DEPARTMENT OF

Physics & Astronomy

WINTER 2021–22

MSU College of **Natural Science** | *Newsletter for Alumni and Friends*

Teaching in the new STEM Teaching and Learning Facility

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In MSU's new STEM Teaching and Learning Facility, introductory physics courses are being taught using some new approaches that take full advantage of the capabilities of the state-of-the-art classrooms.

INSIDE

From the Department Chair...

When I sat down to write this message, I looked back at the previous newsletter from late 2019. There were ways it was like reading something from the distant past. At the same time, when reflecting on the primary aims of the department, our goals built on the land-grant mission of the university are very much the same—making significant discoveries in physics and astronomy and excelling at teaching and mentoring our students. This newsletter describes department members doing many of these things.

Fall semester 2021 found us doing most of our teaching in person, with some online options for the main introductory courses. It has been great to be back in the classroom after being online since March 2020. Everyone—faculty, staff and students—have done an amazing job dealing first with the rapid switch to online in spring 2020, and then preparing and delivering a whole academic year online in 2020-21. Across the board, the response was remarkable, including developing complete electronics and optics labs sent to students at their homes, and instructors going above and beyond to reach and engage their students in the online environment.

> "It has been great to be back in the classroom after being online since March 2020."

This return to campus includes two major milestones. One is the fall 2021 opening of the STEM Teaching and Learning Facility. This building is the re-imagining of the old Shaw Lane Power Plant into a modern teaching facility. We are utilizing this impressive building to teach new versions of the two main strands of introductory physics courses we offer (see story on page 6). The second is the more than 100 incoming freshmen who declared their intention to major in physics and/or astronomy—a new record.

The research mission of the department, "to lead in scientific discovery," has remained the same, even as the pandemic affected how this is accomplished. Examples of this can be found throughout the department. In addition, research expenditures have increased approximately 25 percent over three years—a remarkable number on top of a high level of federal research support. This research success can also be seen in the awards received by students and faculty. The key role of endowed chairs and fellowships is also notable in these accomplishments. Being around the department, it is clear there will be a whole new set of discoveries and awards to brag about in the next newsletter.

In 2019, the department strategic planning process laid out several key diversity, equity and inclusion (DEI) goals. Making the department a more diverse, equitable and inclusive place is an ongoing process, but we have made measurable progress on these goals. Some of the efforts are on the administrative side, and others are local activities including the PAREDS project (see story on page 12) and the "Journey of Scientists" podcasts done by the Women and Minorities in Science student organization.

I'd like to close by noting that in our department, we study the physics of the world around us. However, this study is done by people. MSU physics and astronomy excels because we have great people—students, staff and faculty. The pandemic has only made this clearer.

Stephen Zepf, Chairperson
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ALUMNI CLASS NOTES

Fred Krauss, M.S., physics, '66, worked on MSU's first atom smasher while earning his master's degree. After spending 16 years in the nuclear industry, he took a *temporary* job as a professor at a community college—which lasted 18 years.

Richard Hill, physics, '68; M.B.A., marketing, '75, was the first adoptee to discover his birth family through genetic genealogy DNA testing. He was recently interviewed by Brianne Kirkpatrick of Watershed DNA about his book, *Finding Family: My Search for Roots and the Secrets in My DNA*. The interview was a wide-ranging discussion about adoptees, birth parents and DNA testing. Learn more by visiting: https://www.watersheddna.com/blog-and-news/interview-with-richard-hill

Michael Bozack, astrophysics, '75; M.S., physics, '77, a professor in the Department of Physics at Auburn University, has recently published a second book on college advice and dealing with getting kids ready for the rigors of a large university. Visit www.itsmikebozack.com to learn more.

Daniel Inman, M.A.T., physics, '75; Ph.D., mechanical engineering, '80, just published the 5th Edition of his popular undergraduate text, *Engineering Vibrations.* He also presented keynote addresses via Zoom in 2021 at the 15th Global Congress on Manufacturing and Management (June); the 3rd International Conference on Vibration and Energy Harvesting (July); and the Online Symposium on Aeroelasticity, Fluid-Structure Interaction, and Vibrations (October).

J. Erik Hendrickson, M.S., physics, '90; Ph.D., physics, '94, was named interim chair of the Computer Science Department at the University of Wisconsin — Eau Claire (UWEC) for the 2020-2021 academic year. This fall, he returns to the Physics & Astronomy Department to fulfill a four-year term as chair. He is in his 28th year of teaching at UWEC.

Matthew Craig, physics, '94, recently accepted a position at BAE Systems in New Hampshire as a technology development manager in RF signal exploitation. He is looking forward to his third year playing lacrosse in an "Over 40" league.

Michael Davis, M.S., astronomy and astrophysics, '99; Ph.D., astronomy and astrophysics, '02, was recently named a senior member of SPIE, the international photonics society. This award was given in recognition of Davis's work with ultraviolet spectroscopy and spaceflight astronomical instrumentation.

Matthew Goupell, M.S., physics, '03; Ph.D., physics, '05, was promoted to a full professor of hearing and speech sciences at the University of Maryland-College Park.

Jay Paquette, physics, '09, was recently hired as Radioactive Materials Unit supervisor for the State of Michigan's Department of Environment, Great Lakes, and Energy.

Contact Us

The Department of Physics and Astronomy newsletter is published annually by the College of Natural Science for alumni and friends.

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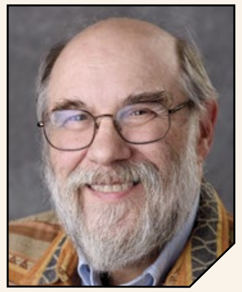
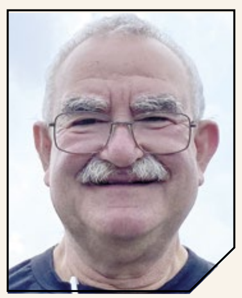
CONNECT WITH NATSCI

Retirements


Linnemann

James Linnemann, Professor Emeritus, retired Dec. 31, 2020. He introduced thousands of Spartans to physics, electronics and statistics and led online data selection efforts in the 1995 discovery of the top quark at the Fermilab D0 experiment. Linnemann founded MSU's Particle Astrophysics group, now with five active faculty. His recent research at the High-Altitude Water Cherenkov (HAWC) observatory in Mexico studies newly discovered TeV gamma ray–emitting objects. Linnemann received his Ph.D. from Cornell University and was elected fellow of the American Physical Society in 2009.


Tomanek

David Tomanek, Professor Emeritus, retired December 31, 2020. He received a Dr.rer.nat. in physics from the Freie Universität Berlin and joined MSU in 1987 as pioneer of computational nanoscience and nanotechnology. His studies focused on structural, electronic, transport and optical properties of low-dimensional systems—in particular, carbon nanotubes. Tomanek was elected fellow of the APS in 2004, received the prestigious Alexander-von-Humboldt Senior Scientist Award in 2005 and the Japan Carbon Award for Life-Time Achievement in 2008. His research on water desalination continues.


Westfall

Gary Westfall, University Distinguished Professor Emeritus, retired May 15, 2021, after 40 years at MSU. Westfall's recent experiments at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory used the Solenoidal Tracker to create a quark-gluon liquid with nearly zero viscosity—a form the universe is thought to have taken a few microseconds after the big bang. At MSU's National Superconducting Cyclotron Laboratory (NSCL), Westfall constructed and operated the 4π Array. He co-authored the textbook *University Physics* and received his Ph.D. in nuclear physics from the University of Texas, Austin.

New Faculty


Henderson

Rachel Henderson, assistant professor, joined MSU on August 16, 2020, as part of the Physics Education Research Lab. Her research aims to develop fair and effective educational practices to increase the representation of women and other historically marginalized groups within the field of physics. She received her Ph.D. in physics from West Virginia University in 2018, and then moved to MSU as a postdoctoral researcher developing assessment tools for understanding student learning within newly transformed physics laboratories. Henderson is currently a member-at-large of the American Physical Society (APS) Topical Group on Physics Education Research.


Rodriguez

Joseph (Joey) Rodriguez, assistant professor, joined MSU on January 1, 2021. His research focuses on understanding how planets form and evolve. Utilizing observations from NASA's Transiting Exoplanet Survey Satellite mission, along with ground-based photometry and spectroscopy, his group is working to discover and characterize new exoplanetary systems. Prior to MSU, Rodriguez was a Future Faculty Leaders Postdoctoral Fellow at Harvard University and a staff astronomer at the Smithsonian Astrophysical Observatory. He received a Ph.D. in 2016 from Vanderbilt University.


Whitehorn

Nathan Whitehorn, assistant professor, joined MSU as an Experimental High Energy Physics researcher on August 16, 2020. Since 2017, Whitehorn's group has taken Cosmic Microwave Background measurements with the 3rd-generation South Pole Telescope, providing insight into the early universe, and is now working on the successor CMB-S4 project. Whitehorn also utilizes the IceCube Neutrino Observatory, the world's largest, in his efforts to detect and discover the first neutrino sources. He received a Ph.D. in physics from the University of Wisconsin–Madison in 2012.

Faculty Honors

Tyler Cocker received the 2021 Young Scientist Award from the Infrared, Millimeter and Terahertz Wave Society for exploring ultrafast physics in single molecules and nanomaterials using techniques that combine femtosecond THz technology with scanning probe microscopy—techniques enabled by the terahertz scanning tunneling microscope to explore ultrafast dynamics. Cocker and his lab use these techniques to reveal how new materials respond to light on the smallest length scales and inform the design of future nanotechnology and molecular electronics.

Ruby Ghosh, founder, CEO and Chief Science Officer of Opti O2, LLC, a start-up company focused on commercializing an optical dissolved oxygen sensor probe system, of which she is lead inventor, received the 2021 Business Woman of the Year Award from *CEO Today.* The system will provide safety from water contaminants to people globally.

Paul Gueye received the 2022 Edward A. Bouchet Award from the American Physical Society (APS) in recognition of his critical contributions to understanding the structure of nuclear particles, and decades of service to physics outreach, diversity and inclusion.

The international IceCube Collaboration, which includes **Claudio Kopper** and **Nathan Whitehorn,** was awarded the 2021 Bruno Rossi Prize by the High Energy Astrophysics Division of the American Astronomical Society for the discovery of a high-energy neutrino flux of astrophysical origin.

Filomena Nunez received APS's Division of Nuclear Physics' (DNP's) Distinguished Service Award for her exceptional contributions toward making the division safe from harassment and the creation of the DNP Allies program, which works to reduce harassment at meetings and to address such problems quickly when they occur.

Artemis Spyrou was elected a 2021 APS Fellow, in part for her work furthering the design of laboratory experiments that can recreate (or even approximate) nuclear reactions occurring in the cosmos.

The following PA faculty received **2021 NatSci Awards** from the college in recognition of excellence in particular areas: **Johannes Pollanen,** NatSci Teacher–Scholar Award; **William Hartman,** Ronald W. Wilson Endowed Teaching Award; **Morten Hjorth-Jenson,** Norman L. and Olga K. Fritz Excellence in Teaching Award; **Huey-Wen Lin** and **Jay Strader,** Early Career Research Awards; and **Mark Dykman,** Research Leadership Award.

Key Grants

Kendall Mahn received a five-year, $1.975 million Department of Energy (DOE) grant to create a high-energy physics instrumentation traineeship in Michigan—the TRAIN-MI Program. Students will take dedicated instrumentation courses combined with a laboratory experience to gain a rigorous, broad and deep understanding of instrumentation.

Morten Hjorth-Jensen and **Huey Wen Lin** were awarded a $750,000, DOE Office of Science (SC) grant, which will enable them to improve the efficiency and scalability of quantum simulation algorithms, providing new insights on their applicability for future studies of nuclei and nuclear matter.

Artemis Spyrou is the lead investigator on a four-year, $5.5 million grant from the National Science Foundation's Division of Physics awarded to the National Superconducting Cyclotron's nuclear astrophysics group to continue its research to address questions about the origin of the elements.

The **Facility for Rare Isotope Beams,** or **FRIB,** has received a four-year, $13 million grant from the DOE SC to help broaden its impact by strengthening its isotope harvesting capabilities through a new lab, the Isotope Harvesting Vault. The vault will help FRIB further develop its isotope harvesting capabilities of extraneous isotopes for use in research outside its regular operations.

Research Feature

Teaching in the new STEM Teaching and Learning Facility

The newest and perhaps flashiest building on campus is the STEM Teaching and Learning Facility. Located at the center of campus, adjacent to Spartan Stadium, this building is the result of an enormous renovation and repurposing of the old Shaw Power Plant into a modern teaching facility. It is the first major building dedicated to teaching to be built on campus in more than 50 years.

Larger classrooms for physics instruction have transformed these courses. An abundance of projectors, moveable screens and mobile work surfaces allows a classroom to easily shift from optimizing collective instruction to facilitating small-group work.

In this new facility, introductory physics courses are being taught using some new approaches that take full advantage of the capabilities of the state-of-the-art classrooms.

In many ways, introductory physics courses have remained the same for decades. Books have new editions, and there are new versions of problems for homework and tests; but to a large extent, the courses would be very familiar to those of you reading this newsletter who might have taken them years ago. At the same time, there have been new understandings of how students might best learn. Moreover, as physics is applied to new areas, the concepts and applications that are most important to these new fields evolves. This is particularly true for life sciences, where a physical understanding of the mechanisms involved has grown in importance.

In response to these trends, physics and astronomy faculty began several years ago to develop new versions of both strands of the major introductory physics course sequences.

> **“[The STEM building] is the first major building dedicated to teaching to be built on campus in more than 50 years.”**
>
> TRANSFORM

For the introductory sequence aimed at engineers and physical scientists, faculty developed a version of the courses known as Projects and Practices in Physics (P-Cubed) and E&M Projects and Practices in Physics (EMP-Cubed). Created by faculty member Danny Caballero with Paul Irving, Richard Hallstein and Daryl McPadden, this course is grounded in a problem-based format where students work in groups to develop solutions to complex problems using fundamental principles. Based on a communities of practice framework, it uses a flipped classroom format, so that active engagement in course content and practice takes place in each class meeting. During a pilot phase, these courses showed significant gains in standard measures relative to large traditional courses. Five sections are now offered each semester in the 2021-22 academic year.

For the introductory physics sequence that serves life science majors, faculty member Lisa Lapidus started re-envisioning the course curriculum by asking the questions: “What physics concepts are most relevant to life science students,” and “Which biology applications are mathematically accessible?”

Most macroscopic biology requires mathematics that is beyond the basic calculus required for these students, but molecular biology does not, as long as computation is included. Therefore, the curriculum, known as P@MCL (Physics at the Molecular and Cellular Level), integrates molecular and cellular biology applications throughout the course. In keeping with the effort to incorporate active learning into all introductory classes, P@MCL is taught studio style, with students using lab activities to develop the concepts they practice later with written and computational problems. Many of the labs are similar to traditional physics setups with the addition of using microscopes to measure the diffusive motion of microspheres and spectrometers to measure absorption and fluorescence of molecules.

Giving Profile

An energizing climate at MSU

When Gerard (Gary) Crawley came to MSU in 1968—for the second time—he noticed that the human environment hadn’t changed. He found the same great spirit of camaraderie and support that he experienced when he first came to MSU for a postdoc position in the Cyclotron—now known as the National Superconducting Cyclotron Lab (NSCL)—after completing his Ph.D. at Princeton University.

Gary and Margaret Crawley

“I had met Henry Blosser, who was then the director of MSU’s Cyclotron lab, at the home of one of my Princeton professors,” Crawley recalled. “Henry spoke about the brand new and very high-quality Cyclotron at Michigan State and convinced me that this would be a good place to do a postdoc.

“I worked with many of the faculty on a variety of nuclear physics projects during that time,” said Crawley, who first came to MSU with his wife, Margaret, and their three children in 1965. “Ideas were floated around continually, and I think we all felt that even though we were a new laboratory with a new Cyclotron we were becoming one of the leading nuclear labs in the U.S.”

> LEADER
>
> **“Climate change is a significant threat for the future, and MSU has the capability to address it . . .”**

After his postdoc, he held a two-year position as a Queen Elizabeth II Fellow at the Australian National University in Canberra. Compared to MSU, he found the Canberra lab to be much more formal and far less collaborative.

“So when I was offered a position back at MSU, it was a fairly easy choice,” said Crawley, who returned to MSU in 1968 as an assistant professor in the physics and astronomy department.

His time at MSU spanned a 30-year career, which included chair of the Department of Physics and Astronomy (1988 to 1994) and dean of the Graduate School (1994-1998).

After leaving MSU in 1998, Crawley held the position of dean of the College of Science and Mathematics at the University of South Carolina and then spent three years overseas at the Science Foundation Ireland (SFI) as head of the Frontiers Directorate.

After his retirement from SFI in 2007, Crawley still had a lot of energy of his own to expend. Working with World Scientific Press (WSP), he edited *The Handbook of Energy*, and a series titled “Critical Energy Issues.” He has also contracted with WSP to produce a three-book set about the climate crisis.

“Climate change is a significant threat for the future, and MSU has the capability to address it in many ways, including the reduction of fossil fuel use by helping to develop improved and safer use of nuclear energy,” said Crawley who, along with his wife, recently established the Gerard and Margaret Crawley Family Fund, which gives an MSU graduate student in nuclear physics the opportunity to spend time at an institution—in the United States or abroad—specializing in the development of nuclear energy, in order to evaluate a possible career path in that field.

“We hope that some of the talented nuclear physics graduate students at the NSCL will work toward solving the issues of cost, safety and storage connected to nuclear energy,” he said.

Student Honors

Spencer Ammerman, a Ph.D. student in the Tyler Cocker group, won the prestigious Best Student Presentation Award at the 2020 Conference on Infrared, Millimeter and Terahertz Waves. The original paper and presentation explored atomically precise graphene nanoribbons using terahertz scanning tunneling microscopy.

Kristen Dage, a Ph.D. student advised by Steve Zepf, was awarded the McGill Space Institute Postdoctoral Fellowship, which supports two to three years of interdisciplinary research at McGill University in Montreal, Canada. Dage will investigate ultra-luminous X-ray sources found in globular clusters.

Gabriel Given and **Caleb Richard Hicks,** FRIB graduate assistants, were selected for the U.S. DOE's Office of Science Graduate Student Research Program, which provides training and access to DOE national laboratory facilities. They will conduct their research at the Los Alamos National Lab.

Vedran Jelic, a postdoc in the Tyler Cocker lab, won Best Poster Prize at the Faster, Smaller, Stronger, Brighter: Advances in Scanning Probe Techniques conference in November for his presentation, "Lightwave-driven scanning tunneling spectroscopy of graphene nanoribbons."

Justin Lane, a Ph.D. student advised by Johannes Pollanen, received the 2021 Mossman Postdoctoral Fellowship from Yale University's Physics Department. The award will support three years of Lane's continued research into quantum information science and condensed matter physics.

Luke Pickering, postdoctoral researcher, was awarded a 2021 University Research Fellowship by the Royal Society of the United Kingdom. Pickering will perform world-leading neutrino oscillation measurements with the T2K experiment and the DOE's upcoming DUNE experiment at the Royal Holloway University of London.

Abigail Stevens, NSF postdoc fellow in the Jay Strader lab, is co-investigator on two successful proposals for the James Webb Space Telescope. The proposals focus on time variability of light from black holes and white dwarfs—dead stars with extreme physics.

Nanoscale tunneling microscopy goes contact-free

A new microscopy technique lets researchers characterize materials with incredible precision while keeping its distance—at least from a nanoscopic perspective.

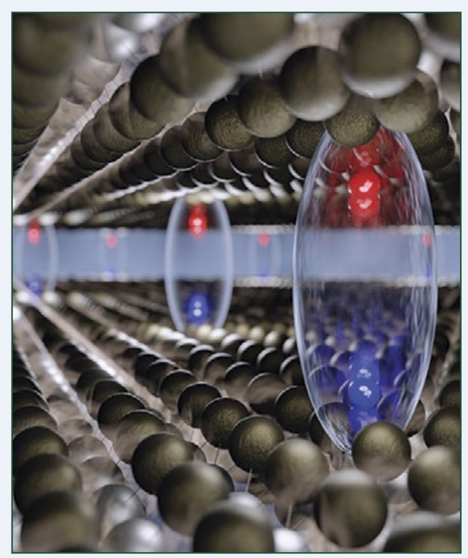
Michigan State University scientists joined an international research team to invent a form of nanoscopy, akin to microscopy, that enables researchers to better characterize and implement materials being developed for emerging technologies like quantum computers and next-generation solar cells.

"We are diversifying the technology so we can look at all the interesting materials we want to," said Tyler Cocker, Jerry Cowen Endowed Chair of Experimental Physics. Using a concept similar to contactless payment, Cocker and his colleagues developed a nano-antenna that uses a weak alternating electric field to scan materials without making contact.

"To achieve high resolution in both space and time, and to capture a new type of snapshot, our team bridged two existing sets of nanoscopy techniques: one that uses light and another that uses electrons," Cocker said. The new method achieves a time resolution as short as a quadrillionth of a second.

Although the new instrument lives in Germany, Cocker said it dovetails nicely with his team's work at MSU's Ultrafast Terahertz Nanoscopy Laboratory exploring new materials for quantum computers as part of a five-institution collaboration supported by a $7.5 million grant from the U.S. Office of Naval Research.

"We think we can apply complementary techniques to the materials studied in this paper, or go in a different direction, such as atomically precise nanostructures grown bottom-up from molecular precursors," Cocker said. "Developing these techniques gives us avenues to explore potentially useful materials."



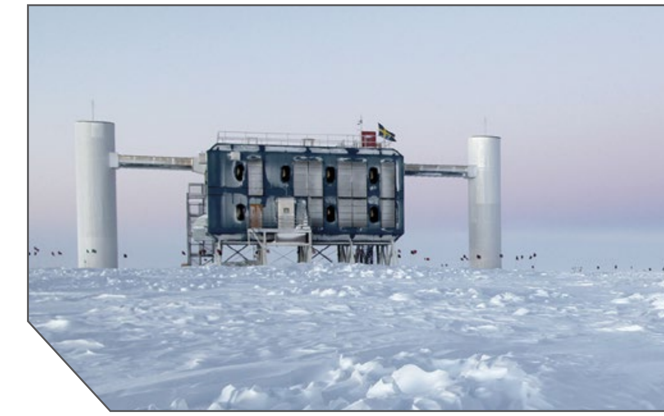
A pulse of terahertz (THz) light probes the ultrafast separation of charges (blue and red circles) and their subsequent evolution. The nano-antenna (top silver object) enables nanoscale THz spatial resolution, and hence sample characterization on the key length scales.

New IceCube detection proves 60-year-old theory

In December 2016, the IceCube Neutrino Observatory—its massive telescope boasting a cubic kilometer of coverage buried in Antarctic ice—detected and recorded the first-ever Glashow resonance event, a phenomenon predicted 60 years ago by Nobel laureate physicist Sheldon Glashow. This detection provides the latest confirmation of the Standard Model, the particle physics theory that explains the universe's fundamental forces and particles.

The event followed from an electron antineutrino that was hurtling through space at nearly the speed of light. While this particle would normally pass through Earth as if it were not even there, it struck an electron deep inside the South Pole's glacial ice, creating a new particle, the W– boson, which quickly decayed, creating a shower of secondary particles.

Nicknamed *Hydrangea*, the resonance event further demonstrates IceCube's ability to do fundamental physics. Glashow resonance events are extremely rare and technologically challenging to detect, requiring an electron antineutrino with a cosmic amount of energy — at least 6.3 peta-electronvolts. Additionally, the neutrino then has to interact with matter, which is not guaranteed. IceCube, however, embodies significant matter in Antarctic ice—and its more than 5,000 detectors take in a tremendous amount of light over a billion metric tons of extremely clear ice.



IceCube Observatory

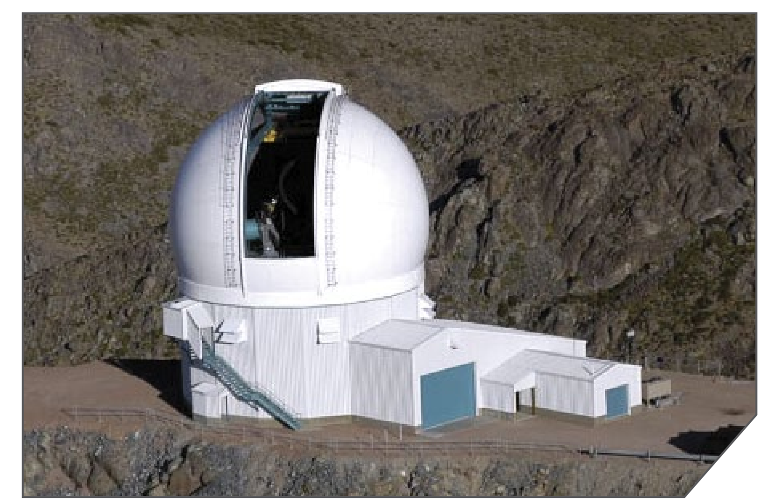
Claudio Kopper and **Nathan Whitehorn** lead IceCube's Diffuse and Atmospheric Flux Working Group behind the discovery.

"Finding it wasn't necessarily a surprise, but that doesn't mean I wasn't very happy to see it," Kopper said.

"This is some of the most impressive technical work I've ever seen," Whitehorn added.

SOAR agreement renewed for five additional years

MSU renewed the operating grant agreement for the Southern Astrophysical Research (SOAR) telescope for five additional years in 2020, along with all of the original partners—University of North Carolina at Chapel Hill, NSF's NOIRLab and Ministério da Ciência, Tecnologia e Inovação (MCTI) da República Federativa do Brasil. The agreement, which extended for 20-plus years, ended in 2020. The renewal allows MSU to retain its original share of observing time on SOAR and was supported by the College of Natural Science, the Department of Physics and Astronomy, the Office of Research and Innovation and the Office of the Provost.



Southern Astrophysical Research (SOAR) telescope

Astronomers at MSU have now published more than 100 peer-reviewed papers using data from SOAR. Recent exciting discoveries from telescope data include insight into the formation of heavy elements, such as gold in the first neutron star, and the neutron star merger detected in gravitational waves in 2017.

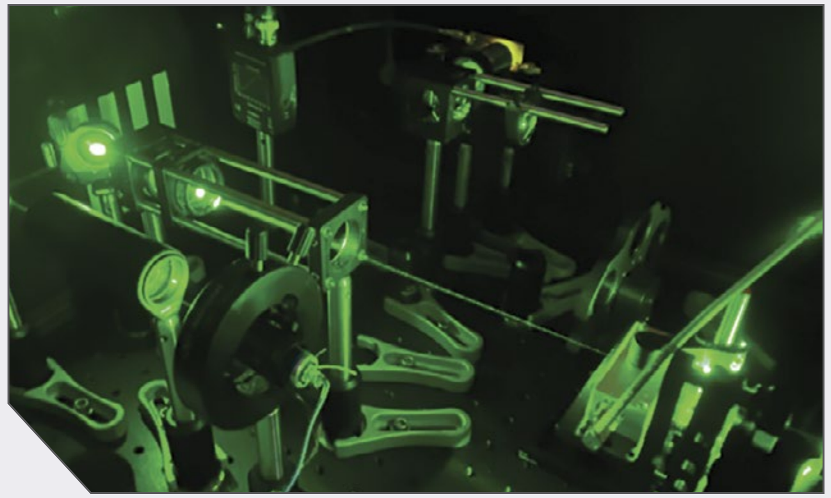
The mountain where SOAR sits is also the site of the next generation Rubin Observatory which, beginning in 2023, will survey the whole sky observable from Chile every few days, essentially making a film of the sky that will allow astronomers to observe exciting transient events, such as novae and supernovae. SOAR is well poised to obtain follow-up data on these newly detected events with Rubin, which will be a forefront telescope for research and training MSU astronomers for years to come.

Physics researchers advance, lead quantum science efforts

Michigan State University has been a leader in quantum science long before the field was the focus of multiple federal agencies and major corporations.

Twenty years ago, the 2002 Department of Physics and Astronomy newsletter announced the creation of an Institute for Quantum Sciences at MSU. The newsletter went on to say that the institute will "provide an environment for scientists and mathematicians to explore the fundamental physical characteristics of quantum systems, implement prototype quantum computers and develop quantum algorithms for novel applications. Quantum computing promises to revolutionize information processing, including rapid decryption, large database searches and other problems that would benefit from the massive parallelism inherent in quantum systems."

This prescient effort by now-senior faculty members has grown greatly in recent years with the hires of junior experimental physics faculty Johannes Pollanen, Tyler Cocker and our newest faculty member, Jonas Becker. They all work in what can broadly be called quantum physics. Notably, they are all or will soon be a Jerry Cowen Endowed Chair of Experimental Physics, highlighting the enormous importance of endowed positions for attracting top faculty. The department is extraordinarily grateful for the generosity of Randy Cowen and the Cowen family for endowing these chairs in recognition of their father, Jerry Cowen, who was a professor in the department.



A laser-based experiment system in the MSU Laboratory for Hybrid Quantum Systems headed by Johannes Pollanen. Cutting-edge systems such as these are routinely used by Polllanen, Becker and Cocker to push the frontiers of quantum science and technology development.

> **"All these collaborations and initiatives are invaluable for providing resources to enable cutting-edge quantum science research."**

QUANTUM

The growth of quantum science can also be seen campus-wide in the founding of the Center for Quantum Computing, Science, and Engineering, better known as MSU-Q. As announced in our last newsletter, this major interdisciplinary initiative brings together the deep and wide-ranging quantum science expertise on campus to raise the level of MSU's overall success in this area. MSU-Q in many ways follows the path laid out by the Institute for Quantum Sciences two decades ago. It is led by John A. Hannah Distinguished Professor of Chemistry Angela K. Wilson. Johannes Pollanen is an MSU-Q associate director.

These joint efforts have also helped grow multi-university initiatives. MSU physics faculty are some of the founding members of the Midwest Quantum Collaboratory (MQC), which had its kickoff meeting in early November, and is focused on strengthening collaborations in quantum science and leveraging these to obtain joint funding to accelerate quantum research among its three major universities—MSU, Purdue University and the University of Michigan. MSU is also a major partner in QuSTEAM, which aims to develop undergraduate curricula that will provide a national educational model for the emerging field of quantum information science and technology. QuSTEAM recently received a $5 million grant from the NSF to carry out its mission.

All these collaborations and initiatives are invaluable for providing resources to enable cutting-edge quantum science research. The discoveries themselves are made by students, postdocs and faculty members working in these areas. It is a joy to see all the activity, effort and contributions being made to the very lively and fast-moving areas around quantum phenomena and the complex interactions between the macroscopic and quantum worlds.

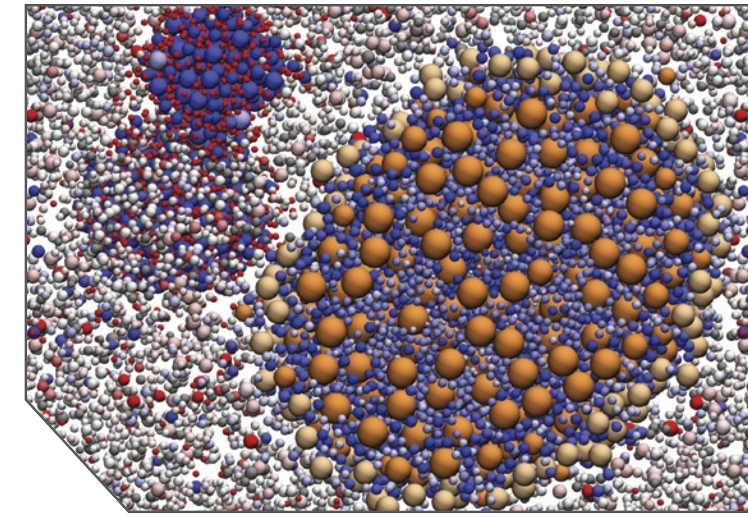
Complex biological phenomenon may have a simple explanation

Even at the microscopic and molecular level, straightforward science can still account for important biological behavior. **Michael Feig** and **Lisa Lapidus's** research published in *eLife* has shown that relatively simple characteristics help RNA and proteins organize themselves because, they believe, when biomolecules congregate, or condense, it can help speed up or enhance a range of cellular functions by bringing functionally related biomolecules closer together.

Although more research is required to uncover the exact workings of condensates, Feig and Lapidus have shown that the relatively basic traits of the biomolecules involved can spur phase separation. Specifically, when RNA and proteins are large enough and have sufficiently strong and opposite electric charges, they can form a condensed phase that is biologically distinct from a more diffuse phase of biomolecules. These remarkably simple drivers suggest that the phenomenon could be widespread in biology.

A significant consequence of such condensates is that it may bring functionally related biomolecules closer together.

"Having them condensed could speed up the process because you don't have to wait for a molecule to show up from far away," Lapidus said.



A simulation of biological macromolecules in a highly simplified model of a bacterial cytoplasm suggests a propensity to form different kinds of condensates based on charge complementarity inside biological cells.

Phase separation is a key mechanism for forming membrane-less organelles, which are responsible for a number of functions in cells, including metabolism and DNA replication—the processes that help cells live. Feig's team revealed the mechanisms with computer simulations, while Lapidus's group tested these findings with experiments.

Feig and Lapidus were initially surprised that the experiment worked without requiring additional special circumstances, such as specific binding interactions. Although the results on phase separation surprised the researchers, their rigorous computational and experimental testing upheld the findings.

"In the end, we could confirm the idea via experiments and convince ourselves that what we saw in the simulations was real," Feig said.

DOE designates FRIB as DOE Office of Science user facility

The U.S. Department of Energy (DOE) designated the Facility for Rare Isotope Beams, or FRIB, as a U.S. DOE Office of Science (SC) user facility at a special ceremony at MSU in September 2021.

The DOE maintains and operates 28 SC user facilities across the country as shared resources for the scientific community. These user facilities are considered a unique resource for the nation's researchers and have become increasingly vital tools of scientific discovery, providing researchers with the most advanced tools of modern science. They've also become an important component of national economic competitiveness.

"[Being designated a DOE SC user facility] means the facility is open for researchers . . . around the nation and world," noted Paul Dabbar, DOE Under Secretary for Science. He further noted FRIB's critical role in strengthening the innovation presence of the United States globally and its ability to drive the next generation of scientific leaders.

"Physics is at the core of DOE, and MSU has the top-rated nuclear physics program," Dabbar said. "I think America and the world have a very interesting set of initiatives coming up . . . and FRIB is absolutely a portion of that driving innovation."

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Physics and Astronomy Research Experiences encourages Drew Scholars to reach for the stars

The summer of 2021 marked the inaugural class of Physics and Astronomy Research Experiences for Drew Scholars, or PAREDS, a partnership between NatSci's Charles Drew Science Scholars and the Department of Physics and Astronomy.

PAREDS offers an eight-week, paid summer research experiences to all physics and astrophysics majors in the Drew program, a residential program that supports student success, particularly those from backgrounds traditionally under-represented in STEM. Research opportunities during PAREDS span fields from neutrino oscillations to nuclear reactions to black holes.

"We see PAREDS as a model for partnerships between the Drew program and other NatSci departments to provide Drew students opportunities for experience, mentoring and research training in a range of scientific disciplinary fields," said Jerry Caldwell, director of the Drew program.

The summer of 2021 marked the inaugural class (pictured above) of PAREDS, a partnership between the Charles Drew Science Scholars Program and the Department of Physics and Astronomy.

The five students in the 2021 cohort received intensive mentoring from faculty and professional development from the PAREDS team that includes Teresa Panurach, a fourth-year NSF graduate research fellow; Laura Chomiuk, associate professor; and Paul Gueye, associate professor at the NSCL.

At the end of the program, students presented their research at a symposium, and several students opted to continue their research projects into the current academic year. Students with a PAREDS experience under their belt are encouraged to use it as a springboard for competitive research experiences at national observatories and labs.

"Students of diverse backgrounds are often weeded out of physics and astronomy programs because of a lack of a supportive environment," said Panurach, who says the program will continue next year. "With the creation of PAREDS, we hope to create a sense of community, inclusivity and collaboration amongst the students to help them succeed academically and reach their career goals."

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