Graduate Studies 2023

MICHIGAN STATE UNIVERSITY
Department of Physics and Astronomy
College of Natural Science

pa.msu.edu

Graduate Studies

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FROM THE **CHAIR'S OFFICE**

Thank you for considering the Physics and Astronomy Graduate Program at Michigan State University. We strive to provide a welcoming and inclusive environment with a wide range of opportunities to grow as a scientist and make exciting new discoveries.

This brochure outlines research of physics and astronomy (PA) faculty that reside in the Biomedical and Physical Sciences (BPS) Building. In this brochure, you will find an alphabetical listing of PA faculty in BPS and an outline of specific areas of research concentration, including areas that overlap with FRIB programs. A second brochure, prepared annually by the Facility for Rare Isotope Beams (FRIB), covers PA and FRIB faculty who are involved in nuclear physics, nuclear astrophysics, accelerator physics and related topics.

In addition to research opportunities with faculty at FRIB, the department has strong connections with several other departments and centers across the MSU campus. Physics and astronomy graduate students may carry out their research under the guidance of faculty in BPS, FRIB or in one of these departments. In the area of computational physics, there are strong ties with the Department of Computational Mathematics, Science and Engineering (CMSE), and multiple faculty members have joint appointments between PA and CMSE. The multi-disciplinary Center of Research Excellence in Complex Materials brings together faculty and students in PA, the Department of Chemistry, and the Department of Chemical Engineering and Materials Science. The Institute for Mathematical and Theoretical Physics provides a collaborative forum for students, postdocs and visitors with theoretical interests, and the CREATE for STEM Institute houses an interdisciplinary team carrying our discipline-based education research. Joint Ph.D. programs are of interest to some students. Several special agreements are in place, including with the Department of Biochemistry and Molecular Biology, and the Department of Electrical and Computer Engineering, and CMSE.

I hope that you find the information in this brochure useful and look forward to seeing you in East Lansing in the fall!

Sincerely,
Stephen Zepf
Chairperson of Physics and
Astronomy Michigan State University

Graduate Student Mentoring

Ph.D. Graduates from the Department of Physics and Astronomy at MSU pursue a wide variety of careers. Some will decide to stay in academia and teach and lead their own research groups, but many of our graduates will join companies, work in National Laboratories or governmental agencies, or pursue other exciting careers. No matter the choice, our graduate program provides many ways to be prepared for what comes after graduate school. In order to navigate the many choices and make the most of your time in our graduate program, we provide a strong and personalized mentoring framework.

Prior to the formation of a guidance committee, which typically happens after about 2 years in the program, you will receive mentoring from a committee consisting of the graduate program director, your research advisor, and a third faculty member who is familiar with your area of research. We are well aware that students come with a wide variety of backgrounds and an individual approach to mentoring is employed at making sure that students can be successful no matter what path led them to our program**.** During orientation you will meet with this committee and additional meetings are scheduled at the end of the fall and spring semesters in the first year In addition, students are strongly encouraged to ask for advice at any time, and Graduate Program Coordinator Kim Crosslan and I are proactive in reaching out to students to make sure that they receive the information and support they need to make progress. We also work together closely with the student-led Physics Graduate Organization (PGO), the Women and Minorities in the Physical Sciences (WaMPS) organization, and the recently established MSU Chapter of the National Society of Black Physicists to support students and to monitor and make improvements to our program where needed.

We ask students to join a research group shortly after entering the Ph.D. program and also receive mentoring from the Professor and other members of the research group. In addition, students are strongly encouraged to seek mentoring from other members of the department. Once you complete the comprehensive exam requirements, you form your own guidance committee, consisting of 5 faculty members and chaired by your primary advisor. They meet with you regularly to provide feedback and advice for your research and course work. They also help you get prepared for your career after your Ph.D., for example by suggesting coursework, internships, or other opportunities that benefit your longterm goals. In addition, there are many opportunities and resources in the Department and on MSU campus to obtain more information and mentoring.

We very much look forward to seeing you in the Department of Physics and Astronomy at Michigan State University. Go Green!

Remco Zegers
Associate Chairperson for Graduate Studies &
Graduate Program Director
Department of Physics & Astronomy

Kim Crosslan
Graduate Program Coordinator
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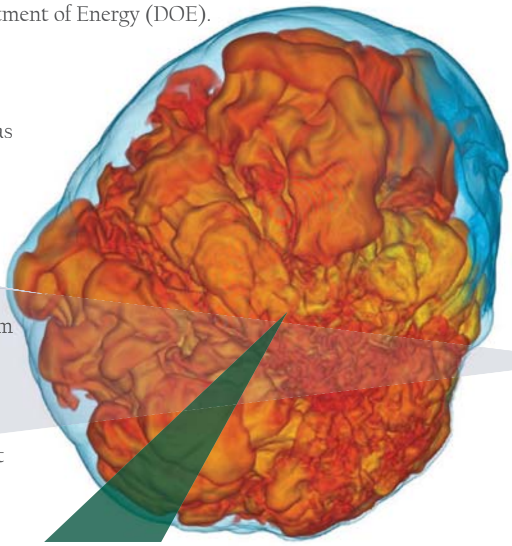
DEPARTMENT
RESEARCH DIRECTIONS

Accelerator Physics and Beam Physics (AB): Accelerator physics of high intensity beams are studied as part of a program that is developing next generation ultrafast electron microscopy instruments (Ruan, Duxbury). There is a strong accelerator physics program associated with MSU's new Facility for Rare Isotope Beams (FRIB), including an Accelerator Science and Engineering Traineeship (ASET) program funded by the Department of Energy (DOE). More details can be found in the FRIB graduate brochure.

Astronomy and Astrophysics (AA): Astronomy and Astrophysics (AA): MSU has strong astrophysics research programs in compact objects (Brown, Chomiuk, Couch, Kerzendorf, Strader, Zepf), nuclear astrophysics (Brown, Couch, O'Shea), galaxy formation and evolution (Donahue, O'Shea, Strader, Voit, Zepf), large-scale simulations (Couch, O'Shea), statistical and computational techniques (Brown, Couch, Kerzendorf, O'Shea,Rodriguez). The observational astronomers use a variety of satellite and ground based telescopes for their studies. MSU astronomers enjoy guaranteed access to the 4.1-m SOAR Telescope, which is co-located on Cerro Pachón with the Large Synoptic Survey Telescope. Several faculty are active in the Joint Institute for Nuclear Astrophysics Center for the Evolution of the Elements (JINA-CEE), centered in FRIB and is directed by Hendrik Schatz (see FRIB brochure). The group also has close ties to the Department of Computational Mathematics, Science and Engineering (CMSE), and a number of the computational faculty (Brown, Couch, Kerzendorf, O'Shea) have appointments there.

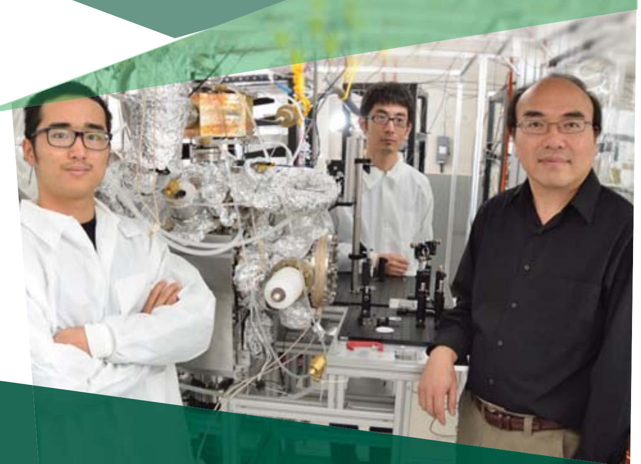


High fidelity computer simulation of a supernova explosion.

Biophysics (Bio): Molecular biophysics research studies the physical processes fundamental to biology at the molecular level. The Molecular Biophysics group (Comstock, Lapidus and other outside the department) study protein and nucleic acid structure and folding, the motion and function of molecular machines, electron transport in living cells and protein misfolding, aggregation and disease. The group uses many state-of-the-art techniques such as optical tweezers, single molecule fluorescence and microfluidic mixers and participates in many interdisciplinary collaborations across campus. Additional biophysics research in the department includes computational efforts focused on gene networks (Piermarocchi)

Computational Physics: The department has faculty working in several areas. In astrophysics there are researchers modeling stars, supernovae, galaxies, and plasma dynamics (Brown, Couch, O'Shea), as well as astrophysical data science that includes large astronomical surveys and neutrino observations with IceCube (Kerzendorf, Kopper). In particle physics there is a group working in the area of Lattice Quantum Chromodynamics (Bazavov, Lin and Shindler), and also the CTEQ collaboration (Yuan, Stump), which calculates parton distribution functions that are essential for analyzing experimental data collected at high energy accelerators such as the Large Hadron Collider. There are also opportunities in computational materials science (Duxbury) as well as in several areas of computational nuclear physics (Bogner, Hjorth-Jensen, Lee, Nazarewicz, Nunes, Pratt).

Condensed Matter (CMP), Materials Physics, and Quantum Information Science (QIS): The MSU Physics and Astronomy Department has faculty engaged in a wide variety of experimental and theoretical condensed matter physics, materials physics, and quantum information science (QIS) and computing. The department is home to the Keck nano-fabrication facility as well as world-class quantum measurement labs, which enable preparation and study of small quantum devices and nanostructures for exploring the exotic properties of mesoscopic and quantum computing systems (Becker,Birge, Pollanen) and low-dimensional electron systems (Pollanen). Unique ultrafast electron diffraction and imaging instruments are available (Ruan), and a collaboration for the design of next generation instruments is active (Duxbury, Ruan, Cocker). Experiments at national facilities for neutron and X-ray scattering are used for analysis of complex materials (Ke). Scanning probe experiments utilize a user facility in PA, or instruments in faculty groups (Tessmer, Zhang, Cocker). Theory ranges from studies of noise and quantum effects in small structures and QIS systems (Dykman), and theories of ultrafast optical (Piermarocchi) and electronic processes (Duxbury). Non-equilibrium dynamics is also an active area of theoretical work at MSU (Maghrebi, Duxbury, Dykman).



Experimental team building an ultrafast microscope to make movies of molecular processes in real time.

High Energy Physics (HEP): Instrument development projects and physics searches are active in several areas, including the ATLAS detector of the Large Hadron Collider at CERN (Brock, Fisher, Hayden, Huston, Schwienhorst), T2K in Japan (Mahn), ICECUBE at the South Pole (DeYoung, Grant, Kopper, Mahn, Tollefson), and the HAWC detector in Mexico (Linnemann, Tollefson). Areas of interest include study of the Higgs sector, top quark processes, neutrino physics and searches for physics beyond the Standard Model. The particle physics experiments HAWC and ICECUBE search for high-energy gamma rays and neutrinos, respectively. Theory efforts include studies of the Standard Model through the CTEQ collaboration, and physics beyond the Standard Model (von Manteuffel, Schmidt, Stump, Yuan). Along with lattice quantum chromodynamics group (Bazavov, Lin, von Manteuffel)

Laying cables for the ICECUBE detectors that are embedded in several cubic kilometers of ice at the South Pole.

Nuclear Physics, Nuclear Astrophysics, Accelerator Physics:See websites www.nscl.msu.edu **and** www.frib.msu.edu

Physics Education Research: The Physics Education Research Laboratory (PERL) is a vibrant and successful group, and is one of the largest physics education research groups in the United States. Current projects include developing and investigating group learning environments to improve students' understanding and scientific skills (McPadden), the use of computers in physics education (Caballero), the experience of two-year college transfer students (Sawtelle), the impact of informal physics environments (Hinko), and designing equitable and inclusive assessment tools (Henderson).

Theoretical and Mathematical Physics (IMTP): Current areas of interest include classical and quantum diffusion in complex systems (Dykman), topological states and gauge theories (Yuan), and quantum optics and quantum dynamics (Dykman, Piermarocchi, Maghrebi, Duxbury). Several faculty members in the math department and in FRIB also work in these areas.

Graduate Student Life

When you are not taking part in exciting, rewarding research at MSU, there is much to do to have an exciting, rewarding life outside of Physics and Astronomy

Fun and Friendship

The graduate students of the department participate in a number of different groups and activities. To name a few:

- Physics choir
- Cross-country skiing and snowboarding
- Rock climbing club
- Art afternoons
- BBQ on the rooftop
- Hiking

The Grand Canonical Ensable (Physics Choir)

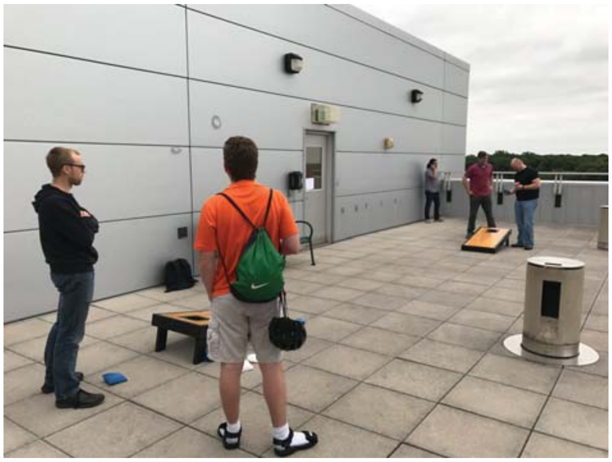
Physics Choir is a group of undergraduate, graduate, post-docs and faculty who meet for one hours twice a week to sign together, just for fun. The choir performs twice a year at a departmental end-of-semester celebration

Outreach and enrichment

The graduate student organizations, Women and Minorities in the Physical Sciences (WaMPS), coordinates several activities throughout the year. Some re enrichment activities for graduate students, and others are outreach activities for the community by graduate students

Art Afternoons

During Art Afternoons, physicists at MSU at any level (undergrad, graduate student, post-doc, staff, faculty etc.,) get together with other artistically inclined physicists and make are for a couple hours every week



Women and Minorities in the Physical Sciences

Women and Minorities in the Physical Sciences (WaMPS) is a graduate student organization at Michigan State University that strives to promote diversity in the physical sciences by encouraging women and minorities to pursue the field, as well as working to create an inviting and supportive community for those who are already part of the physical sciences. WaMPS aims to include students from all backgrounds, so our group is comprised of a variety of students in physics, astronomy & astrophysics and some nuclear chemists

Mentoring program

WaMPS holds a variety of events each semester. They meet monthly to discuss articles or hold workshops about different topics relevant to women and minorities int he field. WaMPS has also taken field trips to museums or to see relevant movies, such as Hidden Figures and the Theory of Everything. We host game nights and barbecues.

WaMPS strives to create a program which fosters collaboration and professional growth in a laid back, relaxed atmosphere. We offer a variety of mentoring events and programs for students in different stages of their education and professional development

Outreach

WaMPS also has a strong outreach program at MSUand within the greater Lansing area. the Outreach Program has put together a series of interactive demonstrations to teach about various topics, including electricity and magnetism and states of matter. These are presented at various outreach events, (Impression 5 Science Center, MSU Girl Scout Day, STEM day and may more) to share our excitement about science with younger generations.

Science and Learning at Michigan State (SL@MS)

This is a summer science experience for local middle school students. During the SL@MS program, students practice science skills in a personalized and student-driven demonstration. Throughout the camp, students also gain knowledge abut waves and their applications in lasers, radios, sound and much more!

Find us on Facebook WAMPS at MSU or email us at wamps@msu.edu

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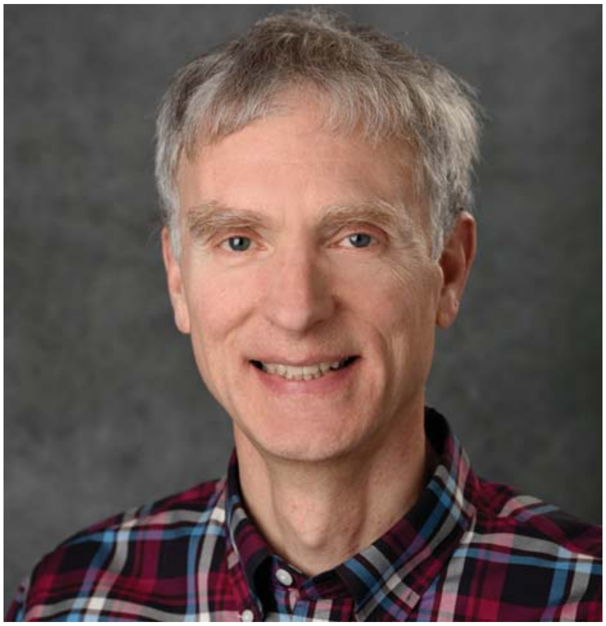
Research Interests

Jonas Becker's Solid-State Quantum Optics Group focuses on the experimental study, control and application of optically active quantum systems such as atomic dopants or crystal defects in a variety of solid-state host materials like synthetic diamond or rare-earty crystals. The group's goal is to recreate optical devices for applications in quantum information processing such as optically controlled quantum bits for spin-based quantum computing or optical quantum memories to facilitate various aspects of photonic quantum information processing. This research involves a broad spectrum of complex optical experiments ranging from working with dense ensembles of dopants and strong lasers to the study of interactions between individual atom-sized quantum systems and single photons. Many of these experiments involve working under cryogenic conditions (currently down to 1.5K) and in strong magnetic fields (up to 9T). The group is part of the newly founded Interdisciplinary Quantum Optical Devices laboratory which aims at closely combining these quantum optical experiments with the fabrication and processing of novel quantum materials, providing a unique synergetic environment with exceptionally short feedback loops between devices and materials development. Becker is also affiliated with the Fraunhofer USA Center Midwest-Coatings and Diamond Technologies Division to further foster the common goal of developing new diamond-based quantum materials.

Biographical Information

Becker received an M.Sc. in Chemistry in 2013 and a Ph.D. (Dr. rer.nat.) in Physics in 2017, both from Saarland University, Germany. There, he worked in the Quantum Optics Group for his graduate research, performing spectroscopic investigations and quantum control experiments of crystal defects in synthetic diamond. His research substantially contributed to making the silicon vacancy center, now a front runner for a quantum networking platform, accessible for quantum information processing applications. Before joining MSU in December 2021, he was a Postdoctoral Research Assistant in the Ultrafast Quantum Optics & Metrology group at the University of Oxford (2017-2020) working on optical quantum memory technologies in atomic vapors and solid-state systems as well as on studies of quantum thermodynamics using diamond defects as a novel experimental testbed. There, he was part of the team that built the first quantum heat engine purely relying on thermal baths to beat the power bound of its classical counterpart, using nitrogen vacancy defects diamond as the engine and quantum coherence within the engine as the non-classical resource. With the group's move in 2020 he joined Imperial College London as a Research Associate in Quantum Information.



Norman Birge

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Research Interests

Norman Birge's research focuses on "mesoscopic physics," the study of materials on small (sub-micron) length scales. This size regime lies between the macroscopic world of things we can see and touch, and the microscopic world of single atoms or molecules. Mesoscopic samples often exhibit novel phenomena not observed in larger samples.

Birge's lab is currently studying the interplay between superconductivity and magnetism in hybrid samples. A few years ago, his group confirmed a theoretical prediction that one can generate spin-triplet electron pairs in systems containing only conventional spin-singlet superconductors in contact with ferromagnets. Since then, they have demonstrated several ways to optimize and control this new effect. They are also working on using ferromagnetic Josephson junctions for cryogenic (superconducting) memory.

Biographical Information

Birge received his his B.A. from Harvard University in 1979 and his Ph.D. from the University of Chicago in 1986. After working two years as a post-doc at AT&T Bell Laboratories, he joined the MSU faculty in 1988. He has been an APS Fellow since 2003.

Raymond Brock

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Research Interests

Raymond Brock performs research in elementary particle physics, primarily at the Fermi National Accelerator Laboratory and The European Center for Nuclear Research (CERN). He is engaged in elementary particle physics research, which is the study of the "inside of the universe," the fundamental building blocks of nature. He and his colleagues perform experiments of long duration and considerable heft at the highest energy particle accelerators in the world.

Biographical Information

Brock earned his Ph.D. from Carnegie-Mellon University in 1980. He joined MSU in 1982. Prior to that, he was a postdoc at the Fermi National Accelerator Laboratory, a graduate student at Carnegie-Mellon University, and an engineer in private industry. He was elected a fellow of the American Physical Society in 2000 and served as chair of the Division of Particles and Fields of the American Physical Society for the year 2011 (he is now past chair of the division).

He has received several awards, including the MSU Teacher Scholar Award in 1985, and the MSU Distinguished Faculty Award in 2004.

Edward Brown

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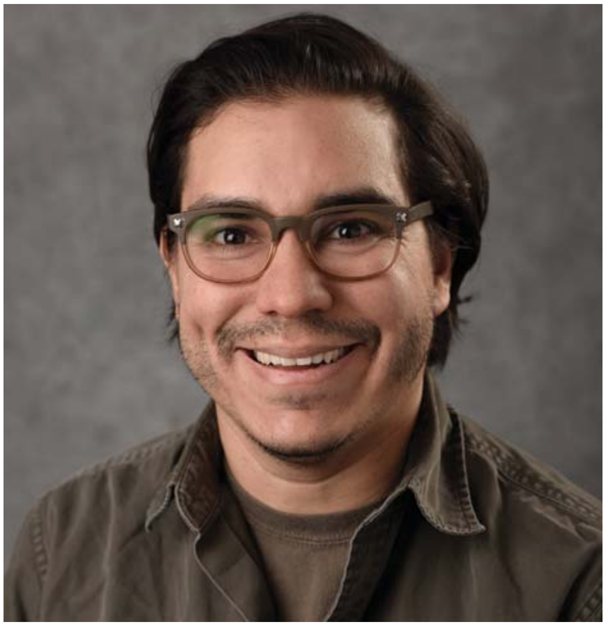
Research Interests

Edward Brown's research interests include stellar and nuclear astrophysics, especially in relation to compact stars—neutron stars and white dwarfs—and stellar explosions. Recent work includes modeling nuclear reactions in the outer layer of neutron stars and constraining the heat capacity and neutrino emissivity of dense matter from observations of accreting neutron stars

Biographical Information

A native of Ohio, Brown did his undergraduate studies at The Ohio State University. He earned his Ph.D. from the University of California, Berkeley, in 1999. Upon graduating, he was awarded an Enrico Fermi Fellowship at the University of Chicago, where he worked in the Center for Thermonuclear Astrophysical Flashes. In 2004, Brown joined the physics and astronomy faculty at Michigan State, with a joint appointment in the National Superconducting Cyclotron Laboratory. He is affiliated with the Joint Institute for Nuclear Astrophysics—Center for the Evolution of the Elements, an NSF Physics Frontier Center. In 2018, Brown became Associate Chair of the Department of Computational Science, Mathematics and Engineering (CMSE) at MSU.

Awards and honors include: The MSU College of Natural Science Teaching Prize in 2015, the MSU Thomas H. Osgood Teaching Award (tenured) in 2013, the MSU Thomas H. Osgood Teaching Award (non-tenured) in 2009, and the University of Chicago's Arthur H. Compton Lecturer in 2001.



Danny Caballero

Lappan-Phillips Associate Professor

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Research Interests

Danny Caballero is a physics education researcher who studies how tools and science practices affect student learning in physics, and the conditions and environments that support or inhibit this learning.

Caballero conducts research from the high school to the upper-division and is particularly interested in how students learn physics through their use of tools such as mathematics and computing. His work employs cognitive and sociocultural theories of learning and aims to blend these perspectives to enhance physics instruction at all levels. His projects range from the fine-grained (e.g., how students understand particular elements of code) to the course-scale (e.g., how students learn to model systems in electromagnetism) to the very broad (e.g., how does computing affect learning across a degree program?). in his work he uses both qualitative and quantitative methods including machine learning. Presently, he co-direct the Physics Education Research Lab at MSU.

Biographical Information

Caballero earned his B.S. in physics from the University of Texas at Austin in 2004. He worked on opto-microfluidics transport and control experiments at the Georgia Institute of Technology earning his M.S. in physics before shifting his research focus to physics education. He helped found the Georgia Tech Physics Education Research group in 2007 and earned the first physics education focused Ph.D. from Georgia Tech in 2011 working on computational modeling instruction and practice. He moved to the University of Colorado Boulder as a postdoctoral researcher and helped transform upper-division physics courses to more active learning environments. He joined the MSU faculty in 2013 where he founded the Physics Education Research Lab.

Awards and honors include: The MSU President's Distinguished Teaching Award in 2018, the MSU Teacher-Scholar Award also in 2018, the MSU College of Natural Science Teaching Prize in 2016, and the MSU Thomas H. Osgood Memorial Award for Faculty Excellence in Teaching in 2015.

Laura Chomiuk
Associate Professor

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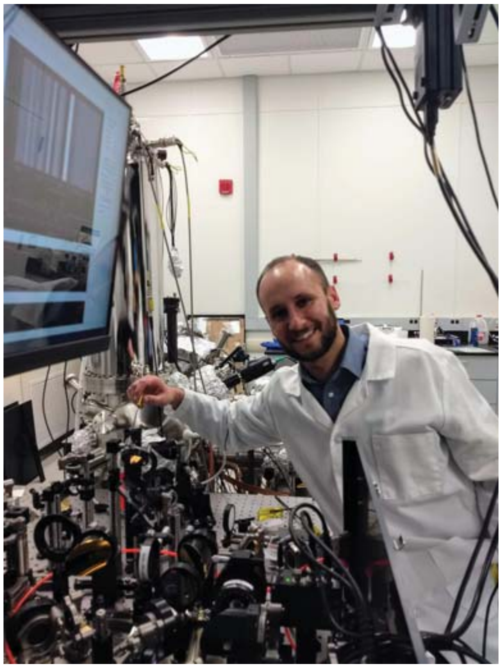
Research Interests
Laura Chomiuk is interested in stellar evolution, stellar explosions, and the feedback effects these explosions have on star formation. She studies novae and supernovae at a range of wavelengths—with a particular focus on radio observations—in order to probe the physics of the ejection mechanisms in these explosions, to constrain the circumstellar environments of the exploding stars, and to test models of both the progenitor systems and of the explosions themselves.

Biographical Information
Chomiuk earned her Ph.D. in astronomy from the University of Wisconsin–Madison in 2010, her M.S. in atmospheric and oceanic sciences from the University of Wisconsin–Madison in 2006, and her B.A. in astronomy and physics from Wesleyan University (High Honors in astronomy) in 2003. She joined the MSU faculty in 2013 and is currently the director of the MSU Campus Observatory.

She has served on the NRAO Users Committee (deputy chair in 2015, chair in 2016) since 2013, and is currently serving on the committee of the Fermi Users Group.

Chomiuk received a Research Corporation for Science Advancement Scialog Fellowship (2015-2016), and is the recipient of a CoSMS Scholarship (2015) and a Thomas H. Osgood Excellence in Teaching Award (2015). She also received the National Radio Astronomy Observatory Jansky Fellowship (2010-2013).



Tyler L. Cocker

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Research Interests

The Cocker Group at MSU uses the new possibilities enabled by terahertz scanning tunneling microscopy (THz-STM) to explore ultrafast dynamics at the ultimate time and length scales of condensed matter physics. Currently, they are recording ultrafast movies of electron densities inside single molecules, nanostructures, and complex materials. These 'nano-movies' reveal how new materials respond to light on the smallest length scales and inform the design of future nanotechnology and molecular electronics.

The Cocker Group is also interested in other ultrafast laser and THz techniques, especially pump-probe spectroscopy and scattering-type scanning near-field optical microscopy (s-SNOM). These alternate approaches complement THz-STM by accessing low-energy elementary excitations in materials such as plasmons, phonons, and interlevel transitions in excitons. Such processes are important for nanomaterial functionality.

Biographical Information

Cocker received his B.Sc. from the University of Victoria in 2006 and his Ph.D. from the University of Alberta in 2012. He was subsequently a Humboldt Postdoctoral Fellow and Junior Group Leader at the University of Regensburg. Cocker played a central role in establishing and developing the field of THz-STM during his Ph.D. and postdoctoral research. The Cocker Group at MSU is now leveraging this experience for science at the new frontier of ultrafast and ultrasmall condensed matter. Cocker joined the MSU faculty in 2018.

Matthew Comstock
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Research Interests
Our lab investigates fundamental biophysical processes using advanced, precision, single-molecule measurement and manipulation techniques via optical tweezers. We investigate how biological molecular machines work: In real-time, we observe individual protein molecular machines marching down RNA or DNA strands and unwinding or extending strands. E.g., we revealed novel doubled-stranded-RNA sensing coupled to the unwinding motor mechanism. Function derives from structure, thus we also investigate how proteins and nucleic acids fold: We pull on single proteins, DNA and RNA and watch individual unfolding and refolding events to build detailed reaction pathways near biological conditions. Most recently, our machine vs. folding expertise has been combined in investigations of the telomerase chromosome extension machinery, where newly synthesized DNA dynamically folds and unfolds into G-quadruplex structures as the protein machinery marches on. For the first time, we have directly tracked the repeated activity of this crucial player in cancer and aging, revealing the coordination between efficiency and delayed product release. At the cellular scale, we manipulate single live cells and measure individual cellular electrochemistry in order to investigate how a small number of cells can combine and grow into electricity producing biofilm. To perform all of these investigations, we design and build frontier biophysical instrumentation combining optical tweezers and single-molecule fluorescence microscopy. We are a multi-disciplinary group that has extensive collaboration both at MSU and beyond.

Biographical Information
Matthew Comstock earned his undergraduate degree in physics from the University of Chicago and in 2008 received his Ph.D. in physics from the University of California, Berkeley, with research focused on optically controlled molecular nanomachines. At the University of Illinois at Urbana-Champaign, Matt jumped into biological physics as a Center for the Physics of Living Cells Postdoctoral Fellow, where he constructed a novel optical tweezers instrument capable of observing in real-time both the structure and the function of individual biological molecular motors at the angstrom scale. Matt joined the MSU faculty in 2012.

Sean Couch

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Research Interests

Sean Couch specializes in large-scale numerical simulations of astrophysical processes, especially aspects of core-collapse supernovae and stellar evolution in an effort to understand the powerful explosions that accompany the deaths of massive stars.

His research team was awarded a U.S. Department of Energy INCITE allocation totaling 250 million core-hours of computing time from 2015 through 2017, one of only three astrophysics projects granted allocations. Couch and his team are using these resources to study magnetohydrodynamic turbulence in supernovae.

Biographical Information

Couch earned his Ph.D. (2010) and his M.A. (2008) in astrophysics from the University of Texas at Austin. He completed his undergraduate work (*magna cum laude*) at Butler University in 2006. He joined the MSU Department of Physics and Astronomy and the Department of Computational Mathematics, Science, and Engineering in June 2015. He was a postdoctoral scholar and Hubble Fellow in the Department of Astronomy and Astrophysics at the University of Chicago from June 2010 through September 2014 and a senior postdoctoral scholar in the TAPIR Walter Burke Institute for Theoretical Physics at the California Institute of Technology just prior to joining MSU.

Tyce DeYoung

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Research Interests

Tyce DeYoung conducts research in particle astrophysics, at the boundary of high energy physics and relativistic astrophysics. Neutrinos will be produced when cosmic rays are accelerated in some of the most extreme environments in the universe: near the supermassive black holes at the centers of active galaxies, in the fireballs produced when gamma ray bursts explode, and in the relativistic shock waves emitted by galactic supernovae. These particles provide information about the astrophysical systems in which they are accelerated, probing physical processes that take place in environments not replicable on Earth. They are also used to study the fundamental properties of the particles themselves, through measurements of neutrino oscillations. The detectors built for these purposes can also be used to search for exotic forms of matter theorized to exist but not yet observed in the laboratory: dark matter, supersymmetric matter, and other particles and interactions beyond the Standard Model of particle physics.

DeYoung's research is focused on the IceCube Neutrino Observatory, the world's largest neutrino detector. He is a co-Principal Investigator for the IceCube Upgrade, which will be deployed at the South Pole in 2022, and is involved in developing the proposal for an extended IceCube-Gen2 observatory. He is an expert in software systems and data analysis, including statistical methods, machine learning, and application of numerical optimization techniques to event reconstruction.

Biographical Information

DeYoung received a B.A. in physics from Grinnell College in 1996, and his Ph.D. from the University of Wisconsin–Madison in 2001. He joined the MSU faculty in 2014. Prior to coming to MSU, he was a postdoctoral researcher at UC Santa Cruz and at the University of Maryland, and on the faculty at Penn State for eight years.

Megan Donahue

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Research Interests

Megan Donahue studies clusters of galaxies and the processes affecting galaxy evolution. Cluster evolution tells us about the matter density of the universe, because the formation of galaxy clusters is governed by gravitational physics. She also studies the metallicity, distribution, and physics of gas within clusters and circumgalactic gas (surrounding galaxies). Perhaps surprisingly, most of the baryons (matter made out of protons and neutrons) in the universe reside in intergalactic gas, not stars. This gas is an important source of fuel for star formation in the galaxies and for the supermassive black holes in the centers of galaxies. Her work includes models and developing tests of these ideas using multi-wavelength (X-ray, UV, optical, and IR) observations of clusters and galaxies.

Biographical Information

Donahue completed her B.S. in physics from the Massachusetts Institute of Technology in 1985, and earned her Ph.D. in astrophysics from the University of Colorado, Boulder, in 1990. She joined the MSU faculty in 2003.

Prior to coming to MSU, she did postdoctoral research in observational astronomy at the Observatories of the Carnegie Institution of Washington in Pasadena, California, and at the Space Telescope Science Institute (STScI) in Baltimore, Maryland. She was an astronomer for STScI, working on the data archive and the James Webb Space Telescope.

In 2012, she was elected AAAS Fellow and in 2016, she was elected APS Fellow.. She has twice received the MSU College of Natural Science Ronald W. Wilson Endowed Teaching Award for teaching Integrative Studies (2008, 2019) and the MSU College of Natural Science Teacher-Scholar Award for contributions to research and teaching (2006). In 2005, she received the MSU physics and astronomy department's Thomas H. Osgood Award for faculty excellence in teaching. Donahue served as President of the American Astronomical Society (AAS) from 2018 - 2020 and is currently completing her one-year term on the AAS Board as AAS Past President.

Phillip Duxbury

Dean - College of Natural Science & Professor

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Research Interests

Phillip Duxbury's specialties include statistical physics, molecular dynamics, rigidity percolation, nanostructure problems, device models, and ultrafast processes.

His research focuses on ultrafast nanocrystallography and applications to ultrafast processes in materials; phase behavior of polymer-nanoparticle mixtures with applications to organic and perovskite solar cells; phase behavior of nanoparticle-lipid bilayer systems with applications to nanotoxicology; and finding the atomic structure of non-crystalline materials, such as isolated nanoparticles and complex molecules, involving the definition and solution of novel inverse problems.

An ongoing basic theory interest is phase transitions in complex, frustrated networks—particularly problems that lie at the interface between combinatorial optimization and statistical physics, such as spin glass, K-SAT, and graph rigidity problems.

Biographical Information

Duxbury earned his Ph.D. from the University of New South Wales in 1983. He joined the MSU faculty in 1986 and had served as chair of the Department of Physics and Astronomy from 2013 - 2018.

Mark Dykman

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Research Interests

Mark Dykman's research includes quantum many-body physics far from thermal equilibrium, quantum information, transport in correlated electron systems, dynamics and fluctuations in nonlinear nanomechanical systems and microwave cavities, and nonlinear optics of solids. An example of the studied phenomena is the dynamics of resonantly driven quantum systems. These systems display fascinating behavior, including topologically trivial and nontrivial quantum phase transitions, such as the onset of the "time crystal" effect. They also display a new and now generally accepted mechanism of switching between coexisting dynamically stable states, which differs from the conventional quantum tunneling and thermal activation and is called quantum activation. Another example is presented by fluctuations of the eigenfrequency of nanomechanical systems as well as qubits of various kinds. Developing the means for revealing and characterizing these fluctuations, as well as identifying the underlying mechanisms, is a challenging task. .

Biographical Information

Dykman earned his Ph.D. from the Institute of Metal Physics, Kiev, in 1973. In 1984 he earned his Doctor of Sciences (USSR Doctor of Physical and Mathematical Sciences) from the Institute of Semiconductors, Kiev. He joined the MSU faculty in 1995. He is a fellow of the American Physical Society.

Wade Fisher

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Research Interests

Wade Fisher's research is in the field of high energy physics—the study of the most basic building blocks of the universe and the fundamental forces through which they interact. Scientists working in this field—commonly known as elementary particle physics—explore the most fundamental questions about the nature of our universe. Fisher performs his research at the highest energy particle accelerators in the world along with colleagues from both MSU and around the world. His work focuses on understanding the physical mechanisms that explain why matter has mass. While mass and its interaction with gravity are the clearest indications that forces exist, the mystery of why particles have mass at all and why observed particle masses span such a great range remains a major focus in high energy physics.

Biographical Information

Fisher received his B.Sc. in physics and math (*summa cum laude*) from the University of Minnesota in 2000 and earned his Ph.D. in physics from Princeton University in 2004. He joined the MSU faculty in 2009. Prior to coming to MSU he was a Leon Lederman Fellow at the Fermi National Accelerator Laboratory in Batavia, Illinois; and a postdoctoral researcher at Princeton University.

Darren Grant

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Research Interests

Darren Grant studies the properties of some of nature's most elusive fundamental particles through the development of ultra-sensitive detectors deployed in extreme locations around the globe. After participating in the discovery of solar neutrino oscillations at the Sudbury Neutrino Observatory as a PhD student, Grant joined the search for dark matter. Since 2007, Grant's research program has focused on measurements of the highest energy neutrinos recorded to date with the IceCube Neutrino Observatory, measuring the properties of the neutrinos and harnessing their information to search for signatures of new physics. His current research activities strike a balance between the development of novel data analyses and detector hardware for the planned next generation very-large-scale neutrino instruments.

Biographical Information

Grant obtained his PhD from Carleton University in 2004 investigating the properties of solar neutrinos with Canada's Sudbury Neutrino Observatory. Following research associate positions at Case Western Reserve University on the Cryogenic Dark Matter Search (2004 - 2007) and the Pennsylvania State University on the IceCube Neutrino Observatory (2007 - 2009), he transitioned to a faculty position in the Department of Physics at the University of Alberta (assistant professor - 2010 - 2014; associate professor - 2014 - 2018). He joined MSU in 2018. Grant is currently the spokesperson for the IceCube Neutrino Observatory, is a recent recipient of NSERC-Canada's E.W.R. Steacie Memorial Fellowship, and elected member of the College of New Scholars, Artists and Scientists of the Royal Society of Canada.

Daniel Hayden

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Research Interests

Daniel Hayden performs research in elementary particle physics, using the ATLAS detector at CERN in Geneva, Switzerland. His main focus is on searches for new physics beyond the current Standard Model. This includes searches for exotic new particles like the Graviton, which could explain why Gravity is so weak compared to the other forces or nature, and heavy bosons like the Z' and W' which could be part of a Grand Unified Theory. As well as physics research Hayden is involved in upgrading the ATLAS trigger hardware, and exploring outreach projects involving virtual reality.

Biographical Information

Hayden earned his PhD at Royal Holloway, University of London (RHUL), in 2012. From there he became a postdoctoral researcher first at RHUL with a STEP fellowship, and then Michigan State University (MSU) in 2013, based at CERN in Geneva, Switzerland. During this time Hayden led one of the flagship searches for new physics in the ATLAS collaboration, and was a sub-group convener in the ATLAS Exotics group overseeing 14 analyses and around 300 people. He joined the MSU faculty in 2019.

Rachel Henderson

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Research Interests

Rachel Henderson is a physics education researcher who leverages quantitive methodologies to study educational practices and assessment tools that can be used for improving learning for all students. As a member of the broader physics community, she is committed to providing fair and effective practices in order to increase the representation of women and other historically marginalized groups within the field of physics. Rachel is most interested in the connection between two lines of work, each with lens to equity and inclusion:(1) developing the next generation of physics assessments and (2) the retention of STEM students from various backgrounds. Broadly, the research questions that she explores are the following: (1) What is the impact of physics assessments, that may or may not be inclusive, on student success? (2) How can we design and utilize our assessments to improve diversity and inclusion within the physics classroom? (3) How can we ensure that we are assessing our students in an equitable manner so that they can become successful career scientists?

Biographical Information

Henderson earned her B.S. in Physics from Slippery Rock University in 2012. She then went on to do her graduate studies at West Virgina University where she earned her M.S. in Physics working on Molecular-Beam Epitaxy growth and characterization of topological insulators before shifting her research to physics education. Henderson then moved to MSU as a postdoctoral research where she worked on the development of formal structures, specifically assessment tools and practices for understanding student learning, to support the newly transformed physics laboratories at MSU.
Henderson currently serves as secretary on the Eastern Great Lakes Section of the APS as well as a member of the Physics Education Research Leadership and Organizing Council (PERLOC).

Kathleen "Katie" Hinko

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Research Interests

Katie Hinko studies physics teaching and learning in the context of informal environments. Examples of informal physics education include after-school physics programs and summer camps for youth, museum exhibits and demonstration presentations. Physics interest and identity development are explicit goals of informal environments, along with learning physics concepts, practices and tools.

Hinko is especially interested in the impact of participation in informal environments on the physics students and physicists who act as facilitators. By investigating 1) the role of informal education in the identities of participants, and 2) informal physics teaching and learning in action, we can determine how better to design, implement and leverage university-sponsored informal physics programs to deepen connections between physicists and the community.

Hinko also studies the institutional structures and cultural practices that make informal physics programs effective and sustainable. This research analyzes the efforts of the physics community toward "physics outreach" and has implications for leaders in physics and in informal physics education for funding, diversity and inclusion measures, and undergraduate and graduate student preparation.

Biographical Information

Hinko earned her Ph.D. in physics from the University of Texas at Austin in 2011. From 2011-2016, she served as the director of educational research and outreach for the JILA Physics Frontier Center at the University of Colorado Boulder. She joined the faculty at MSU in fall 2016.

Joey Huston

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Research Interests

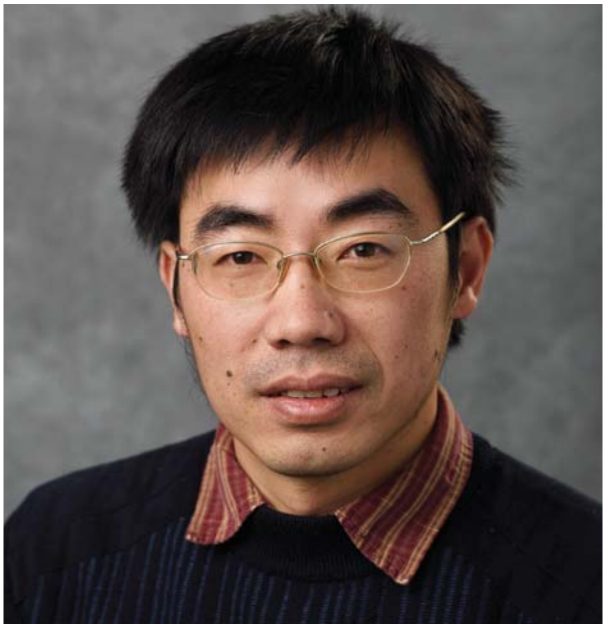
Joey Huston has more than 600 publications with greater than 30,000 citations, including nine renowned papers (more than 500 cites), five of which are experimental papers and four phenomenology.

Huston is working on two high energy physics experiments: CDF and ATLAS. On CDF, he has built parts of the endplug calorimeter, COT, and central preradiator (CPR) upgrades. On ATLAS, he has been involved in the construction and installation of the hadron calorimeter (Tilecal) and the minimum bias trigger scintillators; 32 ten-ton Tilecal modules were instrumented and tested at MSU before being shipped to CERN.

Biographical Information

Huston completed his B.S. at Carnegie-Mellon University in 1976, and earned his Ph.D. from the University of Rochester in 1983. He was a visiting assistant professor at MSU from 1985-1986 and joined the MSU faculty in 1986. He is a fellow of the American Physical Society.

He is the co-spokesman of the CTEQ collaboration. He is a visiting professor at the Institute for Particle Physics at Durham University (UK) and has been invited as a Distinguished Visitor by the Scottish Universities Physics Alliance (SUPA). He has organized many workshops and delivered plenary talks. He is one of the authors of the *Handbook on Perturbative QCD*, published by CTEQ in the *Reviews of Modern Physics*, and one of the authors of the CTEQ parton distribution functions. He has worked on developing many phenomenology tools (such as parton error pdfs, the Les Houches accords) crucial for today's experimental analyses. He has published recent review articles on physics at the LHC and on jet production in hadron-hadron colliders. He is also writing a book for Oxford University Press on QCD at the LHC.



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Research Interests

Xianglin Ke's research focuses on exploring emergent phenomena in strongly correlated materials and complex oxide heterostructures, and understanding the underlying mechanisms. Strongly correlated materials refer to a wide class of materials where the electron-electron Coulomb interaction is large and plays a key role in determining the materials' properties. For strongly correlated materials, the interplay among spin, charge, and lattice degrees of freedom often lead to exotic phases, such as high Tc superconductor, multiferroics, and Mott insulators. On the other hand, by growing different types of complex oxide materials on substrates to form so-called heterostructures, these oxide heterostructures can behave in a drastically different manner from bulk counterparts, largely due to the local structural distortions imposed by the epitaxial strain, the interfacial electronic, and lattice and orbital reconstructions. This leads to a variety of remarkable phenomena emerging in oxide heterostructures, such as 2D electron gas, induced superconducting interface and magnetoelectric coupling. Due to the multifunctionality and tunablitity, correlated oxide heterostructures provide an opportunity to study the intriguing physics and design new materials; it may also lead to innovative applications.

Ke's lab studies materials' properties by combining various neutron scattering techniques, including neutron diffraction, inelastic neutron scattering, and polarized neutron reflectivity, together with bulk electronic and thermo transport measurements. Specifically, the researchers investigate materials' nuclear and magnetic structure, magnetic excitation, interfacial spin structure, and electronic and thermo transport properties.

Biographical Information

Ke earned his Ph.D. in condensed matter physics from the University of Wisconsin–Madison in 2006. He completed his M.S. (2001) and B.S. (1998) degrees at Beijing Normal University, P.R. China. He joined the MSU faculty in 2012. Prior to that, he was the Clifford G. Shull Fellow (2009-2012) at the Neutron Sciences Directorate, Oak Ridge National Laboratory; and a Postdoctoral Scholar (2006-2009) in the Department of Physics and Materials Research Institute at Pennsylvania State University.

Wolfgang Kerzendorf
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Research Interests
A new age of astronomy is dawning. A future in which our personal computers can access exabytes of all-sky data and petaflops of computing. A future in which we can refocus on the physical insights rather than on the minutiae of technology. A future in which we can understand cosmic explosions from stellar births to explosive deaths.

Realizing these opportunities requires a rethinking of the transformation of data to knowledge. Fusing computer science and statistics with astrophysics has the power to bridge the gap between observational data deluge and high-fidelity theoretical simulations.

For the astrophysical research, Kerzendorf's group is interested in understanding why there are supernovae that do not exhibit hydrogen in their spectra. What are their progenitor systems? How do they evolve to become these strange hydrogen-poor stars? He leads an interdisciplinary of astrophysicists and computer scientists to address this question.

On the machine learning side, Kerzendorf is interested to build better knowledge infrastructure that can easily identify information relevant to his research in the hundreds of thousands of papers in astrophysics and related fields.

Biographical Information
Kerzendorf received his PhD in astronomy and astrophysics from the Australian National University, Canberra, in 2011. He then worked as a postdoctoral fellow at the University of Toronto before moving to the European Southern Observatory as an ESO Fellow. He deferred his position as faculty at MSU to work as a Senior Research Associate at New York University. He is cross-appointed between Physics & Astronomy and the Department of Computational Mathematics, Science, and Engineering.

Claudio Kopper

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Research Interests

Claudio Kopper is a high-energy particle physicist working on multi-messenger astroparticle physics as a member of the IceCube collaboration. Throughout his research career, he has been interested in what we can learn about particle physics from looking at the highest-energy particle accelerators in the Universe and how to use advanced data analysis techniques such as the ones enabled by massively-parallel computing on graphics cards (such as the ones found in everyday computers) to make sense of the data we see.

Kopper's primary focus is the IceCube Neutrino Observatory, a particle detector built into a cubic kilometer of natural Antarctic glacier, located deep beneath the South Pole — one of the planet's most extreme environments. Neutrinos, which interact very rarely in nature, represent an ideal messenger with their ability to travel from their point of production to detection almost entirely unimpeded. The IceCube observatory has a vast scientific program including searching for neutrinos from the most violent astrophysical processes such as Gamma Ray Bursts and Active Galactic Nuclei.

His technical expertise is in detector simulation and reconstruction techniques, distributed software systems and data analysis with a focus on machine learning, data mining, and application of numerical optimization techniques. He is an expert in photon tracking through diffusive media (such as glacial ice) on massively parallel high-performance and high-throughput computing (HPC/HTC) clusters using general-purpose graphics processing units (GPGPU). He leads and coordinates searches for diffuse astrophysical neutrino fluxes and works on online real-time follow-up analyses of neutrino events. He was part of the team responsible for the discovery of the astrophysical neutrino flux and his work led to the discovery of the first neutrino-gamma ray connection (blazar TXS 0506+056).

Biographical Information

Kopper completed his diploma in physics at the University of Erlangen-Nürnberg, Germany in 2005 and earned his PhD (Dr. rer. nat.) from the same institution in 2010. Before moving to North America and joining the IceCube collaboration, he spent one year in Amsterdam working at NIKHEF, the Dutch National Institute for Subatomic Physics. He was an inaugural John Bahcall Fellow at the University of Wisconsin—Madison from 2011 and moved to the University of Alberta, Canada in 2014. He joined the MSU faculty in 2018.

Lisa Lapidus

Professor

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Research Interests

Lisa Lapidus is a biological physicist. Her research group studies protein folding, dynamics and aggregation using optical spectroscopy. Her lab currently has the fastest continuous flow mixer in the world, which can mix two solutions and prompt protein folding in ~4 microseconds. The Lapidus lab uses these misers to study the early states of folding and dynamics of unfolded proteins. They use many different optical probes to look at the same protein and often see different kinetics with these different probes. Simple models fail to explain the experimental results so they collaborate with computational biologists to do large-scale simulation of protein folding.

Another resear4ch area is the dynamics of biological molecules under crowded conditions founded in a cell, which is much more concentrated than scientists usually use in the lab. How do folded and unfolded proteins interact when they are typically only a few nanometers away? Under some conditions proteins and nucleic acids can undergo liquid-liquid phase separation, in which concentrated condensates can co-exist with dilute bulk solution. Understanding this type of phenomena requires the development of new experimental and computational techniques.

The group is also looking at how the rates of intramolecular diffusion of unfolded proteins depend on sequence and have found that this rate is related to the propensity for a protein to aggregate. Protein aggregation plays a role in many human diseases—such as Parkinson's, Alzheimer's, and Huntington's. The Lapidus group wants to understand why some sequences are so much more prone to aggregation than others. A better understanding of the processes may eventually lead to treatments or preventive techniques for these and other diseases.

Biographical Information

Lapidus completed her B.S. from University of Michigan (1991) earned her Ph.D. from Harvard University in 1998. She was a postdoctoral fellow at the National Institutes of Health and Stanford University. She joined the MSU faculty in 2004.

Huey-Wen Lin

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Research Interests

Huey-Wen Lin uses supercomputers to nonperturbatively calculate quantities at the quark and gluon level using quantum chromodynamics (QCD). These strong interactions are calculated from the Standard-Model path integral in lattice gauge theory, using a four-dimensional Euclidean spacetime grid. She investigates particle properties that disentangle new physics from background in searches at the Large Hadron Collider (LHC) and beyond. This includes the first lattice calculation of the Bjorken-x dependence of parton distribution functions (PDFs), precision determinations of nucleon properties for electric dipole moment (EDM) studies, dark-matter searches, neutron/nuclear beta decays and more.

Lin's group has world-leading expertise using the lattice to study the Bjorken-x dependence of PDFs. Graduate students and postdocs take leadership roles toward completion of projects published in APS journals such as PRL and PRD. Lin's group is applying machine-learning algorithms to make predictions for lattice observables and attack the "inverse problem" in the lattice PDF approach. Lin's group is also expanding into quantum computing; she organized the first MSU-IBM quantum-computing bootcamp with Qiskit in 2019.

Biographical Information

Lin earned her Ph.D. from Columbia University. She was research assistant professor at University of Washington, and visiting assistant professor at University of California, Berkeley, before joining MSU in 2016.
Lin is also in the Department of Computational Mathematics, Science and Engineering (CMSE). She was awarded an NSF CAREER Award in 2017. She started the Women in LQCD group (http://www.facebook.com/WLQCD), which has become an annual event, and serves on the international lattice diversity and inclusion committee.

Mohammad Maghrebi

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Research Interests

Mohammad Maghrebi is interested in quantum many-body systems and quantum phases of matter. These phases emerge due to the collective behavior of macroscopic systems (more is different!). Maghrebi is particularly interested in systems that are driven away from equilibrium. With the recent advances in quantum simulation platforms, non-equilibrium quantum matter is at the forefront of research. A prime example is driven-dissipative systems where an external drive such as laser prevents relaxation and thermalization and instead creates exotic steady states. Recently, Maghrebi has been awarded the prestigious Young Investigator Award from the Air Force Office of Scientific Research for his work and proposals on driven-dissipative systems.

Maghrebi is also interested in bringing the powerful tools of quantum information into the domain of condensed matter systems. In particular, he is interested in finding patterns of quantum entanglement in many-body systems. Entanglement, the most fundamental property of quantum mechanics, provides a deep insight into the complex nature of quantum systems in and out of equi-librium.

With his diverse background, Maghrebi is also interested in exploring analog condensed matter systems emulating high energy physics, black holes and even the early universe. Different branches of physics often merge and create new paradigms; a desire to merge seemingly disparate areas of physics is at the heart of Marghrebi's research.

Biographical Information

Maghrebi earned his Ph.D. from the Massachusetts Institute of Technology in 2013, followed by a postdoctoral appointment at the Joint Quantum Institute in Maryland. He joined the MSU faculty in 2017.

Kendall Mahn

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Research Interests

Elementary particle physics is a field devoted to understanding the fundamental forces and components of the universe. While our understanding of the universe, the Standard Model, has held up well to precision tests, there are recent indications that it is not a complete description. Kendall Mahn's research interest is in the small subatomic particle, the neutrino. Neutrinos have a small, nonzero mass; the origin of this mass is not currently understood. We know neutrinos have mass as we observe "neutrino oscillation," a purely quantum mechanical effect where one neutrino type, or "flavor" will convert to a second kind over distances of hundreds to thousands of miles.

Mahn works on the accelerator-based experiments which produce powerful beams of neutrinos or antineutrinos (T2K and DUNE). The Tokai-to-Kamioka experiment uses a >99% pure muon neutrino beam sent over a distance of 295km in Japan. In 2013, T2K announced the discovery of electron neutrinos "appearance" - that is, the conversion of nuon neutrinos to electron neutrinos due to oscillation. This transition may have important implications for the matter-antimatter asymmetry of the universe, and is a necessary process to allow for future experiments to search for CP violation in the neutrino sector. precision measurements made by T2K and a subsequent US-based Deep Underground Neutrino Experiment (DUNE) will help us understand the nature of the neutrino in detail.

Mahn has also worked on the IceCube Experiment, a neutrino observatory located at the South Pole that has a broad program in neutrino astrophysics and makes precision measurements of neutrino oscillation in a complementary way to T2K.

An Important componenet of her work is understanding how neutrino-nucleon interactions affect measurements of neutrino oscillation for current and future experiments. She is interested in exploring new measurements of neutrino-nucleon scattering at detectors in the T2K beamline and in using data from other experiments, notably electron scattering experiments, to help constrain and improve interaction models.

Biographical Information

Kendall Mahn earned her Ph.D. from Columbia University in 2009. She joined the MSU Department of Physics and Astronomy in 2014 as a high energy particle (HEP) experimentalist.

Daryl McPadden

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Research Interests

Daryl is a physics education researcher who develops and studies active learning classrooms in introductory physics, in particular looking at the scientific skills that students are developing and how learning environments influence those skills

Biographical Information

Daryl received her B.S. in Engineering Physics from the Colorado School of Mines in 2013. She then went to Florida International University for her Ph.D. in Physics, which was received in 2018. At FIU, her research focused on students' use of representations (equations, diagrams, pictures, etc) in a University Modeling Instruction classroom. While doing her Ph.D., she also worked on curriculum development for an Integrated Science Learning Environment (ISLE) laboratory and for University Modeling Instruction, with a particular focus on introductory electricity and magnetism courses. Daryl then joined the MSU Physics Education Research Lab (PERL) as a postdoc in April 2017, where she has worked on the development of Electricity and Magnetism Projects and Practices in Physics (EMP-Cubed). In 2019, Daryl joined the MSU faculty as a fixed-term assistant professor, where she has been working on the development of Fabrica Physics Mechanics and E&M courses in collaboration with Dr. Paul Irving. These courses are an integrated lab and discussion course, which focuses on students' development of scientific practices. Daryl's interests lie in understanding, evaluating, and improving active learning courses.

Brian O'Shea
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Research Interests
Brian O'Shea is a computational and theoretical astrophysicist. His research focuses on theoretical and numerical studies of galaxy formation and evolution, with a particular emphasis on the formation of the first galaxies, the evolution of Milky Way-like galaxies and their dwarf satellites, the astrophysics of galaxy clusters, and plasma turbulence. He is also interested in numerical methods for exascale supercomputers, including developing highly performant and scalable codes for cosmological structure formation and plasma turbulence.

Biographical Information
O'Shea earned his Ph.D. from the University of Illinois at Urbana-Champaign in 2005. He holds a joint faculty appointment at MSU between the Department of Physics and Astronomy; the Department of Computational Mathematics, Science, and Engineering; and the National Superconducting Cyclotron Laboratory. He is also a member of the Joint Institute for Nuclear Astrophysics, the Michigan Institute for Plasma Science and Engineering, and the Great Lakes Consortium for Petascale Computation.

Carlo Piermarocchi

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Research Interests

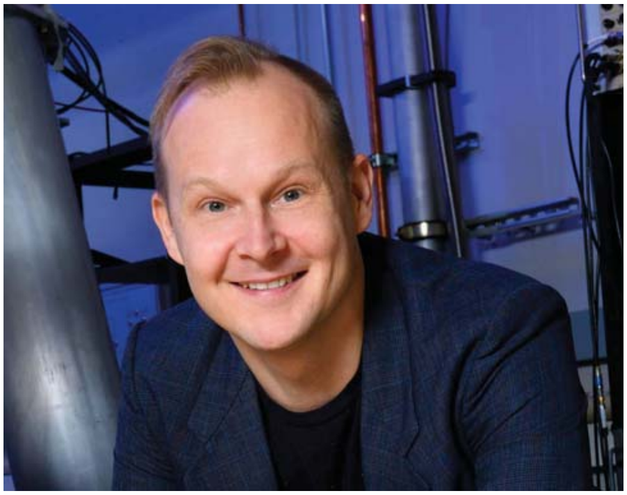
The Piermarocchi Theory Group focuses on condensed matter physics, information theory, and control theory in quantum and biological systems. Specifically, they work in the areas of optical control and information processing in semiconductors, exciton and polariton optics, and signaling in complex biological networks.

Semiconductor materials and nano-systems can be controlled at the quantum level using lasers. This group's approach directly focuses on designing optical devices with a functional role in memories, information processors, or network components. The researchers are also interested in the properties and the dynamics of optical excitations in semiconductors (excitons) in confined and/or periodic nanostructures, such as quantum wells, quantum wires, or arrays of quantum dots. Their work on the control theory of signaling networks in cells is based on concepts from statistical physics and information theory.

Biographical Information

Piermarocchi received his Ph.D. in theoretical physics from the Swiss Federal Institute of Technology (EPFL), Lausanne, in 1998, and his Laurea Degree in physics (*summa cum laude*) from the University of Pisa in 1994. He joined the MSU faculty in 2002.

Awards and fellowships include the Donald D. Harrington Faculty Fellowship at the University of Texas, Austin (2005-2006); the Thomas H. Osgood Memorial Faculty Teaching Award (2004); and a Swiss NSF Research Fellowship (1999-2000). He is the co-founder and chief scientific officer of Salgomed, Inc., a California company that applies systems biology concepts and algorithms from physics to discover novel therapeutics. Piermarocchi was co-organizer of a Harrington Symposium on Solid State Cavity Quantum Electrodynamics in Austin, Texas (2006), a member of the Program Committee for the Quantum Electronics and Laser Science Conference (QELS)(2006-2008) and chair of the sub-committee (2013 and 2014). He is also a panelist and reviewer for NSF.



Johannes Pollanen

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Research Interests

Johannes Pollanen's experimental research group at MSU, the Laboratory for Hybrid Quantum Systems (LHQS), explores the fundamental physics and potential quantum information (QI) applications of low-dimensional electron systems (e.g. electrons on helium, graphene, etc.) and superconducting circuit based quantum bits (qubits). Additionally, the researchers are interested in combining these systems to create new hybrid quantum platforms that bring together a variety of interacting degrees of freedom. Low temperatures (< 10mK) and high magnetic fields (up to 14T) are required to produce the quantum properties that the group investigates. Pollanen's group uses a diverse set of experimental techniques—including high-field magneto-transport, microwave quantum-optics, and advanced surface acoustic wave techniques—to interrogate these fascinating quantum materials and qubit devices.

Biographical Information

Pollanen earned his Ph.D. in 2012 from Northwestern University, where he worked in the Low Temperature Physics Group to understand the properties of complex many-particle quantum systems and engineer novel quantum mechanical forms of matter. During this time, he discovered a new chiral state of superfluid 3He, which he stabilized by introducing anisotropic disorder to the superfluid in the form of high porosity silica aerogel. Before joining the physics and astronomy faculty at Michigan State in January 2016, Pollanen was an IQIM postdoctoral scholar at the Institute for Quantum Information and Matter (IQIM) at the California Institute of Technology. At Caltech, he studied the exotic properties and many-body quantum states of single and bilayer 2d electron systems in ultra-clean semiconductor heterostructures grown via molecular beam epitaxy (MBE).

*Superconducting QUantum Interference Device

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Research Interests

Joey Rodriguez's research focuses on understanding how planets form and evolve by studying exoplanets, planets that orbit stars other than the Sun, and the disks of gas and dust that they form within. Using observations from NASA's Kepler, K2 and Transiting Exoplanet Survey Satellite (TESS) missions, combined with ground-based photometry and spectroscopy, he works to discover and characterize new exoplanet systems that can help us understand key questions about planetary formation and evolution. He also studies disk eclipsing systems, where a young star is eclipsed by ether its own circumstellar disk or one around another body in the system (i.e.. rings). These rare events allow us to directly investigate the dust and gas (the building blocks of planets) around a young star, and combined with millimeter mapping from ALMA provide a more complete picture of the full system architecture.

Biographical Information

Rodriguez earned his B.S. (2010) in Astrophysics and Psychology from Rutgers University and his M.S. (2012) in applied and engineering physics from George Mason University. In 2016, he received his Ph.D. from Vanderbilt University for using transiting exoplanets and eclipsing disks to understand planet formations and evolution. Prior to arriving at MSU in January 2021, he was a Future Faculty Leaders Postdoctoral fellow (2016-2019) at Harvard University and an Astronomer (2019-2020) for the Smithsonian Astrophysical Observatory, working at the Center of Astrophysics | Harvard & Smithsonian

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Research Interests

Chong-Yu Ruan's specialties include ultrafast phenomena, surface and interface science, nanostructure and dynamics, and phase transition. His research group is interested in the phenomena occurring on the ultrafast timescale, namely from 10^{-9} to 10^{-15} seconds. Accessing this timescale opens up new grounds for elucidating intricate properties and exploring novel phases of matter away from equilibrium.

The research team is among a handful of groups in the world actively developing electron-based ultrafast imaging and spectroscopy for studying materials and molecular processes in the ultrafast time scale and with atomic scale resolution. The electron-based technology is advantageous in nondestructive investigation of nanomaterials and interfaces due to its larger scattering factor from the atoms.

Research has been directed in understanding the photophysical and photochemical processes in nanomaterials, including searching the optical route of graphite-to-diamond transformation, and investigating surface plasmonic effects and phase transitions of nanocrystals. More recently, through controlling light-matter interaction that results in unique transient photodoping effects, the group explored the metastable and hidden phases to understand the underlying interaction-driven nature responsible for macroscopic quantum phase transformations in complex electronic materials. Beyond investigating the fundamental physics, mechanistic understanding of the elemental processes in light-induced phase transition and energy transport in nanoscale materials and interfaces are important to implement an array of applications in optoelectronics, such as memory, nanoelectronics technologies, and clean energy sciences such as photovoltaics, and photocatalysis.

Biographical Information

Ruan earned his Ph.D. from the University of Texas at Austin, in 2000. He joined the MSU faculty in 2004. Among his awards and honors are the Sidhu Award from the Pittsburgh Diffraction Society in 2005 and an Outstanding Young Researcher Award from the International Organization of Chinese Physicists and Astronomers in 2009. He is a member of the American Physical Society, the American Chemical Society and the Optical Society of America.

Vashti Sawtelle

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Research Interests

Vashti Sawtelle is a physics education researcher who studies how learning environments support (or inhibit) students from diverse backgrounds in their learning physics. She focuses her work on understanding the role that active learning, modeling, and interdisciplinary classrooms (e.g., physics for biologists) play in creating supportive learning environments for all students.

Biographical Information

Sawtelle received her Ph.D. in physics education in 2011 from Florida International University, where she worked in the Physics Education Research Group. There, she focused on the development of physics self-efficacy for students—particularly women—in a Modeling Instruction environment. She moved to the University of Maryland Physics Education Research Group as a postdoctoral researcher. She joined the MSU faculty in 2014.

Sawtelle's work focuses on understanding equitable learning environments at the undergraduate level. Originally, her work centered on the experiences of women in physics and bringing modern theories such as social-cognitive theory to understanding dynamics of gender and science. Currently, she has broadened this perspective to include understanding how students from diverse backgrounds experience physics and science and how these students come to identify as scientists. From the social context, her interests include understanding how students develop self-efficacy to do science, how that contributes to the development of science identities, and how those identities are related to issues of equity in the science community. She is particularly interested in understanding the interaction between individual students and the learning environment and draws heavily from ethnographic methodologies to support her work.

While co-directing the Physics Education Research Lab at MSU, she continues to collaborate with and build from her background in Modeling Instruction at FIU and NEXUS/Physics from UMD.

Carl Schmidt
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Research Interests

Carl Schmidt's research focuses on standard model and new physics calculations to be used in comparisons with experimental data at high-energy colliders. He has been involved in calculating higher-order quantum chromodynamic corrections to Higgs boson production in association with jets at the Large Hadron Collider (LHC), as well as the standard model background to the di-photon decay channel of the Higgs boson at the LHC. This is one of the most important channels used in the discovery of the Higgs boson, and also in the determination of the Higgs boson properties.

Schmidt is part of the CTEQ-TEA group, which performs a global analysis of many different experimental data in order to extract parton distribution functions (PDFs). These PDFs can be interpreted as the probability for a particular parton (quark or gluon) in the proton to scatter with some fraction of the proton's momentum in a high-energy scattering process. Recently, he has been involved in the introduction of electro-weak corrections to the CTEQ-TEA PDF analysis. This requires the inclusion of the photon as a parton in the proton. His research group has constrained the photon PDF using data from the ZEUS collaboration on isolated photon production in deep inelastic electron-proton scattering.

He is also interested in new physics models that address theoretical issues related to the Higgs boson and the electroweak symmetry breaking. This involves both building and analyzing the models theoretically, as well as making phenomenological predictions from the new physics models that can be tested at high energy colliders.

Biographical Information

Schmidt earned his Ph.D. from Harvard University in 1990. He joined the MSU faculty in 1995.

Reinhard Schwienhorst
Professor

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Research Interests
Reinhard Schwienhorst is a particle physicist, exploring the energy frontier, studying the laws of nature at the highest energies together with his MSU colleagues and collaborators from around the world on the ATLAS experiment at CERN near Geneva, Switzerland.

The CERN LHC is a proton-proton collider that is expected to discover new particles and reveal physics at the electroweak symmetry breaking scale. Schwienhorst says he is excited for the breakthroughs in the understanding of our world that should emerge. He works in the top quark group on single top quark production and in the exotics group on searches for new physics. He also works on hardware projects aimed at upgrading the ATLAS muon detector for future running.

Together with collaborators, including very talented MSU students and Abrams planetarium, Schwienhorst is producing planetarium shows on particle physics, the LHC, and the ATLAS experiment.

Biographical Information
Schwienhorst earned his Ph.D. from the University of Minnesota in 2000 and his Physik Diplom from the Westfälische Wilhelms Universität Münster in 1995. He joined the MSU faculty in 2006.

Jay Strader
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Research Interests
Jay Strader's research is centered in two areas. The first is near-field cosmology with massive globular clusters—using the stellar populations and kinematics of clusters to constrain the formation and assembly histories of nearby galaxies, with a focus on their outer halos. He also studies the properties of globular clusters themselves, including the presence of black holes, multiple stellar populations, and stellar winds from red giants. He discovers and studies black holes in the dense stellar environments of globular clusters using data from optical, X-ray and radio telescopes. This work sheds light on the formation of black holes in the death throes of massive stars and helps guide tests of Einstein's theory of general relativity.

Much of Strader's work is conducted through use of the Southern Astrophysical Research Telescope. SOAR is 4.1-meter telescope located in Chile and is a joint venture between MSU, the University of North Carolina at Chapel Hill, the country of Brazil and the National Optical Astronomy Observatories.

Biographical Information
Strader received his Ph.D. in astronomy and astrophysics from the University of California, Santa Cruz, in 2007. He completed his B.S. in physics and mathematics at Duke University in 2001. He joined the MSU faculty in 2012. Prior to that, he was a Hubble Fellow and Menzel Fellow at the Harvard-Smithsonian Center for Astrophysics. In 2015, he was named a fellow of the David and Lucile Packard Foundation, a prestigious award that honors the country's most innovative early-career scientists.

Dan Stump

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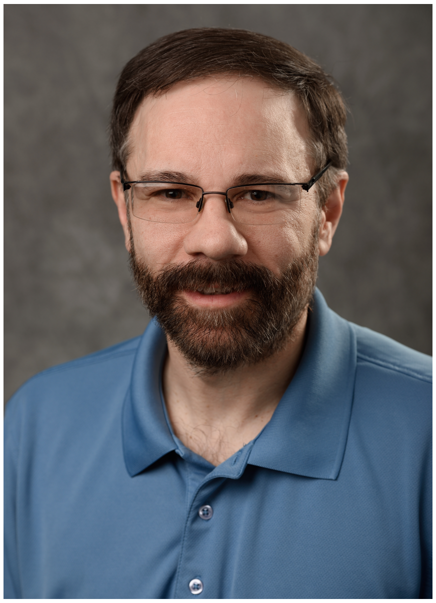
Research Interests

In the modern theory of high-energy physics, the proton (and all strongly interacting particles) is a bound state of the quark and gluon fields. Two important questions are: How do the QCD interactions produce the spectrum of bound states? How are the quarks and gluons distributed in momentum in the proton?

Dan Stump's current research interest is in the use of scattering data to find the momentum distributions of the quarks and gluons. This includes the construction of the CTEQ parton distribution functions that are widely used in the analysis of current and future accelerator experiments. His past research has focused on the spectrum of hadron states using an MIT bag model approach, and studies in lattice gauge theory to help understand the confinement mechanism in QCD.

Biographical Information

Stump received his Ph.D. from the Massachusetts Institute of Technology in 1976. He joined the MSU faculty in 1980. In addition to research in theoretical high energy physics, he has taught all levels of physics courses—introductory, advanced undergraduate, and graduate. His primary goal in teaching is to help students advance to the next level of understanding, so that by the end of their education they can work independently, especially in the field of physics.



Stuart Tessmer

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Research Interests

Stuart Tessmer's research focuses on developing and applying low-temperature scanning probe techniques to study the behavior of charges in nanoscale systems. Areas of interest include nanoelectronics, correlated electron systems, semiconductor defects and interfaces, superconductivity, quantum interference and confinement, and bio-electronics. His group is especially interested in the physics of superconductors, topological insulators, and nanoelectronics.

The researchers study the physics of electrons inside nano systems, such as single-atom defects and atomic scale structures. These tiny systems can be imbedded inside metals, semiconductors and superconductors. To see what the charges do on nanometer-length scales, the research group develops and applies incredibly sensitive tools called scanning probe microscopes. One of the experimental methods they use is called Charge Imaging, which is based on a charge sensor with a noise level of 0.01 electrons per root Hz. The method has proven to be capable of resolving the quantum structure of trapped electrons at low temperatures.

Biographical Information

Tessmer earned his Ph.D. (1995) and his M.S. (1992) degrees from the University of Illinois at Urbana-Champaign. He completed his B.S. degree (1989) at the University of Washington. He joined the MSU faculty in 1998.

Kirsten Tollefson

Associate Dean of the Graduate School & Professor

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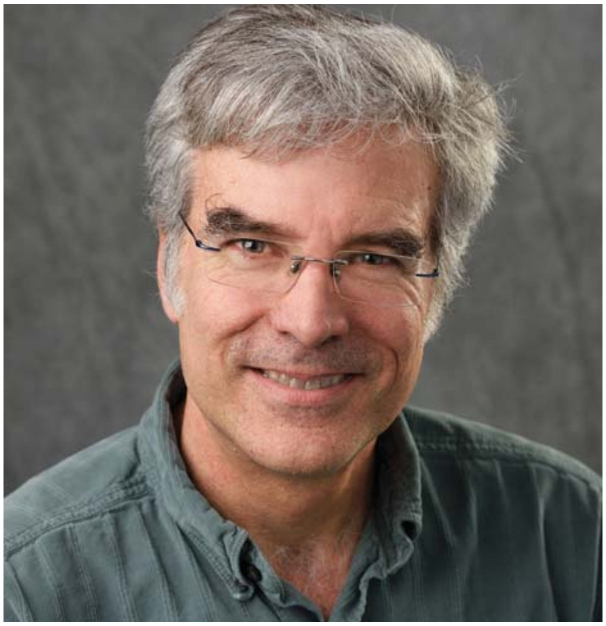
Research Interests

Kirsten Tollefson's research currently focuses on particle astrophysics. She studies the most extreme environments in the universe - gamma-ray bursts, pulsars, supernovae and black holes - to investigate questions such as "What is dark matter?" And "What is the physics of the Universe at the highest energies?". She works on two experiments - the High Altitude Water Cherenkov (HAWC) Gamma-Ray Observatory near Puebla, Mexico and the IceCube Neutrino Observatory at the South Pole. HAWC was built to detect the highest energy light (called gamma rays) coming from sources in the sky, like the Crab Nebula, and is scheduled to take data until 2023. She has recently joined a new effort to build a HAWC-like gamma-ray observatory in the southern hemisphere called the Southern Wide-Field Gamma-ray Observatory (SWGO) that is in a planning and designing phase. She is also a member of the IceCube experiment which is a gigaton-scale neutrino detector that is currently undergoing an upgrade and has plans for an extended next generation facility to be built over the next decade. She uses data from both experiments to answer questions relevant to multi-messenger astronomy. Her technical expertise includes silicon strip detectors, software-based triggering and databases.

Before working on HAWC, Tollefson participated in two hadron collider experiments: CDF at Fermilab and ATLAS at CERN. She studied the heaviest of the quarks, called the top quark, and was convener of CDF's Top Quark Group from 2006-2009. While on ATLAS, she also searched for exotic particles such as W and Z bosons. She contributed to the trigger systems on both ATLAS and CDF and was CDF's Trigger and Dataset Working Group leader from 2004-2006.

Biographical Information

Tollefson completed her bachelor's degree at Gustavus Adolphus College in 1992 and earned her Ph.D. from the University of Rochester in 1997. She joined the MSU faculty in 2002.



G. Mark Voit

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Research Interests

G. Mark Voit's research explores how the hydrogen and helium gas that pervaded the early universe becomes transformed into the stars and galaxies we see today. Gravity draws matter into increasingly larger structures as time passes, but as stars begin to form, feedback from supernovae and supermassive black holes start to inhibit additional star formation. Voit is particularly interested in how feedback mechanisms operate in groups and clusters of galaxies. He also studies how the properties of dark matter and dark energy can be deduced from observations of the evolution of galaxy clusters.

Biographical Information

Voit earned his Ph.D. in astrophysics from the University of Colorado in 1990, and his A.B. in astrophysical sciences from Princeton in 1983. He joined the MSU faculty in 2003. Just prior to that, he was an astronomer at the Space Telescope Science Institute, working on the Hubble Space Telescope project for eight years. Before that, he was a Hubble Fellow at Johns Hopkins for two years, and a Research Fellow at Caltech for three years.

Andreas von Manteuffel

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Research Interests

Andreas von Manteuffel's research area is the theory of elementary particles.

The Standard Model of particle physics successfully describes matter and its electromagnetic, weak and strong interactions down to distances well below the size of nucleons. Scattering experiments at high-energy colliders such as the Large Hadron Collider (LHC) at CERN are crucial to further establish the Standard Model or to find new physics beyond it. A firm interpretation of the experimental data and the identification of possibly small deviations from the Standard Model require concise theory predictions.

Manteuffel's research focuses on providing predictions with unprecedented precision for important collider observables involving the Higgs boson, the electroweak gauge bosons or other particles. These precision calculations are performed in perturbative Quantum Field Theory. They rely heavily on the application and development of advanced mathematical methods and efficient computational tools. Software developments include the computer algebraic treatment of novel special mathematical functions and the solving of large symbolic systems on high-performance supercomputers.

Biographical Information

Manteuffel earned his Ph.D. from Heidelberg University in 2008. After postdoctoral researcher positions at the University of Zurich and Johannes Gutenberg University Mainz, he joined the MSU faculty in 2016.

Nathan Whitehorn
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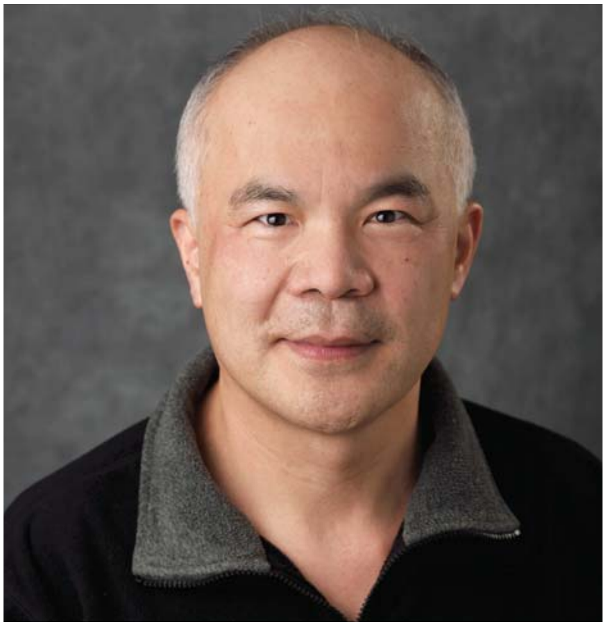
Research Interests:
Nathan Whitehorn's research is at the intersection of experimental particle physics and high-energy astrophysics, addressing questions such as the origin of ultra-high-energy cosmic rays and the nature of rarely-interacting particles like neutrinos and axions using data from the cosmic microwave background and neutrino observations of the sky, as well as other topics involving the universe at extremes. His current projects include the IceCube Neutrino Observatory and the South Pole Telescope, both of them co-located at the South Pole, and expanding into the forthcoming CMB-S4 and IceCube Gen2 experiments. His group's day-to-day research focuses on data analysis and instrumentation development.

Biographical Information:
Whitehorn earned his PhD (2012) from the University of Wisconsin-Madison. He joined the MSU faculty in 2020. Prior to coming to MSU, he was an assistant professor in the physics department at the University of California, Los Angeles. in the more distant past, he held postdoctoral positions at the University of California - Berkeley and the University of Wisconsin-Madison.



Chien-Peng Yuan

Wu-Ki Tung Professor of Particle Physics

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Research Interests

Chien-Peng Yuan's research involves the interplay between QCD theory and experimental data from many experiments, including recent experiments at the CERN Large Hadron Collider (LHC). This global analysis of data is necessary to deepen the understanding of QCD, and to determine the probability distributions of the partons in the proton. The resulting CTEQ (CTEQ-TEA) Parton Distribution Functions have been essential to the interpretation of experiments at the world's leading high energy collider facilities—Fermilab (Batavia, IL), RHIC (Brookhaven, NY), DESY (Hamburg, Germany), and CERN (Geneva, Switzerland). Yuan's team continues their world-leading contributions to enable making precision predictions on collider phenomenology and precise determination of the SM parameters at lepton-hadron and hadron-hadron colliders, relevant to the high energy physics and nuclear physics communities.

His group is actively involved in the development of transverse momentum resummation methods in essential collider processes, relevant to the phenomenology of weak gauge (W and Z) bosons, Higgs boson, photon pairs, and New Physics particles (such as W-prime and Z-prime bosons). They have been implemented in the ResBos code.

In the early 1990s, Yuan had proposed how to detect the single top events at hadron colliders and performed higher order calculation to improve the theory prediction on its production and decays, and to explore the potential of using top quark polarization to test SM and distinguish New Physics models.

Biographical Information

Yuan earned his Ph.D. from the University of Michigan in 1988. He joined the MSU faculty in 1992. He has been a fellow of the American Physical Society since 2013.

Stephen Zepf
Chairperson & Professor

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Research Interests
Stephen Zepf's research is primarily in extragalactic astronomy, with a long-standing focus on the formation and evolution of galaxies. Much of his work in this area uses the properties of globular cluster systems of galaxies to test models of galaxy formation and evolution. He has recently also been working on black holes and neutron stars in extragalactic globular clusters. The research in these areas often utilizes data from the Hubble Space Telescope, the Chandra X-ray Telescope and various ground-based optical telescopes, including MSU's SOAR telescope.

Biographical Information
Zepf earned his Ph.D. (1992) and his M.A. (1987) from Johns Hopkins University. He joined the MSU faculty in 2001. Prior to coming to MSU, he was assistant professor and director of graduate studies in the astronomy department at Yale University. Before that, he was a Hubble Fellow at UC Berkeley and a postdoctoral fellow at Durham in the UK.

He is currently on the board of directors for the SOAR telescope, and was recently on the National Academy Panel on the Galactic Neighborhood as part of the 2010 Decadal Survey for U.S. Astronomy and Astrophysics. He was also a director of the Center for the Study of Cosmic Evolution at Michigan State, and co-chaired a program on globular clusters at the Kavli Institute for Theoretical Physics in Santa Barbara. He received the MSU College of Natural Science Faculty Mentoring Award in 2014 and a Michigan State University Distinguished Faculty Award in 2013.

Pengpeng Zhang

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Research Interests

Pengpeng Zhang's research is in the area of condensed matter experiments with emphasis on understanding the fundamental properties of electronic and photovoltaic nanomaterials using scanning probe microscopy in conjunction with device characterization, and further manipulating the properties of these nanomaterials and devices via surface and interface engineering. The ability to control the synthesis of materials with nanometer precision has the potential to revolutionize technology. However, the utility of engineered nanomaterials for important applications such as energy conversion and storage devices, nanoscale electronics and molecular/biological sensors has in many cases been severely limited by interfacial phenomena that emerge at the nanoscale. It is thus crucial to develop a thorough atomic- and molecular-level understanding and a precise control of surfaces and interfaces.

One of Zhang's group's current research interests is to promote the understanding and control of hetero-interfaces between organic and inorganic materials. The central problem among various interfacial phenomena is the charge behavior—charge injection, distribution, and separation at the interface. Fundamental insights on this topic may lead to improved efficiency of organic-inorganic hybrid solar cells, as well as the rational design of nanomaterials with controlled properties via regulation of surfaces and interfaces. Such an understanding will come from careful characterization of surfaces and interfaces with scanning probe microscopy, and the correlation of nanoscale phenomena with macroscopic device performance, which is the primary methodology in Zhang's research.

Biographical Information

Zhang earned her Ph.D. from the University of Wisconsin–Madison, in 2006, and her M.S. (2000) and B.S. (1997) from Beijing Normal University. She joined the MSU faculty in 2009. Prior to that, she was a postdoctoral scholar at Pennsylvania State University.

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