



Physics & Astronomy

MSU College of Natural Science | Newsletter for Alumni and Friends

This year has been a tremendously successful one in the Department of Physics and Astronomy (PA), with some changes and several remarkable advances.

First, on Aug. 16th, Professor Steve Zepf became interim chair of the department and I became dean of the College of Natural Science (NatSci). I am excited about this new role and, looking back, the past five years as PA chair have been inspiring and rewarding. The department is first-class, and I plan to continue supporting PA excellence from the dean's office. Steve is a PA administration veteran and has been instrumental in building our astronomy and astrophysics program into a national powerhouse. The department is in good hands!

Several remarkable faculty hires were made this year—Darren Grant, Claudio Kopper and Tyler Cocker (see page 5), along with Wolfgang Kerzendorf, an international expert in the analysis of big data, who will join the department in fall 2019 after spending a year at the Flatiron Institute in New York—a major data center for the analysis of big data in a variety of different contexts.

Grant and Kopper will arrive on October 10, rounding out a program that began five years ago and allows MSU to take a national leadership position in the IceCube Neutrino Observatory at the South Pole. This effort began with Professor Jim Linnemann alerting us to an emerging leader in IceCube—Tyce DeYoung—whom we hired in 2014. This year, DeYoung chaired a faculty search that attracted Grant and Kopper to MSU.



Former physics and astronomy department chair Phil Duxbury—now MSU College of Natural Science dean (left)—hands off the “department baton” to Steve Zepf, who began serving as interim chair on Aug. 16.

Taken together, these hires and the existing MSU expertise in astronomy and astrophysics establish MSU as a major center in these areas.

Cocker joined the department in January this year as an assistant professor, with a focus on ultrafast quantum dynamics at the ultimate time and length scales of condensed matter physics.

changing fields in physics. An MSU group in PA, including Professors Norman Birge, Mark Dykman and Johannes Pollanen, has well-established programs in QIS, with expertise in superconducting flux storage protocols, the analysis of noise and coherence effects in quantum systems, and unique qubit architectures—including the possibility of using individual electron spins on

the surface of superfluid helium as a unique and tunable QIS architecture. This group will run a workshop in this area at MSU Oct. 1-3, 2018. Read more on page 6.

As always, we are very appreciative of the endowments and gifts given to the department, which help keep the department vital and competitive. Thank you for your continued support.

“... ON AUG. 16, PROFESSOR STEVE ZEPF BECAME INTERIM CHAIR OF THE DEPARTMENT AND I BECAME DEAN OF THE COLLEGE OF NATURAL SCIENCE.”

An understanding of quantum dynamics is essential to the development of quantum information science (QIS).

QIS, which includes quantum computing, sensing and secure transmission protocols, has suddenly re-emerged as one of the most rapidly



Bruce Beckert, physics, '52, and his wife, Nancy—also an MSU alumna—are coming up on their 67th wedding anniversary. A licensed pilot since 1946, Beckert joined his father's business (a manufacturer of air pollution control equipment) in 1954, where he served as the company's president for most of the next 63 years, until the business closed in December 2017. In retirement, Beckert spends a great deal of his time restoring a light aircraft—a Vans RV-6—and authoring short stories.

David Balzarini, physics, '60, is Professor Emeritus of condensed matter physics at the University of British Columbia, Vancouver, Canada, where he has been a faculty member since 1968.

Dennis Flood, M.S., physics, '64; Ph.D., physics, '67, was chosen to receive the 2018 WCPEC-7 Award at the World Conference on Photovoltaic Energy Conversion in recognition of his outstanding contributions to photovoltaic technology and for his work in bringing the world photovoltaic community together.

Richard Hill, physics, '68, spoke on "Finding Family with DNA Testing" at the National Genealogical Society's Family History Conference in Grand Rapids, Mich., May 2-5.

Terry McDaniel, M.S., physics, '70; Ph.D., physics, '73, retired from university teaching and industrial R&D in data storage technology. McDaniel lives in Volcano, Calif., and Tucson, Ariz., and is an adjunct

professor of optical sciences at the University of Arizona. He continues to publish papers on magnetic recording technology.

Dale Force, physics, '74; M.S., physics, '76, was named a senior member of the Institute of Electrical and Electronics Engineers.

Jan M. Ludwinski, astrophysics, '80, has completed 33 years at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif., where, over the years, he has led planning efforts for the Galileo mission to Jupiter, the Mars Exploration Rovers, the Kepler survey of exoplanets and now for a mission to return to Europa to explore its habitability. He has also led individual mission proposal efforts and managed the Proposal Office in JPL's Innovation Foundry.

David Ball, physics, '81, is a test manager at the Arnold Engineering Development Complex in Tullahoma, Tenn.

John Gentry, M.S., physics, '87, is a clinical radiation oncology physics consultant at St. Elizabeth Boardman Cancer Center in Boardman, Ohio. Gentry recently received his third patent.

Christopher Hanley, astrophysics, '96; M.S. astrophysics and astronomy, '98; Ph.D., astrophysics and astronomy, '02, is a principal systems integration and test engineer at the Space Telescope Science Institute (STScI) in the Baltimore, Md., area. Hanley is also the technical lead for the James

Webb Space Telescope (JWST) STScI I&T team. In August 2017, he was a co-recipient of the George W. Goddard Award from SPIE, the international society for optics and photonics.

Joseph Kozminski, M.S., physics '01; Ph.D., physics, '05, was awarded the Homer L. Dodge Citation for Distinguished Service to the American Association of Physics Teachers in July 2017. He was also elected to the board of directors of the Advanced Lab Physics Association this past winter.

Jeris Stueland, physics, '02, is a senior director of strategy at CVS Health in Providence, R.I. Stueland and her husband, Toopan, had their third child, Hari Milo, on Jan. 3, 2017. Hari Milo has been welcomed by big sister Vashti (age 4) and big brother Rithik (age 2).

Matthew Nemeth, physics, '04, has worked in business for 14 years. His degree has helped him properly collect and process data, perform critical analytics using advanced mathematics and present findings in a concise manner. This has helped his business find market niches (data anomalies) and make inroads to new revenues.

Elias Garratt, physics, '06, received his Ph.D. in condensed matter physics in 2013 from Western Michigan University, Kalamazoo, Mich. He is now an assistant professor at Michigan State University in the Department of Chemical Engineering and Materials Science.

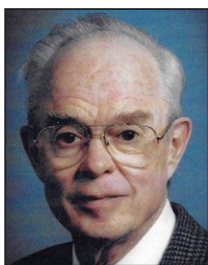


Brent Barker, M.S. physics '09; Ph.D. physics, '14, is enrolled in the M.A. Clinical Mental Health Counseling Program at Roosevelt University in Chicago.

Jeffrey Kost, physics, '10, started a position as a postdoctoral research fellow at the Institute for Basic Science in South Korea in September

2017, continuing his research in theoretical high energy physics and cosmology.

Alumni Honors



Parker

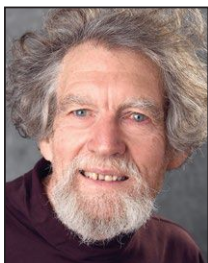
A NASA spacecraft making humanity's first mission to a star was named after astrophysicist and MSU alumnus **Eugene Parker** (B.S., physics, '48). The Parker Solar Probe launched in July. Parker is the father of solar wind theory, which triggered new explanations of phenomena involving fixed stars, the interstellar medium and the galaxy.



Woollam

John Woollam (M.S., physics, '63; Ph.D., solid state physics, '67) received a 2017 Outstanding Alumni Award from the College of Natural Science. Woollam is an internationally renowned expert in ellipsometry and a worldwide leader in the production of spectroscopic ellipsometry instrumentation. He is the George Holmes Distinguished Professor of Electrical Engineering at the University of Nebraska-Lincoln.

Retirement



Pumplin

Jon Pumplin, professor, retired from the department in spring 2018. Pumplin joined the MSU faculty in 1970. His primary area of research was theoretical high energy physics—more specifically, the determination of parton distribution functions using theoretical properties of subatomic particles and matching them with data from highly energetic particle collision experiments to refine the understanding of those properties. He received his Ph.D. in physics in 1968 from the University of Michigan in Ann Arbor.

Deaths



Harrison

Michael Harrison, professor emeritus, died April 7, 2018. He was 85 years old. Harrison received his Ph.D. from the University of Chicago and joined MSU in 1961 as a theoretical physicist. He retired in 2008. Harrison was the principal investigator for the 1968 Center of Excellence Grant, which laid the foundation for MSU's National Superconducting Cyclotron Laboratory.



Kaplan

Tom Kaplan, professor emeritus, died December 30, 2017. He was 91 years old. Kaplan received his Ph.D. in physics from the University of Pennsylvania and joined MSU in 1970 as a theoretical condensed matter physicist. He continued to publish and actively research until August 2017.



McManus

Hugh McManus, professor emeritus, died on March 30, 2018, at the age of 99. McManus received his Ph.D. from the University of Birmingham, England, and joined MSU in 1960 as a high-energy physicist. He retired in 1980.



Schroeder

Peter Schroeder, professor emeritus, died February 25, 2018. He was 89 years old. Schroeder received his Ph.D. from the University of Bristol in the U.K. and joined MSU in September 1961 as an experimental condensed matter physicist. He retired in 1997. Schroeder published several papers on the general field of conduction in metals, including work on a system used recently in extracting information from magnetic media.

Chris Adami and **Remco Zegers**, professors, were named 2017 American Physical Society Fellows for significant contributions to the field of physics—Adami for novel, methodological contributions to the study of evolution; and Zegers for his efforts to elucidate spin-isospin response of nuclei.

Danny Caballero, assistant professor, was presented with the 2018 MSU President's Distinguished Teaching Award for his teaching excellence and internationally recognized research program.

Laura Chomiuk, assistant professor, was named a 2017 Cotrell Scholar by the Research Corporation for Science Advancement. She also received a five-year 2018 National Science Foundation (NSF) Early CAREER Award, one of NSF's most prestigious honors for early career faculty.

Megan Donahue, professor, was elected president of the American Astronomical Society, the major organization of professional astronomers in North America.

Alexandra Gade, professor, received MSU's 2018 William J. Beal Outstanding Faculty Award. Gade is a leading experimental scientist in nuclear physics who investigates the structure of the atomic nucleus at the extremes of neutron-proton asymmetry.

William (Bill) Hartmann, professor, was awarded the 2017 Acoustical Society of America Gold Medal for his seminal contributions to research and education in psychological acoustics and service to the society.

Heiko Hergert, assistant professor, was selected for a 2017 U.S. Department of Energy (DOE) Early Career Award.

Huey Wen Lin, assistant professor, was awarded a five-year 2017 NSF

Early CAREER Award, one of NSF's most prestigious honors for early career faculty.

Kendall Mahn, assistant professor, was selected as an analysis coordinator for the international Tokai to Kamioka (T2K) Experiment, which studies the properties of the neutrino.

Johannes Pollanen, assistant professor, was invested as the Jerry Cowen Endowed Chair of Experimental Physics in September 2017. Randy Cowen established the chair in honor of his father's life and career as a professor at MSU.

Vashti Sawtelle, assistant professor, and **Danny Caballero**, assistant professor, received 2018 MSU Teacher-Scholar Awards, given to early-career assistant and associate professors who have earned the respect of students and colleagues for devotion and skill in teaching.

Reinhard Schwienhorst, associate professor, was recognized as the Large Hadron Collider's top physics working group convenor in 2018.

Brad Sherrill, University Distinguished Professor, was awarded the 2018 Tom W. Bonner Prize in Nuclear Physics from the American Physical Society for his scientific and community leadership in the discovery and exploration of exotic nuclei.

Jaideep Taggart Singh, assistant professor, was selected for a 2018 DOE Early Career Award to support his research in experimental atomic and nuclear physics.

Michael Thoennessen, University Distinguished Professor, was named editor in chief of the American Physical Society, effective September 2017.

David Tomanek received MSU's 2017 William J. Beal Outstanding

Faculty Award for his outstanding research into new materials and nanostructures for use in new technologies, and his excellence and innovation in teaching.

Chien-Ping (C.-P.) Yuan, professor, was invested as the inaugural Wu-Ki Tung Endowed Professor in Particle Physics. The chair was established by the Tung family to honor Wu-Ki Tung, an internationally known particle physicist at MSU from 1992-2007.

Four faculty members were awarded 2017 College of Natural Science Awards. They are: **Alexandra Gade**, Outstanding Faculty Award; **Michael Thoennessen**, Junior Faculty Mentoring Award; and **Tyce DeYoung** and **Lisa Lapidus**, Faculty Teaching Prizes. 🌟

Contact Us

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CONNECT WITH NATSCI

New Faculty

Two key faculty members will be joining the department this fall to assist in the leadership of the IceCube Neutrino Observatory:



Grant

Darren Grant, professor, will begin work as spokesperson of the IceCube Collaboration on Oct. 10. Grant, an expert in detector development for astroparticle physics, will lead research, development and production efforts at MSU for future upgrades of the IceCube Neutrino Observatory. Grant earned his Ph.D. in physics in 2004 at Carleton University in Ontario, Canada. Currently, he is associate professor and principal investigator of the IceCube Neutrino Observatory Group and the Dark Matter Search Group at the University of Alberta, Edmonton.



Kopper

Claudio Kopper will join the physics and astronomy department on Oct. 10 as an associate professor. Kopper will head the IceCube Neutrino Observatory's working group, measuring astrophysical neutrino flux and applications of high-performance computing and machine learning to IceCube data analysis. Kopper earned his Ph.D. in physics at FAU Erlangen in Germany and co-authored the paper on the IceCube discovery of the first evidence of high-energy astrophysical neutrinos. He is currently assistant professor at the University of Alberta, Edmonton.



Cocker

Tyler Cocker, assistant professor, joined the department in January 2018. With a focus on experimental condensed matter physics, Cocker's research uses lightwave-driven terahertz scanning tunneling microscopy, or THz-STM, capable of capturing ultrafast snapshots of single atoms to inform the design of future nanotechnology and molecular electronics. Before joining MSU, Cocker spent five years at the University of Regensburg in Germany as a postdoctoral researcher, an Alexander von Humboldt Fellow and a junior group leader. He also held a visiting researcher position at ARCNL in Amsterdam. Cocker received his Ph.D. in physics at the University of Alberta, Edmonton.

Student Honors

Jacob Calcutt, a physics and astronomy graduate student, received a 2018 Department of Energy (DOE) Science Graduate Student Research (SCGSR) Fellowship to work at the Fermi National Accelerator Laboratory in Batavia, Illinois, conducting experimental research in high energy physics.

Elizabeth Drueke, an MSU graduate with degrees in advanced mathematics and physics currently pursuing a graduate degree at the University of Michigan, and **Alison Peisker**, a doctoral student in physics, were selected for the prestigious National Science Foundation (NSF) Graduate Research Fellowship Program.

Steven Fromm, a physics undergraduate major, received a four-year DOE Computational Science Graduate Fellowship (2018-2022).

Philipp Grete, a research associate in physics and astronomy, was the sole recipient of the German Astronomical Society's 2017 Most

Outstanding Dissertation Award for his dissertation, "Large eddy simulations of compressible magnetohydrodynamic turbulence."

Clair Kopenhafer, a doctoral student in astrophysics and astronomy, received a 2017 DOE Computational Science Graduate Fellowship (CSGF) and is currently in a four-year collaboration (2017-2020) with Associate Professor Brian O'Shea.

Zachary Matheson, a doctoral student in physics, received a 2017 DOE SCGSR Award to study theoretical nuclear physics at the Livermore National Laboratory for six months with mentor Witold Nazarewicz, MSU Hannah Distinguished Professor and FRIB chief scientist.

Jessica Micallef, a physics and computational science doctoral student, received the 2017 Association for Computing Machinery Fellowship

and a four-year NSF Graduate Fellowship (2017-2020) working with her advisor, Tyce DeYoung, associate professor of physics.

Crispin Monteras-Martinez and **Roy Ready**, physics and astronomy graduate students, were selected for the DOE SCGSR Program, which supports up to one year of graduate research under a DOE laboratory scientist.

Abigail Stevens and **McKenzie Warren**, research associates in physics and astronomy, received 2018 National Science Foundation Postdoctoral Research Fellowships. Warren received funding for the project, "Moving supernovae beyond the standard model: A study of neutrino flavor mixing in core-collapse supernovae." Stevens received funding for the project, "Mapping matter in strong gravity: Spectral-timing of black holes and neutron stars."

Abrams Planetarium receives grant to fund meteorite display

MSU's Abrams Planetarium will use a grant of nearly \$100,000 to build an interactive display in its lobby that will focus on meteorites, those flying chunks of rock and space debris that not only find their way into the Earth's atmosphere but are able to make it all the way to the ground.

When completed, the exhibit will also include 3-D models of meteorites, as well as information on spacecraft that have cruised our solar system and scale models of the solar system.

The grant, totaling \$97,259, is from the Institute of Museum and Library Services.

The highlight of the exhibit will be dozens of meteorites, eight of which were found in Michigan.

"The display will feature meteorites found from around the world but will



Shannon Schmoll, director of MSU's Abrams Planetarium, is using a grant from the Institute of Museum and Library Services to build an interactive display in its lobby that will focus on meteorites.

put front and center the Michigan meteorites in our collection, a little piece of our state's own 'space heritage' so to speak," said Shannon Schmoll, Abrams Planetarium director.

The project is a joint venture between Abrams, the MSU Museum, the Department of Earth and Environmental Sciences and the MSU School of Journalism.

"The goal is to create an exhibit with multiple points of entry—from the authentic meteorites to touchable replicas, from the hands-on to the multimedia interactives, from the history of meteorites to the future of space exploration," Schmoll said. "To do this well and with best exhibit creation practices in mind, we will need custom-made cabinets, displays, signage and qualified staff to do all of this."

The plan is to have a soft launch in July 2019, timed to coincide with the 50th anniversary of the first moon landing, with a major launch planned for the fall of 2019.

Fall conference on Quantum Information Science

The Department of Physics and Astronomy at Michigan State University will be hosting a workshop this fall on Quantum Information Science (QIS) titled "MSU workshop on QIS: Are we at a crossroads?"

The workshop, which will be held October 1-3 at MSU's Kellogg Hotel and Conference Center, will bring together a diverse community of quantum science researchers from academia, industry and startups to discuss the most exciting challenges and opportunities presented by near-term quantum computing advances, including the potential for QIS applications in chemistry, materials science, computer science, engineering and mathematics.

"The burgeoning field of QIS is poised to revolutionize all of these fields," said Johannes Pollanen, Jerry Cowen Chair of Experimental Physics and conference co-coordinator. "Developing tools and theories to exploit quantum phenomena for information processing will lead to disruptive applications in precision sensing, complex simulation and computing. MSU is looking to expand its research position in this exciting quantum ecosystem."

In addition to Pollanen, the workshop is being organized



(L to R): Norman Birge, Johannes Pollanen and Mark Dykman.

by MSU physicists Phillip Duxbury, Norman Birge and Mark Dykman in collaboration with an interdisciplinary advisory committee representing chemistry, engineering and mathematics.

John Woollam: Giving back to help others build careers

About 50 years ago, MSU Professor Peter A. Schroeder had a profound impact on a particular graduate student. Now, that graduate student wants to pay it forward to students who are following in his footsteps.

John Woollam, a George Holmes Distinguished Professor of Electrical Engineering at the University of Nebraska – Lincoln, established the Peter A. Schroeder Physics Fellowship Fund in 2012. He said it's important to him to help students build their careers—through teaching, mentoring, advising—just as Schroeder did for him.

“Dr. Schroeder let us find our way, discover new things, feel the excitement. He never micromanaged; he simply gave guidance along the way,” Woollam said. “That management style followed me into my adult life. That is the basis for the principles of my teaching.”



John Woollam (inset above, and on his sailboat, *Whisper*) credits his enjoyment of life and successful career to his mentor, Peter Schroeder.

A native of Kalamazoo, Mich., Woollam received a B.A. in liberal arts from Kenyon College in Ohio prior to coming to MSU, where he received his M.S. in 1963 in physics and his Ph.D. in 1967 in solid state physics.

Woollam's first job was with the NASA Lewis Research Center in Ohio, where he worked for 13 years. While there, he took classes, one at a time, to earn his M.S. in electrical engineering from Case Western Reserve University in 1978. From there, he went directly to teach at Nebraska.

Woollam, who worked in Schroeder's lab from fall of 1961 to fall of 1967, credits him with his career success. He felt that the best way to honor that was to establish a fellowship fund in Schroeder's name. He hosted Schroeder and some of his graduate students at his lake property about five years ago and encouraged them to contribute to the fellowship fund.

“We wanted to honor Peter, to show our gratitude for his mentoring,”

Woollam said. Schroeder passed away in February 2018.

Woollam is now in his 40th year of teaching at Nebraska, where many of his colleagues are MSU graduates. He teaches optics and their applications in spectroscopy and measurements, which is the basis for the company he founded in 1987—the J.A. Woollam Co.—a university spin-off that has emerged as a worldwide leader in the production of spectroscopic ellipsometry instrumentation. The company manufactures ellipsometers for a wide range of applications and, with distributorships in more than a dozen countries, has sold more than 2,500 ellipsometers worldwide. Woollam is named on 57 patents and his company has secured more than 200 patents to date. Most of the engineers he's hired are his former students, or students of colleagues.

Again, he credits his successful business model to Schroeder.

“Peter mentored me and many other students. Now, we are mentoring others who, in turn, will go out and mentor future students,” Woollam said.

Woollam is the recipient of many honors, including the R.F. Bunshah Award from the International Conference on Metallurgical Coatings and Thin Films (2017) and the American Physical Society (APS) Prize for Industrial Applications of Physics (2013). He is a fellow of the National Academy of Inventors, the APS and the American Vacuum Society.

“MSU had a great effect on me personally, on my enjoyment of life, my career. It's pretty fabulous. I can't imagine better,” Woollam said. ♡



Blazing the trail in multimessenger ASTROPHYSICS

The IceCube Neutrino Observatory is the first detector of its kind, designed to observe the cosmos from deep within the South Pole ice. More than 5,000 photo sensors are embedded in the ice more than a mile below the surface to watch for faint flashes of lights produced when neutrinos react with atoms in the ice.

Michigan State University (MSU) is blazing the trail in multimessenger astrophysics—a new area of science that the National Science Foundation (NSF) is calling one of its ten “big ideas” for future investments in science and engineering.

“At MSU, we’re succeeding in opening a new window on the universe,” said Tyce DeYoung, associate professor of physics. “There have been tremendous discoveries in this area in the past few years, and it’s an exciting time to be involved with this type of science.”

DeYoung defines this type of astrophysics as using messengers other than light—such as electromagnetic radiation, gravitational waves, cosmic rays and, most recently, neutrinos—to learn about the universe.

MSU is one of the primary universities involved in the IceCube Neutrino Observatory at the Amundsen-Scott South Pole Station, an international collaboration of more than 300 scientists in 12 countries.



**“AT MSU, WE’RE SUCCEEDING IN OPENING
A NEW WINDOW ON THE UNIVERSE.”**

“Neutrino astronomy offers us a very different view of the universe that we can’t get from other types of telescopes,” DeYoung explained. “Neutrinos tell us what’s happening deep inside of the source, similar to a medical x-ray showing us what’s inside the human body. Better understanding the properties of these incredibly powerful astrophysical accelerators may give us insight into some of the physics that we don’t yet understand.”

“Five years ago, we discovered a flux of neutrinos coming from distant objects in the universe, but we hadn’t yet identified the individual sources,” he continued. “Since that time, we’ve been working on building partnerships with other types of telescopes—gamma ray telescopes, x-ray telescopes, radio telescopes, optical telescopes—to jointly observe potential sources.”

The big break came last fall for the IceCube collaboration.

“In September 2017, we observed a very high-energy neutrino,” DeYoung said. “Based on its energy it was likely to have come from some extragalactic source. We alerted the astronomical community to this for follow-up observations.”

Telescopes around the world detected the source in gamma rays as well. This collective data provided evidence for

the first individually identified source of high-energy neutrinos.

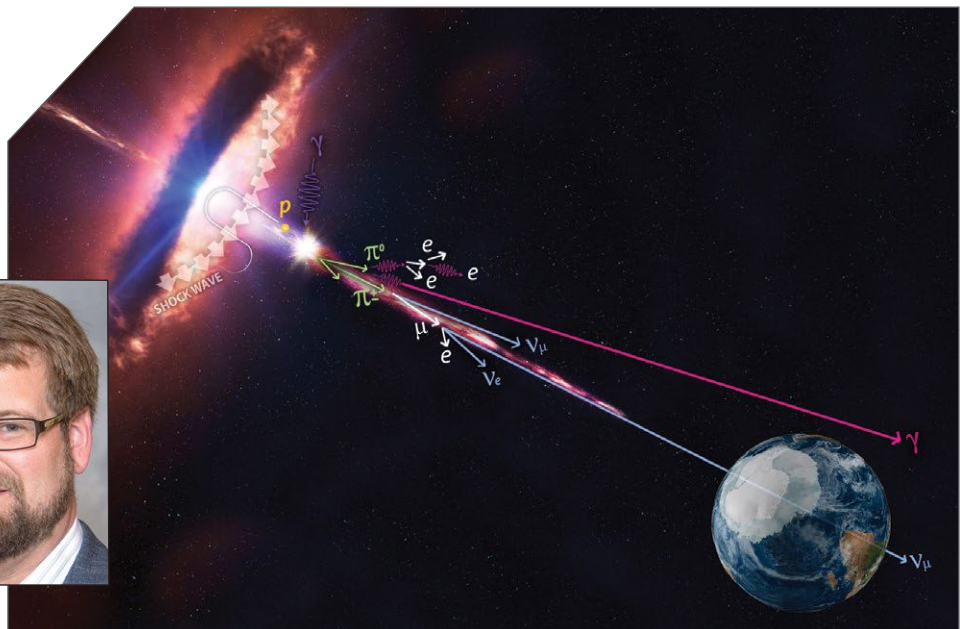
The scientific community had discovered a blazar named TXS 0506+056—a giant elliptical galaxy with a massive, rapidly spinning black hole at its core that emits a jet of ultrarelativistic particles aimed toward us. It is situated in the night sky just off the left shoulder of the constellation Orion and is about four billion light years from Earth.

“These intriguing results represent the remarkable culmination of thousands of human years of intensive activities by the IceCube collaboration to bring the dream of neutrino astronomy to reality,” said Darren Grant, an associate professor of physics at the University of Alberta and current spokesperson of the IceCube collaboration. He will join MSU’s physics and astronomy department as a professor this fall. Claudio Kopper, assistant professor of physics at the University of Alberta, and an expert in computational modeling and data analysis, will also join the MSU faculty as an associate professor this fall.

“With these new faculty, MSU will rank as one of the top institutions in IceCube, which is by far the world’s most successful neutrino telescope,” DeYoung said.

A long-term commitment from NSF and MSU is critical to advancing this area of research. MSU and its partners in the IceCube collaboration have submitted a \$22.7 million proposal to NSF for an IceCube upgrade, with \$1.9 million of those funds earmarked for activities at MSU.

“This upgrade will give us better angular resolution for neutrino astronomy and also enhance our



In the artistic rendering above, a blazar is accelerating protons that produce pions, which produce neutrinos and gamma rays. In July 2018, astronomers for the first time provided evidence for a known blazar as a source of high-energy neutrinos. Inset: Tyce DeYoung, associate professor of physics, is part of the MSU team that works with the IceCube Observatory.

measurements of neutrino properties,” DeYoung said.

In addition, MSU will directly be a major partner in the upgrade if it is approved, contributing \$3.4 million toward new photosensors and establishing a sensor assembly, testing and development facility on campus.

“NEUTRINOS TELL US WHAT’S HAPPENING DEEP INSIDE THE SOURCE, SIMILAR TO A MEDICAL X-RAY SHOWING US WHAT’S INSIDE THE HUMAN BODY.”

“We’re also going to be doing much of the data analysis, and we intend to capitalize on the research advances that MSU has invested in over the past couple of decades—data science machine learning, and cyber-enabled science and research,” DeYoung said.

The expected completion date for the IceCube upgrade is February 2023.

The next step is IceCube-Gen 2, the next generation observatory. This project, which would cost in the range of \$300-400 million, would increase

the size of the neutrino telescope by nearly a factor of 10.

“This would allow us to detect more neutrinos and see dimmer neutrino sources,” DeYoung said. “And it would greatly enhance our view of the universe through neutrinos and give us much more information on the accelerators of

the highest energy cosmic rays—blazars like TXS 0506, and possibly other sources such as exploding stars, colliding galaxy clusters or whatever else the universe has in store for us.”

MSU’s Institute for Cyber-Enabled Research (iCER) and the Department of Computational Mathematics, Science and Engineering will play key roles in advancing multimessenger astrophysics.

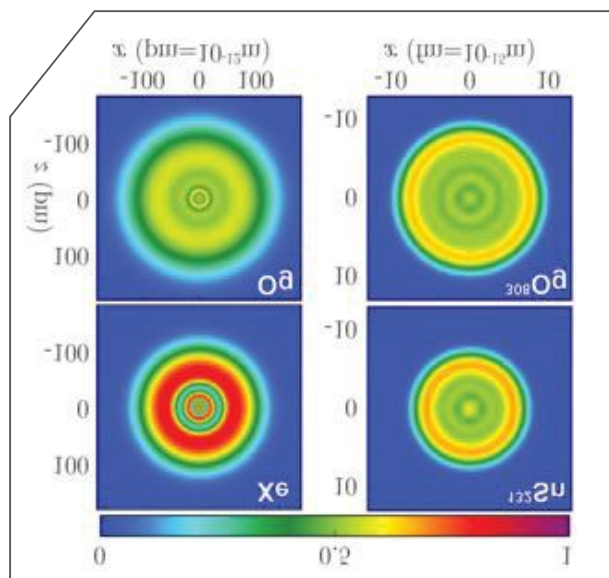
“This synergy, and these resources from NSF and MSU, will enable us to use the cosmos as our laboratory, to give us insight into how physics works in conditions that we will never be able to replicate on Earth,” DeYoung said. ▲

“Solid” evidence: Oganesson noble, but not a gas

Scientists at MSU and Massey University have calculated the structure of oganesson, a relatively new element that has proved elusive to study. First synthesized in 2002 at the Joint Institute for Nuclear Research in Russia, oganesson is the only element of group 18 of the periodic table (noble gases), which doesn't naturally occur and must be synthesized in experiments.

“The superheavy elements represent the limit of nuclear mass and charge; they inhabit the remote corner of the nuclear landscape, whose extent is unknown,” said Witek Nazarewicz, MSU Hannah Professor and Facility for Rare Isotope Beams chief scientist.

Studying one of the heaviest elements with the highest atomic number to ever be synthesized is no easy task. Oganesson is radioactive and extremely unstable with a



Originally thought to be a gas, oganesson is now predicted to be a solid.

half-life of less than a millisecond, making it impossible to examine by chemical methods. This means computing its electronic and nuclear structure is the next best thing, which is, in itself, a formidable undertaking.

Massey's Distinguished Professor Peter Schwerdtfeger of the New Zealand Institute for Advanced Study, together with Nazarewicz and their respective teams, were able to make these calculations.

The work suggests that oganesson electrons aren't confined to distinct orbitals and are distributed evenly. Additionally, oganesson was thought to be a gas under normal conditions but is now predicted to be a solid.

The MSU team complemented atomic calculations by computing the structure of protons and neutrons inside the oganesson nucleus, which indicated a smeared-out structure for the neutrons as well. The protons however retain some shell-like ordering.

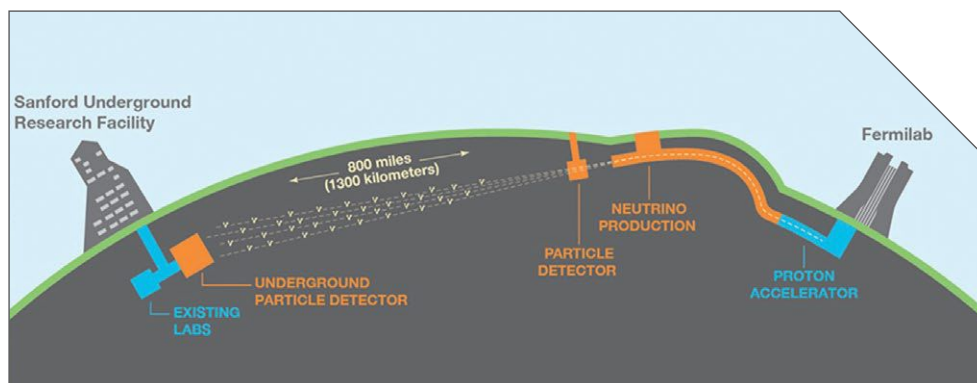
Groundbreaking physics on behalf of neutrinos

On July 21, 2017, dignitaries, scientists and engineers from around the world gathered at the Sanford Lab in South Dakota and the U.S. Department of Energy's Fermilab in Illinois to participate in the simultaneous groundbreaking ceremony for the Long-Baseline Neutrino Facility (LBNF).

LBNF will be constructed over the next decade to house the Deep Underground Neutrino Experiment (DUNE). Fermilab will send a beam of neutrinos 800 miles through the earth to the four-story, liquid argon-filled particle detector at the Sanford Lab built nearly one mile underground to study the interactions of neutrinos with argon atoms.

DUNE was conceived, designed and will be built by a team of 1,000 scientists and engineers from more than 160 institutions in 30 countries in order to investigate neutrinos, the most abundant and mysterious matter particles in the universe.

“These kinds of projects are quite thrilling,” said Kendall



Schematic of the Long-Baseline Neutrino Facility.

Mahn, MSU assistant professor of physics and astronomy and one of the participating scientists. “People from all over the world unite to tackle difficult questions.”

Mahn and her colleague Carl Bromberg, MSU professor of physics and astronomy, will test the electronics of DUNE detectors under cryogenic conditions and investigate what will potentially be learned about neutrino interactions.

“Neutrinos have been a source of new, unexpected physics,” Mahn said. “The DUNE program will answer many questions we have about the nature of neutrinos.”

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Flame Tubes and Elephant Toothpaste: Science Theatre goes to the U.P.

For the past eight years, Patrick Morgan, outreach coordinator for MSU's Department of Physics and Astronomy, has been making the trek to Michigan's Upper Peninsula each spring break with a group of students.

This year's group included eight undergraduates and one graduate student—all part of Science Theatre, which was launched in 1991 by a group of MSU graduate students. Science Theatre uses interactive stage presentations and hands-on activities to demonstrate concepts in biology, chemistry, physics and other fields to get children and adults excited about science.

In March, Morgan and his group visited 30 cities in the U.P., presenting 59 shows to more than 15,000 K-12 students in 62 schools.



2018 Science Theatre participants.

"We go to these schools at no cost to them; it's a fantastic opportunity for many rural schools which, due to distance and budget constraints, can't afford to have similar programs visit," Morgan said.

"One demonstration that we love to present is the Flame Tube—a six-foot tube with holes across the top and a hose attached to a propane tank. After filling the tube and lighting the holes, we set a speaker up to the side and send tones through, allowing the audience to see the sound wave with the fire," he said. "Another demonstration that students love is Elephant Toothpaste, a classic demonstration about exothermic reactions and catalysts.

"This trip was possible only because of the dedication of my students," Morgan added. "Their willingness to go through almost 30 hours of training and practice—as well as the week spent driving and presenting—is what allowed this to happen." 🍀