
- "Experimental Determination of Phonon Thermal Conductivity and Lorenz Ratio of Single-crystal Bismuth Telluride," M. Yao, C.P. Opeil, S. Wilson, and M. Zebarjadi, *MRS Communications* 7, 922 (2017).
- "Experimental Ddetermination of Phonon Thermal Conductivity and Lorenz Ratio of Single Crystal Metals: Al, Cu, and Zn," M. Yao, M. Zebarjadi, and C.P. Opeil, *Journal of Applied Physics* 122, 135111 (2017).
- "Enhancement of Thermoelectric Performance of n-Type PbSe by Cr Doping with Optimized Carrier Concentration," Q. Zhang, E.K. Chere, K. McEnaney, M. Yao, F. Cao, Y. Ni , S. Chen, C.P. Opeil, G. Chen, and Z. Ren, *Advanced Energy Materials* 5, 1401977 (2015).
- "N-type Thermoelectric Material Mg2Sn0.75Ge0.25 for High power Generation," W. Liu, H.S. Kim, S. Chen, Q. Jie, B. Lv, M. Yao, Z. Ren, C.P. Opeil, S. Wilson, C.-W. Chu, and Z. Ren, *Proceedings of the National Academy of Sciences, USA* 112(11), 3269 (2015).
- "Experimental Determination of Phonon Thermal Conductivity and Lorenz Ratio of Single-Crystal Bismuth Telluride," M. Yao, C.P. Opeil, S. Wilson, and M. Zebarjadi, *MRS Communications* 7, 922 (2017).
- "Experimental Determination of Phonon Thermal Conductivity and Lorenz Ratio of Single Crystal Metals: Al, Cu, and Zn," M. Yao, M. Zebarjadi, and C.P. Opeil, *Journal of Applied Physics* 122, 135111 (2017).
- "N-type Thermoelectric Material Mg2Sn0.75Ge0.25 for High Power Generation," W. Liu, H.S. Kim, S. Chen, Q. Jie, B. Lv, M. Yao, C.P. Opeil, S. Wilson, C.-W. Chu, and Z. Ren, *Proceedings of the National Academy of Sciences of the United States of America* 112, 3269 (2015).
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YING RAN

Associate Professor of Physics

Ph.D., Massachusetts Institute of Technology, 2007

Quantum condensed matter theory, electronic systems with strong interaction, frustrated magnets, high-Tc superconductors, topological aspects of condensed matter system such as topological defects and topological band insulators.

SELECTED PUBLICATIONS

- "Filling-enforced Constraint on the Quantized Hall Conductivity on a Periodic Lattice," Y.-M. Lu, Y. Ran, and M. Oshikawa, *Annals of Physics* 413, 168060 (2020).
- "Colossal Mid-infrared Bulk Photovoltaic Effect in a Type-I Weyl Semimetal," G.B. Osterhoudt, L.K. Diebel, X. Yang, J. Stanco, X. Huang, B. Shen, N. Ni, P. Moll, Y. Ran, and K.S. Burch, *Nature Materials* 18, 471 (2019).
- "Dyonic Lieb-Shultz-Mattis Theorem and Symmetry Protected Topological Phases in Decorated Dimer Models," X. Yang, S. Jiang, A. Vishwanath, and Y. Ran, *Physical Review B* 98, 125120 (2018).
- "Anyon Condensation and a Generic Tensor-network Construction for Symmetry Protected Topological Phases," S. Jiang and Y. Ran, *Physical Review B* 95, 125107 (2017).
- "When Chiral Photons Meet Chiral Fermions—Photoinduced Anomalous Hall Effects in Weyl Semimetals," C.-K. Chan, P.A. Lee, K.S. Burch, J.H. Han, and Y. Ran, *Physical Review Letters* 116, 026805 (2016).
- "Symmetric Tensor Networks and Practical Simulation Algorithms to Sharply Identify Classes Of Quantum Phases Distinguishable by Short-range Physics," S. Jiang and Y. Ran, *Physical Review B* 92, 104414 (2015).
- "Generalized Modular Transformations in 3+1D Topologically Ordered Phases and Triple Linking Invariant of Loop Braiding," S. Jiang, A. Mesaros, and Y. Ran, *Physical Review X* 4, 031048 (2014).
- "Changing Topology by Topological Defects in Three-dimensional Topologically Ordered Phases," A. Mesaros, Y.-B. Kim, and Y. Ran, *Physical Review B* 88, 035411 (2014)
- "A Classification of Symmetry Enriched Topological Phases with Exactly Solvable Models," A. Mesaros and Y. Ran, *Physical Review B* 87, 155115 (2013).
- "Interface Eengineering of Quantum Hall Effects in Digital Heterostructures of Transition-metal Oxides," D. Xiao, W. Zhu, Y. Ran, N. Nagaosa, and S. Okamoto, *Nature Communications* 2, 596 (2011).
- "Quantum Hall Effects in a Weyl Semi-Metal: Possible Application in Pyrochlore Iridates," K.-Y. Yang, Y.-M. Lu, and Y. Ran, *Physical Review B* 84, 075129 (2011).
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- "Topological Insulators in Three Dimensions from Spontaneous Symmetry Breaking," Y. Zhang, Y. Ran, and A. Vishwanath, *Physical Review B* 79, 245331 (2009).
- "Helical Metal Inside a Topological Band Insulator," Y. Ran, Y. Zhang, and A. Vishwanath, *Nature Physics* 5, 289 (2009).

FAZEL TAFTI

Associate Professor of Physics

Ph.D., University of Toronto, 2011

Experimental condensed matter physics, topological order, superconductivity, quantum phase transitions, spin liquids, low dimensional magnets, material synthesis, single crystal growth, electrical, thermal, thermo-electric transport measurements, high pressure and high field experiments, neutron and x-ray scattering techniques.

SELECTED PUBLICATIONS

- "Anisotropy of the magnetic and transport properties of EuZn2As2," Z.-C. Wang and F. Tafti et al., *Physical Review B* 105, 165122 (2022)
- "First Demonstration of Tuning Between the Kitaev and Ising Limits in a Honeycomb Lattice," F. Bahrami and F. Tafti et al., *Science Advances* 8, eabl5671 (2022).
- "Evidence of a Coupled Electron-phonon Liquid in NbGe2," H.-Y. Yang and F. Tafti et al., *Nature Communications* 12, 5292 (2021).
- "Weyl-mediated Helical Magnetism in NdAlSi." J. Gaudet and F. Tafti et al., *Nature Materials* 104, 014102 (2021).
- "Colossal Magnetoresistance Without Mixed Valence in a Layered Phosphide Crystal.". Z.-C. Wang and F. Tafti et al., *Advanced Materials* 33, 2005755 (2021).

ZIQIANG WANG

Professor of Physics

Ph.D., Columbia University, 1989

Theory of correlated electronic materials: high temperature superconductors and transition metal oxides, pnictides, and chalcogenides; Mott transition and spin liquids in Mott-Hubbard systems; heavy fermion physics; quantum Hall systems; correlated and topological phases of quantum electronic matter.

SELECTED PUBLICATIONS

- "Roton Pair Density Wave in a Strong-Coupling Kagome Superconductor," H. Chen and Z. Wang et al., *Nature* 599, 222 (2021).
- "Cascade of Correlated Electron States in a Kagome Superconductor CsV3Sb5," H. Zhao and Z. Wang et al., *Nature* 599, 216 (2021).
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FACULTY PROFILES

- "Atomic Line Defects and Topological Superconductivity in Unconventional Superconductors," Y. Zhang, K. Jiang, F. Zhang, J. Wang, and Z. Wang, *Physical Review X* 11, 011041 (2021).
- "Observation of Magnetic Adatom-induced Majorana Vortex and its Hybridization with Field-induced Majorana Vortex in an Iron-Based Superconductor," P. Fan and Z. Wang et al., *Nature Communications* 12, 1348 (2021).
- "Electronic Structure and Two-Band Superconductivity in Unconventional High-Tc Cuprates Ba2CuO3+δ". K. Jiang and Z. Wang et al., *Physical Review B* 103, 045108 (2021).
- "Three-dimensional Stacking of Canted Antiferromagnetism and Pseudospin Current in Undoped Sr2IrO4: Symmetry Analysis and Microscopic Model Realization," Y-P. Huang, J-W. Dong, Z. Wang, and S. Zhou, *Physical Review B* 104, 165145 (2021).
- "Nematic Transition and Nanoscale Suppression of Superconductivity in Fe(Te,Se)," H. Zhao and Z. Wang et al., *Nature Physics* 17, 903 (2021).
- "Chiral Superconductivity in Heavy-fermion Metal UTe2," L. Jiao and Z. Wang et al., *Nature* 579, 523 (2020).
- "Discovery of Quantum Limit Chern Magnet TbMn6Sn6," J.-X. Yin and Z. Wang et al., *Nature* 583, 533 (2020).
- "Atomic Line Defects and Zero-energy End States in Monolayer Fe(Te,Se) High-temperature Superconductors," C. Chen and Z. Wang et al., *Nature Physics* 16, 536 (2020).
- "Correlated Insulating Phases of Twisted Bilayer Graphene at Commensurate Filling Fractions," Y. Zhang and Z. Wang et al., *Physical Review B* 102, 035136 (2020).
- "Zero-energy Bound States in the High-temperature Superconductors at the Two-dimensional Limit," C. Liu and Z. Wang et al., *Science Advances* 6, eaax7547 (2020).
- "Dynamical Slave-boson Mean-field Theory of the Mott Transition in the Hubbard Model in the Large-*z* Limit," S. Zhou, L. Liang and Z. Wang, *Physical Review B* 101, 035106 (2020).

ILIJA ZELJKOVIC

Professor of Physics

Ph.D., Harvard University 2013

Experimental condensed matter physics; spectroscopic-imaging scanning tunneling microscopy (SI-STM); spin-polarized STM; molecular beam epitaxy (MBE); topological materials; correlated electron systems; high-temperature superconductors; strain induced phase transitions.

SELECTED PUBLICATIONS

- "Manipulation of Dirac Band Curvature and Momentum-dependent g-factor in a Kagome Magnet," H. Li and I. Zeljkovic et al., *Nature Physics* (2022).
- "Rotation Symmetry Breaking in the Normal State of a Kagome Superconductor KV3Sb5," H. Li and I. Zeljkovic et al., *Nature Physics* 18, 265 (2022).
- "Cascade of Correlated Electron States in a Kagome Superconductor CsV3Sb5, " H. Zhao and I. Zeljkovic et al., *Nature* 599, 216 (2021).
- "Imaging Antiferromagnetic Domain Fluctuations and the Effect of Atomic-scale Disorder in a Doped Spin-orbit Mott Insulator," H. Zhao and I. Zeljkovic et al., *Science Advances* 7, abi6468 (2021).
- "Nematic Transition and Nanoscale Suppression of Superconductivity in Fe(Te,Se)," H. Zhao and I. Zeljkovic et al., *Nature Physics* 17, 903 (2021).
- "Nanoscale Decoupling of Electronic Nematicity and Structural Anisotropy in FeSe Thin Films," Z. Ren and I. Zeljkovic et al., *Nature Communications* 12, 10 (2021).

BRIAN B. ZHOU

Assistant Professor of Physics

Ph.D., Princeton University 2014

Experimental condensed matter physicist investigating atomic-scale defect centers in solids for quantum information processing and nanoscale sensing. Using the nitrogen-vacancy center in diamond to demonstrate novel quantum dynamics and to probe magnetism and light-matter interactions in condensed matter systems.

SELECTED PUBLICATIONS

- "AC Susceptometry of 2D van der Waals Magnets Enabled by the Coherent Control of Quantum Sensors," X.-Y. Wang and B.B. Zhou et al., *PRX Quantum* 2, 030352 (2021).
- "Spatiotemporal Mapping of a Photocurrent Vortex in Monolayer MoS2 Using Diamond Quantum Sensors," B.B. Zhou, P.C. Jerger, K.-H. Lee, M. Fukami, F. Mujid, J. Park, and D.D. Awschalom, *Physical Review X* 10, 011003 (2020).
- "Extreme Diamond-based Quantum Sensors," J.J. Hamlin and B.B. Zhou, *Science* 366, 1312 (2019).
- "Quantum Technologies with Optically Interfaced Solid-State Spins," D.D. Awschalom, R. Hanson, J.Wratchrup, and B.B. Zhou, *Nature Photonics* 12, 516 (2018).
- "Holonomic Quantum Control by Coherent Optical Excitation in Diamond," B.B. Zhou, P.C. Jerger, V.O. Shkolnikov, F.J. Heremans, G. Burkard, and D.D. Awschalom, *Physical Review Letters* 119, 140503 (2017).
- "Accelerated Quantum Control Using Superadiabatic Dynamics in a Solid-State Lambda System," B.B. Zhou, A. Baksic, H. Ribeiro, C.G. Yale, F.J. Heremans, P.C. Jerger, A. Auer, G. Burkard, A.A. Clerk, and D.D. Awschalom, *Nature Physics* 13, 330 (2017).

OUTCOMES

Recent Dissertations

2023–2024

Faranak Baharami, "Tuning the Low-Energy Physics in Kitaev Magnets"

Tyler Dodge, "Electromatic Simulations of Exotic Phenomena in Engineered Materials"

Mark Schiller, "Nanoscale Experimental and Numerical Investigations of Novel Photonic Devices"

2022–2023

Zheng Ren, "Molecular Beam Epitaxy Synthesis and Investigation of Fe-based Quantum Materials"

Bryan Rachmilowitz, "Molecular Beam Epitaxy Synthesis and Nanoscale Characterization of Topological Insulator Thin Films and Their Interface with High Temperature Superconductors"

Eric Kenney, "Local and Bulk Measurements in Novel Magnetically Frustrated Materials"

2021–2022

Victoria Gabriele, "Light Driven Selective Dissociation of Biomolecules"

Mason Gray, "Electronic Spectroscopy of Topological Superconductor Feteo.55se0.45"

Joshuah Heath, "Novel Metallic Behavior in Topologically Non-Trivial, Quantum Critical, and Low-Dimensional Matter"

Yiping Wang, "Exploring Magnetic Collective Modes and 2d Heterostructures with Raman"

Tong Yang, "Algebraic Learning: Towards Interpretable Information Modeling"

2020–2021

Wenping Cui, "Statistical Mechanics of Microbiomes"

Matthew Heine, "Ab Initio Theory of Thermal Spin-Lattice Disorder in Iron and Invar"

Lidong Ma, "Investigation of Multicolored and White Light Emission from IR-Excited Nano-Particles"

Gavin Ousterhoudt, "Spectroscopy of Topological Materials"

Hung-Yu Yang, "Novel Electromagnetic Responses in Topological Semimetals"

Xu Yang, "Symmetry and Topology in Condensed Matter Physics"

He Zhou, "Probing the Strongly Correlated Quantum Materials with Advanced Scanning Tunneling Microscopy/Spectroscopy"

MORRISSEY COLLEGE OF ARTS AND SCIENCES

The oldest and largest of the University's eight schools and colleges, the Morrissey College of Arts and Sciences offers graduate programs in the humanities, social sciences, and natural sciences, leading to the degrees of Doctor of Philosophy, Master of Arts, and Master of Science. In addition, numerous dual-degree options are offered in cooperation with the Carroll School of Management, the Boston College Law School, the Lynch School of Education and Human Development, and the School of Social Work.

With approximately 900 graduate students and more than 500 full-time faculty, the Morrissey College of Arts and Sciences is small enough to know you as a person, but large enough to serve you and prepare you for a rewarding life and satisfying career.

Research Instrumentation and Facilities

Departmental resources include TEM, SEM, and XRD facilities, a wide array of materials preparation and fabrication equipment, extensive computational facilities, low-temperature STM, several mK refrigerators and high-field magnets (up to 46 tesla), and AFM and NSOM. These facilities are housed in the newly expanded and renovated Higgins Hall. Also new to the University is a professionally staffed, state-of-the-art Integrated Sciences Nanofabrication Clean Room Facility, with complete photolithographic and nanolithographic capabilities, including electron beam and focused ion beam instruments.

The Department of Physics has strong collaborations with many outside facilities, including Los Alamos, Oak Ridge, and Brookhaven National Laboratories, as well as the Institute for Complex Adaptive Matter and the ISIS Rutherford-Appleton Laboratory.

Academic Resources

BOSTON AREA CONSORTIUM

The Boston Area Consortium allows graduate students to cross-register for courses at Boston University, Brandeis University, and Tufts University.

BOSTON COLLEGE LIBRARIES

The University is home to eight libraries, containing nearly 3 million volumes; more than 700 manuscript collections, including music, photos, art, and artifacts; 625,000 e-books; and more than 600 electronic databases. O'Neill Library, Boston College's main library, offers subject-specialist librarians to help with research, to set up alerts to publications in areas of interest, and to answer any research- and library-related questions.

THE BOSTON LIBRARY CONSORTIUM

The Boston Library Consortium allows Boston College students access to millions of volumes and other services at 19 area institutions in addition to the world-class resources available through the Boston College Library System.

STUDENT LIFE AND CAMPUS RESOURCES

Boston College is located on the edge of one of the world's most vibrant cities. Just six miles from downtown Boston—an exciting and dynamic place to live and learn—Boston College is an easy car or "T" ride away from a booming center for trade, finance, research and education.

Home to some of New England's most prestigious cultural landmarks, including the Museum of Fine Arts, the Isabella Stewart Gardner Museum, Boston Symphony Hall, and the Freedom Trail, Boston provides a rich environment for those passionate about art, music, and history. For sports fans, Boston hosts a number of the country's greatest sports teams: the Celtics, Patriots, Bruins, and, of course, Fenway Park's beloved Red Sox. Found within a short drive from Boston are some of New England's best recreational sites, from the excellent skiing in New Hampshire to the pristine beaches of Cape Cod.

Boston also offers a wide range of family friendly attractions, including the Children's Museum, New England Aquarium, Franklin Park Zoo, and the Museum of Science. There are roughly 50 universities located in the Boston area, and the large student population adds to the city's intellectually rich and diverse community. Events, lectures, and reading groups hosted by world-renowned scholars abound on area campuses, providing abundant opportunities to meet and network with other graduate students and faculty throughout the Boston area.

The University

Boston College is a Jesuit university with 15,000 students, 880 full-time faculty, and more than 190,000 active alumni. Since its founding in 1863, the University has known extraordinary growth and change. From its beginnings as a small Jesuit college intended to provide higher education for Boston's largely immigrant Catholic population, Boston College has grown into a national institution of higher learning that is consistently ranked among the top universities in the nation. Boston College is ranked 36*th* among national universities by *U.S. News & World Report*.

Today, Boston College attracts scholars from all 50 states and over 80 countries, and confers more than 4,300 degrees annually in more than 50 fields through its eight schools and colleges. Its faculty members are committed to both teaching and research and have set new marks for research grants in each of the last 10 years. The University is committed to academic excellence. As part of its most recent strategic plan, Boston College is in the process of adding 100 new faculty positions, expanding faculty and graduate research, increasing student financial aid, and widening opportunities in key undergraduate and graduate programs.

The University is comprised of the following colleges and schools: Morrissey College of Arts and Sciences, Carroll School of Management, Connell School of Nursing, Lynch School of Education and Human Development, Woods College of Advancing Studies, Boston College Law School, School of Social Work, and Clough School of Theology and Ministry.

General Resources

HOUSING

While on-campus housing is not available for graduate students, most choose to live in nearby apartments. The Office of Residential Life maintains an extensive database with available rental listings, roommates, and helpful local real estate agents. The best time to look for fall semester housing is June through the end of August. For spring semester housing, the best time to look is late November through the beginning of the second semester. Additionally, some graduate students may live on campus as resident assistants. Interested students should contact the Office of Residential Life.

STUDENT LIFE AND CAMPUS RESOURCES

JOHN COURTNEY MURRAY, S.J., GRADUATE STUDENT CENTER

One of only a handful of graduate student centers around the country, the Murray Graduate Student Center is dedicated to the support and enrichment of graduate student life at Boston College. Its primary purpose is to build a sense of community among the entire graduate student population and cultivate a sense of belonging to the University as a whole. Its amenities include study rooms, a computer lab, two smart televisions, kitchen, deck and patio space, complimentary coffee and tea, and more. Throughout the year, the center hosts programs organized by the Office of Graduate Student Life and graduate student groups. The Murray Graduate Student Center also maintains an active job board (available electronically), listing academic and non-academic opportunities for employment both on and off campus.

MCMULLEN MUSEUM OF ART

Serving as a dynamic educational resource for the national and international community, the McMullen Museum of Art showcases interdisciplinary exhibitions that ask innovative questions and break new ground in the display and scholarship of the works on view. The McMullen regularly offers exhibition-related programs, including musical and theatrical performances, films, gallery talks, symposia, lectures, readings, and receptions that draw students, faculty, alumni, and friends together for stimulating dialogue. Located on the Brighton campus, the McMullen Museum is free to all visitors.

CONNORS FAMILY LEARNING CENTER

Working closely with the Graduate School, the Connors Family Learning Center sponsors seminars, workshops, and discussions for graduate teaching assistants and teaching fellows on strategies for improving teaching effectiveness and student learning. Each fall, the Learning Center and the Graduate School hold a "Fall Teaching Orientation" workshop designed to help students prepare for teaching. The center also hosts ongoing seminars on college teaching, higher learning, and academic life; assists graduate students in developing teaching portfolios; and provides class visits and teaching consultations, upon request. Through these and other activities, the Connors Family Learning Center plays an important role in enhancing the quality of academic life at Boston College.

MARGOT CONNELL RECREATION CENTER

The Margot Connell Recreation Center redefines the future of fitness and recreation at Boston College. The 244,000-square-foot, four-story structure offers our community an inspired space to play, pursue sports, gather with friends, and work out. This facility includes a fitness center, rock climbing wall, jogging track, aquatics center, wood-floor basketball courts, tennis courts, multi-activity courts, multi-purpose rooms for spin, yoga, and fitness classes, and so much more.

BOSTON COLLEGE CAREER CENTER

The Boston College Career Center works with graduate students at each step of their career development. Services include self-assessment, career counseling, various career development workshops, resume and cover letter critiques, and practice interviews. In addition to extensive workshop offerings, Career Center staff members are available throughout the year for one-on-one advising about any aspect of the career path. The Career Resource Library offers a wealth of resources, including books, periodicals, and online databases.

ADMISSION AND FINANCIAL INFORMATION

The application deadline for fall admission is January 2. Please visit bc.edu/mcgs for detailed information on how to apply.

Application requirements include:

Application Form:	Submitted online, via the MCGS website.
Application Fee:	$75, non-refundable.
Abstract of Courses Form:	A concise overview of background and related courses completed in an intended field or proposed area of study.
Official Transcripts:	Demonstrating coursework completed/degree conferral from all post-secondary institutions attended.
Three Letters of Recommendation:	From professors or supervisors. It is highly advisable that at least one letter be from an academic source.
Statement of Purpose:	A brief (1-2 page) discussion of an applicant's preparation, motivation, and goals for their proposed course of study.
GRE General Test:	Official score report (recommended).
GRE Subject Test:	Official score report (recommended).
Proof of English Proficiency: (*international only*)	Official TOEFL/IELTS reports accepted.

Financial Assistance

DEPARTMENT FUNDING

The Department of Physics offers five years of funding to all qualified Ph.D. students contingent upon satisfactory academic performance and progress toward degree completion. Support for qualified students is available in the form of teaching assistantships. Research assistantships are also available during the summer and academic year, depending on research area and the extent of current funding.

FEDERAL FINANCIAL AID

Graduate students can apply for federal financial aid using the FAFSA. The loans that may be available to graduate students are the Federal Direct Unsubsidized Stafford Loan and Perkins Loan, based on eligibility. If additional funds are needed, student may apply for a Grad Plus Loan. For more information, see the Graduate Financial Aid website at bc.edu/gradaid or contact the Graduate Financial Aid Office at 617-552-3300 or 800-294-0294.

OFFICE FOR SPONSORED PROGRAMS

The Office for Sponsored Programs (OSP) assists both faculty and graduate students in finding sources of external funding for their projects and provides advice in the development of proposals. OSP maintains a reference library of publications from both the public and private sectors listing funding sources for sponsored projects. In the recent past, graduate students have received research support from prominent agencies, corporations and organizations such as the Fulbright Commission, the Guggenheim Foundation, the National Science Foundation, the American Political Science Association, the American Chemical Society, and the American Association of University Women.

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