

COLLEGE OF SCIENCE DEPARTMENT OF PHYSICS

The Spectrometer

Summer 2018



Oregon State
University

The Spectrometer

Summer 2018

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On the cover

An artist's interpretation of a galactic explosion. The historic discovery of a binary star kilonova explosion in the summer of 2017 proved astrophysicist Davide Lazzati's prediction, published one month before, about the visibility of gamma ray bursts on Earth. See p. 8.



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College of Science



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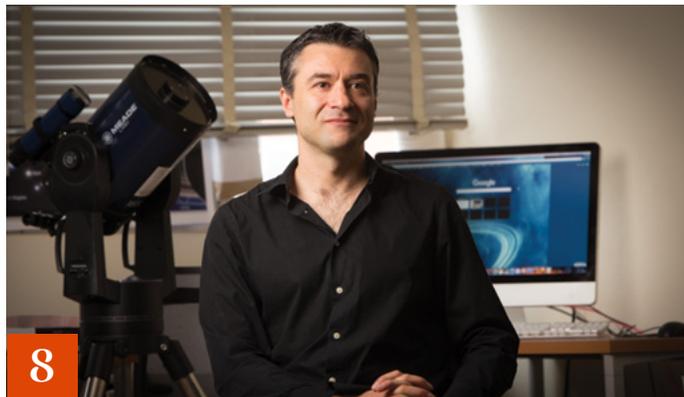


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FROM THE HEAD

Welcome to the Department of Physics' annual newsletter! I am eager to share exciting news and happenings with you.

First, some goodbyes and hellos. We welcome Professor of Practice David Craig, whose research is in quantum cosmology. David built and chaired the physics department at LeMoyne College in New York and co-chairs a task force on undergraduate physics at the American Physical Society. Clarissa Amundsen, our undergraduate administrator, received a major promotion as office manager for OSU Academic Technologies. We are proud of her but sad to see her go. Judy Burks, our new undergraduate assistant, has hit the ground running, thanks to her extensive OSU experience. Judy is also an accomplished artist, whose Benny the Beaver wall hanging now complements the orange floor in her office.

On the facilities side, our new Paradigms in Physics classroom has proven to be wildly successful since opening five years ago. When not used for our classes, workshops or study sections, the facility is reserved by other departments. To expand, we have reclaimed room 328 and, thanks to the support of generous alumni and friends, are beginning to transform it into an innovative learning studio that can accommodate 60 students.

Speaking of innovation, in these pages you'll read about our latest efforts to improve student success, including new pedagogies in our introductory courses, an online version of the general physics sequence due to launch in fall 2019 and two new popular sophomore courses. The key challenge is that since our classes are popular (read: full), we are constantly searching for more space and teaching assistants to keep up with demand. But bringing more students into the joy of physics is a good thing!

Fermilab Director Nigel Locker visited campus to present last year's annual Yunker Lecture, "50 Years of Fermilab." He even taught a nuclear and particle physics class during his visit, which was a treat for our students. Enjoy a video of his lecture on our website.

But unequivocally, the highlight of our year was the solar eclipse last August. Learn more about the fantastic program that our amazing students and faculty put on (see p. 12). Their work garnered many statements and letters of appreciation from visitors across the country and the world.

Our stellar students and faculty continue to receive numerous honors as described in more detail on page 4. We are very proud of them all, and I hope you'll join me in celebrating their excellent achievements.

Here's to another exciting year of physics at OSU!



Heidi Schellman
Department Head

Erratum

In the last issue of *The Spectrometer*, we misspelled the last name of our donors, Ben and Elaine Whiteley, in the announcement of the 2015 Ben and Elaine Whiteley Materials Fund Fellowship award. We apologize for the error.

Friend us on social media!

Keep up with the latest physics news and join our online community! Search for Physics at Oregon State on Twitter and LinkedIn.

ON THE MOVE

Our stellar students

Ben and Elaine Whiteley scholarship
recipient **Bethany Matthews**



Club nabs national honors

Congratulations to our Society of Physics Students (SPS), which won a 2016–17 Outstanding SPS Chapter award from the SPS National Council. This is the highest level of distinction, received by less than 10 percent of chapters annually. Go OSU Physics!

Summer research puts learning into action

Working in research labs on campus, in Oregon, across the country and the world, our undergraduates gained invaluable experience during the summer of 2017 through National Science Foundation Research Experience for Undergraduates (REU) positions and industrial internships. This is just one example of experiential learning that makes our graduates stand out and excel in the workforce after graduation.

Yousif Almulla did an REU program at Oak Ridge National Laboratory in Tennessee with Dr. Jacek Jakowski, using density functional theory to understand how qubits, a unit of quantum information, work.

Hassan Alnatah developed a protocol with physicist Bo Sun to construct a 3-D printed cell model based on confocal imaging.

Hazel Betz interned at the Fault Isolation and Failure Analysis Laboratory at Intel in Hillsboro, Oregon. She analyzed samples with a scanning electron microscope and designed proof-of-concept experiments to improve device-probing characteristics.

Katelyn Chase did an REU program at the University of Utah, working with Dr. Michael Vershinin in the physics and astronomy department. She studied the effect of trimethylamine N-oxide on the stability of kinesin-1 motor proteins.

Aaron Dethlefs worked in Janet Tate's Lab commissioning the College of Engineering's new Physical Property Measurement System for transport experiments on semiconductors.

Patrick Flynn worked with Dr. Arnd Scheel at the University of Minnesota in the mathematics department to solve partial differential equations with applications to bacteria migration.



Recognizing excellence in our graduate students

Atul Chhotray (Ph.D. '17, Lazzati group) was awarded our 2017 Graduate Research Award. A native of India, Atul joined OSU in 2014 as a transfer student from North Carolina State University.

Carly Fengel (Minot Lab) received the Department's 2017 Peter Fontana Outstanding Graduate Teaching Assistant Award.

Bethany Matthews (M.S. '17, Tate Lab) received the Ben and Elaine Whiteley Materials Research Fellowship. This scholarship provides support for materials research in the College of Science. Earlier this year, Bethany won a U.S. Department of Energy Office of Science Graduate Student Research Award.

Nicole Quist (M.S. '16, Ostroverkhova Lab) has been chosen for the U.S. Delegation for the sixth International Conference on Women in Physics. She will help write the U.S. conference proceedings paper and create a national poster representing the status of American women in physics and the problems they experience. Nicole also received an OSU Graduate School Travel Award to present her nanophotonics research at the 2018 SPIE (the international society for optics and photonics) Photonics West meeting in San Francisco.

Ian Founds studied students' use of the chain rule in thermodynamics with Paul Emigh and Corinne Manogue of the OSU Physics Education Research (PER) group and presented his work at the PER Conference in Cincinnati, Ohio, last summer.

Cassandra Hatcher received a SURE Science Scholarship to work with Davide Lazzati, studying X-ray polarization from Compton scattering in asymmetric supernova remnants.

Garrett Jepson won a SURE Science Scholarship to work in David Roundy's research group evaluating a new Monte Carlo code written in the programming language Rust for use in studying fluids. He also worked with physicist Guenter Schneider, using machine learning techniques to locate and identify the cells in a microscopy image.

Ryan Lance developed a new analysis for optical spectroscopy of thin films in the Tate Lab and received an honorable mention for his presentation at OSU's Summer Undergraduate Research Conference.

Chris May, working in David Roundy's research group, developed an improved code for studying the Weeks-Chandler-Anderson fluid.

Dublin Nichols, a SURE Science Scholar, built a microscope rig that enabled him to stack atomically thin crystals in Ethan Minot's lab.

Gabriel Nowak completed a Science Undergraduate Laboratory Internship in the Atomic, Molecular, and Optical sciences group in the Chemical Sciences Division at Lawrence Berkeley National Laboratory. He studied laser-generated nanoparticle array formation and the ensuing dynamics of charge transfer.

Jesse Rodriguez modeled plasmas in Mark Cappelli's lab at Stanford University's Department of Mechanical Engineering.

Nikita Rozanov studied how a protein interacts with certain nanoparticles using molecular dynamics simulations. He worked under Caley Allen in Rigoberto Hernandez's group at Johns Hopkins University Department of Chemistry as part of an REU at the Center for Sustainable Nanotechnology.

Tanner Simpson worked in David Roundy's group testing broad histogram Monte Carlo methods using the square well fluid. He presented his work at OSU's Summer Undergraduate Research Symposium.

Abe Teklu worked with Richard Moyer to analyze divertor footprints in the DIII-D tokamak to assess the accuracy of computational models, supported by a program at General Atomics in San Diego funded by the U.S. Department of Energy.

Attila Varga received a SURE Science Scholarship to work with physicist Kathryn Hadley on modeling rotating star-disk systems.

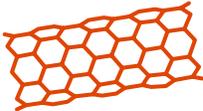
John Waczak tested and developed a model for the dynein motor protein, working in David Roundy's group.

Jeremy Meinke won the 2017 WIC Culture of Writing Award for his thesis, "Single-Molecule Analysis of a Novel Kinesin Motor Protein." Jeremy's work in Weihong Qiu's lab for two years was supported by Undergraduate Research, Innovation, Scholarship and Creativity (URISC) and SURE Science awards.

Physics faculty **Weihong Qiu** and **Bo Sun** hosted SURE Science Scholars Youngmin Park (biochemistry and biophysics) and Theresa Dinh (biology) in their labs last summer. **Oksana Ostroverkhova** (organic optoelectronics) hosted URISC (Undergraduate Research, Innovation, Scholarship & Creativity) scholar Mark Li (chemical engineering).



Mirek Brandt received a fellowship to study at the Kupcnet-Getz International Science Summer School at the Weizmann Institute in Israel. During eight weeks with Dr. Boaz Katz, Mirek modeled the spectrum of type 1a supernova, given some arbitrary explosion model, in order to eventually test the supernova detonation models studied by Dr. Katz. He then returned to campus to begin his Goldwater Fellowship in the Graham Lab. A very busy summer!



WAVES OF IMPACT

Faculty news

National and global honors

Heidi Schellman has been selected Chair of Commission 11 of the International Union for Pure and Applied Physics, an organization that fosters international cooperation in physics toward solving problems of concern to humanity. The C11 commission promotes the international exchange of research and views in particle and fields, oversees international conferences and sponsors a bi-annual Young Scientist Prize.

Bo Sun received a prestigious Scialog Award for Cancer Research from the Gordon and Betty Moore Foundation to study collective cancer cell dynamics. Sun and collaborators have found that human cells can mechanically change their surroundings, opening the door to insights on a variety of physiological processes, from cancer to wound healing and embryo development.

Matt Graham was named one of 10 Rising Researchers for 2017 by SPIE, the international society for optics and photonics.

Oksana Ostroverkhova was chosen by the American Physical Society (APS) as Woman Physicist of the Month for May 2017. Granted by the APS's Committee on the Status of Women in Physics, the award highlights exceptional female physicists, recognizing their positive impact on others' lives and careers.

University honors

Janet Tate was named a 2018 OSU Distinguished Professor, the highest academic honor the university can bestow on a faculty member. Tate presented a lecture as part of the Recognizing Excellence event on campus this spring.

Henri Jansen received OSU's prestigious Dar Reese Excellence in Advising Award, recognizing those who contribute significantly to academic advising while still succeeding in teaching, research and service. This winter he was named Associate Dean of Academic Student Affairs for the College of Science to have an even broader impact on science students.

KC Walsh won the OSU Faculty Teaching Excellence Award. This coveted award is for full-time faculty with fewer than 10 years of service who devote a significant amount of time to teaching and who have successfully enhanced classroom effectiveness through original scholarly research and its application.

Corinne Manogue received the F.A. Gilfillan Award for Distinguished Scholarship for her outstanding contributions to research in higher education physics. She presented the 2018 F.A. Gilfillan Memorial Lecture, "Catalyzing the transformation of science learning at OSU," on April 5, 2018 (see p. 14).

David McIntyre has been named the 2018 Honors College Eminent Professor. The award recognizes faculty for outstanding teaching, research and undergraduate mentorship.

Weihong Qiu, along with biochemistry and biophysics faculty Elisar Barbar, Afua Nyarko and Viviana Perez, and Peter Eschbach from OSU's Electron Microscopy Facility, won the College Impact Award, a new \$10,000 award seeding an early-stage research or innovation effort that advances the College's strategic goals and addresses a pressing 21st century issue. The award recognizes their collective work in establishing OSU as a global hub for research on intrinsically disordered proteins (IDPs), which are increasingly important in cancer and aging research.



Electrons on a string: Nanoelectronics group

Carbon nanotubes (CNTs) are quasi-one-dimensional materials with unique properties that make them ideal for next generation electronics and quantum computers. When they were first built 20 years ago, physicists around the world celebrated the new devices, which provided a rare experimental testing ground for one-dimensional strong correlations. The media hailed potential CNT applications such as building a space elevator or desalinating seawater. Despite original enthusiasm, however, 20 years later the unique electronic properties of CNTs remain poorly understood.

Today the **Minot Lab** is at the forefront of a renewed effort to make CNTs a model system for studying strong correlations and developing exciting applications. The lab has gained headway on a big CNT mystery, the exact arrangement of the carbon atoms. Carbon atoms can be bound together into various diameters and chiralities in approximately 500 possible nanotube structures. To understand the properties of a particular CNT and how to control them, researchers must first understand its structure.

The Minot Lab is using novel opto-electronic techniques to shine a light on CNT structure. A tunable light source is focused on an individual CNT. Some wavelengths of light are strongly absorbed and a photocurrent is detected. Other wavelengths of light pass straight through the CNT and no photocurrent is detected. After testing a full spectrum of wavelengths, the lab matches the color spectrum to the “CNT Atlas” to identify the exact species of CNT.

These advances in mapping out CNT structures facilitates further investigations into their properties. If a CNT has a metallic band structure, for example, strong interactions can cause an electrical charge to move incredibly fast along the filament. These same interactions can also cause a “log-jam” when electron density is at a critical value. When

the log-jam occurs, electrical current is completely frozen. Theorists have proposed several theories for the origin of this strange transition between metallic and insulating behavior. The competition between these theories adds to the impetus for new experiments on CNTs.

Graduate students **Lee Aspitarte, Dan McCulley and Mitchell Senger** recently performed a series of experiments switching metallic CNTs between conductive and insulating states. They learned for the first time how this transition depends on CNT diameter, chirality and dielectric environment.

The Minot Lab has only scratched the surface of interaction-driven phenomena in ultra-clean CNTs. Newly installed low-temperature physics equipment at OSU will enable deeper exploration of these fascinating quantum phases. The lab will also continue its NSF-funded work on nanoscale solar cells made from semiconducting CNTs with a goal of building photovoltaic devices that harness a greater fraction of the solar spectrum.

Neutrinos, big data unlock a fundamental mystery

by Heidi Schellman

The **Schellman research group** studies neutrinos, the lightest elementary particles that have no charge and only feel the weak interaction (responsible for radioactive decay) and gravity. Because neutrinos interact so rarely, we need both very intense particle beams and very large detectors, resources available at only a few places in the world like Fermilab in Batavia, Illinois, the Sanford Underground Research Facility (SURF) in South Dakota and CERN (the European

Organization for Nuclear Research) in Geneva, Switzerland.

Our group is part of two major international research efforts pursuing matter-antimatter differences in neutrino physics. The really big one is the Deep Underground Neutrino Experiment (DUNE), which has over 1,000 collaborators from 160 institutions worldwide. DUNE will aim a beam of neutrinos from Fermilab to SURF starting in 2026 to study a phenomenon called neutrino oscillations, where a neutrino starts out being of one type (like a muon neutrino) and, once it moves far enough away – minimally the distance between Illinois and South Dakota – appears as another type (like an electron neutrino). We know this effect exists, but don't yet know if it is the same for neutrinos and their antimatter twins, anti-neutrinos.

Amounts of matter and antimatter should theoretically be equal, and figuring out why our observable universe is made up almost exclusively of matter is one of the big mysteries of physics. The DUNE experiment hopes to provide insight into this puzzle by determining how big a difference there is between matter and antimatter in the neutrino sector.

The DUNE neutrino detector will consist of four Weniger-class volumes located 4,850 feet underground in the Homestake mine, each filled with 17,000 tons of liquid argon. The rare neutrino interactions will be detectable from the small amounts of ionization they produce when they hit the argon atoms, causing electrons to drift across a 100 kilovolt electric field, detected on planes of thin wires spaced 5 millimeters apart. The time it takes them to drift gives us three-dimensional information, about 20 GB of data every time we read it out.

We are currently in the prototype phase of the experiment. Two 1/20th-size prototype detectors under construction at CERN are scheduled to run this fall followed by construction in South Dakota. Our goal is to complete the first of four modules in 2024.

Oregon State is involved in two aspects of DUNE. First, graduate student **Amit Bashyal** is doing design studies for the intense neutrino beams being designed as part of Fermilab's Long-Baseline Neutrino Facility. Secondly, we are co-leading the software and computing effort for the overall DUNE project, planning the infrastructure that will allow us to move the huge data samples from South Dakota to the national labs and then reconstruct and classify any recorded neutrino interactions. This is Big Data with a capital 'B,' up to five GB/sec (gigabytes per second) and 30 petabytes per year (we are currently doing data challenges to test our ability). We are honored and beyond excited to play a key role on the international team of physicists, engineers and computer scientists working together to make this happen.

A smaller, related project is a first study of anti-neutrino interaction physics in the DUNE experiment energy range that was recently accepted for publication by Physical Review D. The study is a part of Fermilab's MINERvA experiment, a much smaller detector located close to the neutrino source. We are one of approximately 70 collaborators who have been running MINERvA since 2010. We take our turns at remote monitoring shifts in a small control room on OSU's campus. Postdoc **Mateus Carneiro** and graduate student **Amit Bashyal** are now using our new data samples to improve on our recent paper, which showed signs of significant nuclear-correlation effects that raise the expected neutrino interaction rates by around 20 percent.



Welcome David Craig

David Craig joined us this fall as associate professor of practice. In addition to teaching and research, he is supervising undergraduate physics laboratories and laboratory curriculum development.

After receiving a B.S. from Princeton University, Craig earned his Ph.D. ('96) at the University of California, Santa Barbara under the supervision of James B. Hartle. At the Canadian Institute for Theoretical Astrophysics, he worked as a national research fellow with Don N. Page, and then spent a year as a visiting scientist at the Perimeter Institute for Theoretical Physics. In his research, Craig is applying the quantum theory of gravity to the quantum theory of the universe as well as the foundations of quantum mechanics. He's asking the Big Questions!

Prior to OSU, Craig rebuilt the physics program as physics professor and department chair at Le Moyne College in Syracuse, New York. He won Le Moyne's Teacher of the Year award in 2010 and served on the education committee of the American Physical Society.

Craig currently co-chairs the Best Practices for Undergraduate Physics Programs task force, a national blue-ribbon panel charged with preparing a report and guide to assess and improve undergraduate physics programs. Thanks to Craig, OSU Physics is at the frontlines of this national inquiry and its forthcoming insights.

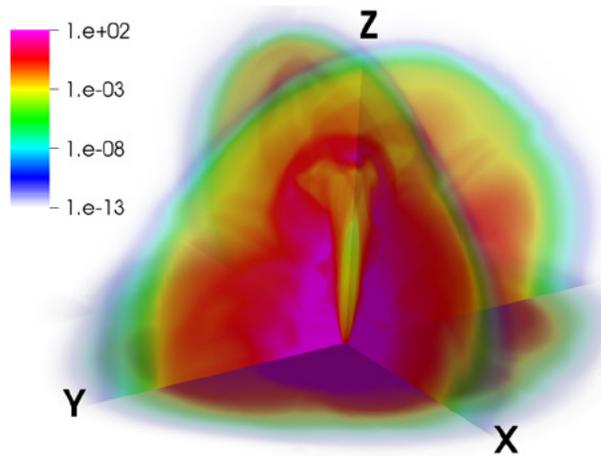
This 10 m³ ProtoDUNE — a single unit of the ultimate DUNE detector — will contain 'only' 800 tons of argon. Photo courtesy of CERN.



ASTRO PHYSICS DAZZLES AT OSU

Daide Lazzati
has helped put
OSU Astrophysics
on the map.





A three-dimensional computer simulation of the outflow from a binary neutron star merger. The simulation shows a relativistic jet that propagates along the vertical (Z) axis, seen as a blue-green cigar-shape at the center of the image. As it propagates, it pushes the surrounding material, creating a wide outflow (the green material in the X and Y directions) of hot plasma, called a cocoon.

OSU Astrophysics, which has been gaining momentum ever since theoretical astrophysicist **Davide Lazzati** was hired in 2013, enjoyed a really spectacular 2017. Hosting an international conference and graduating the first two astrophysics doctoral students would be news enough, but the Lazzati team also published a paper predicting the visibility of gamma ray bursts on Earth — one month before the prediction was proved true by the historic discovery of a binary star kilonova explosion and its measurable gamma ray burst! The summer of 2017 put OSU Astrophysics on the map. A dynamic future lies ahead.

Last June, OSU hosted the third Fifty One Erg, an international workshop on the physics and observations of supernovae, supernova remnants and other cosmic explosive phenomena, attracting more than 100 astronomers and astrophysicists from around the world to LaSells Stewart Center. The more than 50 scientific presentations included a special Science Pub talk, “Turning Stars into Gold,” presented by Professor Enrico Ramirez-Ruiz from the University of California at Santa Cruz.

Last July, **Atul Chhotray** was the first astrophysics student to earn a Ph.D. from OSU. Atul presented a thesis on the dynamics and radiation processes in relativistic jets and is now a postdoctoral researcher at the Anton Pannekoek Institute for Astronomy at the University of Amsterdam. In October, **Chris Mauney** was the second astrophysics student to successfully defend his doctoral thesis, a study of the micro-physics of dust nucleation in stellar explosions. He is now a postdoctoral researcher at Los Alamos National Labs in New Mexico.

Last but certainly not least, August 2017 was marked by the historic discovery of GW170817, a kilonova explosion that is our world’s first observed multi-messenger cosmic source. Observed almost simultaneously in gravitational waves by LIGO (the Laser Interferometer Gravitational-Wave Observatory) and European Gravitational Observatory’s Virgo detector and in gamma-rays by the Fermi satellite, GW170817 was produced by the merger of a binary system made of two neutron stars. This “simultaneous detection of gamma rays and gravitational waves from the same place in the sky is a major milestone in our understanding of the universe,” said Lazzati.

The Lazzati Group had long performed research on such systems and was among the first in the world to consider emission from a component called the “cocoon” and predict that, even in unfavorable geometry, a gamma-ray signal would be detected on Earth. Before the detection of GW170817, however, there was no evidence that a flash of gamma-rays would be seen following a binary neutron star merger. To Lazzati, it was stunning to have his prediction made “just by pen and paper, almost” proved true to a worldwide audience only one month later.

Many mysteries remain to be unraveled surrounding the event. Observations will continue throughout 2018 to pin down the energetics and geometry of the explosion. In particular, scientists are debating whether a very fast jet survived after the collision, and whether events such as GW170817 and the extremely luminous short gamma-ray bursts are different only because of a different viewpoint or because of their intrinsic physical properties. 2018 is expected to be as exciting as 2017 for the OSU Astrophysics group: stay tuned!

STUDENT SUCCESS SKYROCKETS

The new year started with a bang: The American Physical Society (APS) selected the OSU Department of Physics as one of three top universities for improving undergraduate physics education in 2018. The APS Award for Improving Undergraduate Physics Education recognizes excellence in undergraduate physics education to support best practices in education at the undergraduate level. Past awardees have shown significant impact on undergraduate physics students.

For 21 years, we proudly served as a national model for a holistic approach to improving the educational experience for undergraduates, from our nationally recognized, upper division curriculum redesign and Paradigms in Physics to lower-division reform, thesis research experiences for all majors and attention to co-curricular community-building. This national recognition underscores the high quality of our program. And as you can see below, our momentum continues!

Shifting to a new paradigm

Now in its second year, Paradigms 2.0 takes what we have learned during the last 20 years of teaching physics to revitalize the undergraduate program

and to expand its scope into new research areas.

Ethan Minot and **Elizabeth Gire** created two new sophomore courses which are extremely popular. Contemporary Challenges in Physics, with more than 60 students enrolled winter term, teaches modern physics through real world examples, such as sustainable energy challenges and space exploration. Techniques of Theoretical Mechanics leverages students' understandings of introductory sequence concepts to understand more powerful techniques, such as Lagrangian and Hamiltonian dynamics and special relativity. Students can take the new courses simultaneously with the intro sequence to gain early exposure to more applied and advanced topics.

The junior-year Paradigms sequence was redesigned to further enhance student success. The six courses were expanded to five weeks and include Quantum Fundamentals, Energy and Entropy, Oscillations and Waves, Periodic Systems, Static Fields and Central Forces. Students can also take the new senior-level electives in astrophysics, particle physics and biophysics.

Engaging kids through next gen science teachers

by Liz Gire and Emily van Zee

One of the best ways to ensure a strong future for science is by training the next generation of teachers to awaken children's innate curiosity about nature. In the Inquiring into Physical Phenomena course, future elementary school teachers learn about the physics of climate change and ways to teach these topics to children. The central theme is "What happens when light from the Sun shines on the Earth and Moon?"

In the laboratory-based course, future teachers practice the scientific process in order to infuse it in their teaching. They make claims from evidence, use observational evidence to identify powerful ideas, and finally create a mathematical model to predict results. At the end of the course, students map their learning experiences to the Next Generation Science Standards.

In addition to practicing science, students think about how to engage children. Each week, they use everyday materials to teach a friend or family member one of the experiments or concepts from the course. The capstone event is a group trip to Lincoln Elementary School, where students get the opportunity to teach 5th graders about reflectivity. By learning about learning, practicing engaging teaching techniques and learning about physics, students embark on their teaching careers with the confidence and experience to ignite a passion for science – and physics! – in their students.



KC Walsh continues to raise the bar on student success.

Project BoxSand Update

The introductory physics sequence, Project BoxSand, continues to be energized by creator **KC Walsh's** passionate leadership and the incorporation of Evidence-Based Instructional Practices (EBIP). Four years ago, Walsh flipped the classroom structure, replacing traditional lectures with hands-on learning. Students use class time to work on applying theories they are introduced to before class by watching short pre-lecture videos.

To support the flipped classroom, a Learning Assistant (LA) program launched three years ago. LAs are undergraduate students who have already taken the course and are selected based on their physics knowledge and outgoing personality. Trained in physics pedagogy, the LAs help with flipped lectures, hold additional office hours and maintain a social media presence.

Both of these innovations have made a tremendous difference in student success: The drop/fail rate has decreased from 36 percent to 13 percent in Physics 201 alone over the past five years. Students report being much more satisfied with the course and standardized tests of knowledge retention have remained constant or even increased.

Another significant advance was the introduction of open resources that replace the traditional textbook. Walsh launched BoxSand.org, a website for students to engage with the best open resources online along with custom content such as pre-lecture videos.

Currently, Walsh is researching how student engagement with these resources correlates with performance in the class (by tracking students' clicks). The ultimate goal is to create robust predictive analytics to inform best-practice interventions for struggling students before it is too late. Last year, more than 2.5 million data points were collected. Early insights suggest that slow and steady really does win the race and that cramming is not an effective way to study.

The BoxSand team is developing an adaptive learning homework system to be launched in fall 2018 that integrates with the website. This addition will make the course completely open source, collectively saving our students \$150,000-plus per year. After initial deployment, the team will add a new feature, AsyncSync, that will allow students to collaborate on the same assignment in real-time, day or night.

From BoxSand to AsyncSync, Walsh and his team are creating a foundation for one of the department's greatest challenges: To provide a completely online introductory series that incorporates EBIP. Active engagement and peer learning practices have become the industry standard, but achieving high levels of interaction in an online course is much more challenging. Thanks to innovative new technology, such as AsyncSync, collaborative virtual labs, real-time support from the Wormhole and Virtual Flipped Classes, our Ecampus sequence is slated to launch in fall 2019 and will bring EBIP to the online classroom. At that point, the department will launch a comparative study of on- and off-campus courses. Stay tuned!

LIGHTING THE WAY

Outreach and engagement



OSU's Space Grant Festival attracted thousands to campus. Below, Randall Milstein prepares a telescope.



Eclipse and the OSU150 Space Grant Festival

Last summer's total solar eclipse was a great opportunity for public outreach, and our amazing students and faculty put on a fantastic program. Two astronomy graduate students, Tyler Parsotan and Atul Chhotray, worked with Corvallis schools and the public library on teacher training modules and, through the Astronomy Club that they co-founded, provided Department of Physics-branded eclipse glasses to 5,000 community members. They then led an outreach team of 20 other students that reached more than 2,000 campus visitors during the eclipse weekend.

Physics faculty **Randall Milstein** and **Davide Lazzati** gave many public talks to rapt audiences. OSU received many statements of appreciation from visitors both near and far.

Special kudos goes to Randall Milstein, physics instructor and Oregon NASA Space Grant Consortium Astronomer-in-Residence, who worked tirelessly to maximize outreach for a year leading up to the event as well as plan meticulously for a well-run OSU150 Space Grant Celebration. He provided no fewer than six radio interviews, nine television interviews (including Al Jazeera America and CBS Saturday Morning), 15 interviews for newspapers and magazines (from as far away as Australia), five podcast interviews, nine solar filter workshops, 11 statewide outreach events reaching 4,000 Oregonians (two to standing-room-only crowds), two pre-eclipse solar viewing events with 600 guests, two eclipse weekend star parties involving 1,600 guests, and an eclipse day viewing with solar telescopes at OSU's Peavy Field with over 2,000 visitors. Phew!

Physics without borders

The department was involved in more than 20 outreach events during the 2017-18 academic year. In addition to the solar eclipse, highlights include astronomy nights on the roof of Weniger Hall, OMSI Meet-a-Scientist events featuring our faculty and graduate students, Discovery Days, Mi Familia Weekend, Discovering the Scientist Within, and many visits to classrooms and Family Science Nights at area schools. See our website for a robust list of past and future outreach events.

Family Science Nights have been a yearly staple in Corvallis schools for over a decade. But in May 2017, it was only the second one for Timber Ridge School, a combined middle and elementary school serving a rural area on the northern edge of Albany. About 200 students of all ages attended the event. Middle-schoolers acted as guides and sold snacks as a fundraiser.

Our physics demos included classics like levitating ping-pong balls with a hair dryer and the ever-popular hovercraft. As usual, the line for the

hovercraft rarely dropped below a dozen students, continuing to draw a crowd to the end of the hall throughout the evening. Many were eager to learn how the hovercraft worked and several kids remarked “I want to make one!”

Mi Familia Weekend is an annual two-day event that is designed to introduce diverse and underrepresented K-12 students and their families to college life at OSU. The event includes a hands-on showcase of science, and physics-led demonstrations included a magnetic levitation track, hovercraft, Tesla coil, liquid nitrogen freezing, and much more. KC Walsh and learning assistants from the introductory physics course brought a host of fun physics toys to engage the kids and even the parents.

Discovery Days is a beloved tradition at OSU that brings 1,800 elementary school children to campus to enjoy science over the course of two days. Students experience hands-on science demonstrations, play trivia games and see live creatures of all sorts from local business Brad’s World

Reptiles. The star attraction of the physics demo was a rotating chair that dramatized centrifugal versus centripetal force. Students lined up to take a spin, using hand weights to test how concentrating their center of mass increased their speed of rotation, while extending their hands slowed it.

Discovering the Scientist Within brought 23 middle school girls from across Oregon to campus to spend the day learning about physics by playing with some of our coolest physics toys.

The girls drew “physicists doing physics” on the wall-mounted touch screens in our hi-tech studio classroom, played with our superconducting train, rode our rotating chair, spun our precessing bicycle wheel, and experimented with our standing wave strobe setup and tabletop hovercrafts. The girls used OSU diffraction glasses to look at atomic emission spectra and zoomed down the halls of Weniger on our leaf-blower hovercraft. They also did some “light painting” in the dark and finished the day with homemade liquid nitrogen ice cream. What is better than that?



Physics students volunteer at Family Science Nights, bringing physics to rural areas in Oregon



Corinne
Manogue

Transforming science learning

Corinne Manogue, a pioneer in science education research as well as a theoretical physicist, presented the College of Science 2018 F.A. Gilfillan Memorial Lecture, “Catalyzing the transformation of science learning at OSU” on April 5, 2018.

Manogue provided a panoramic view of how science education has transformed over the last twenty years at Oregon State and across the country, shifting from top-down lectures to interactive workshops and collaborative learning. Manogue has led this movement in many ways, including researching and developing the use of various manipulables for physics such as concrete erasable surfaces, giant whiteboards and a partial derivatives machine with pulleys and strings to empower students to understand thermodynamics equations and the concept of entropy.

Manogue’s pioneering work is rooted in her own experience as a child of “most of the big education reforms” in the 1960s and 70s, from new math in elementary school to the revolutionary new high school physics education developed at MIT. Her passion for inclusion is also fueled by contrasting aspects of her own experience as a woman physicist. As a double-major math and physics undergraduate at the all-women’s Mount Holyoke College, Manogue experienced what it was like to be part of a strong cohort. In contrast, as one of only a few women Ph.D. candidates at the University of Texas, Austin, she was part of a minority and found the entrenched sexism “distressing.” Arriving at OSU in 1987 as the first woman tenure-track physics professor, Manogue was ready to roll.

In the late 1990s, as the Paradigms in Physics undergraduate reform that she helped instigate flourished, Manogue delved into physics education research, iteratively applying new methods in her own classes to improve student success. Many of the students and postdocs she involved in her work have gone on to become leaders in physics education research in their own right. In 2004 Manogue was elected a Fellow of the American Physical Society for her role in the development of the innovative Paradigms curriculum, which helps students transition from lower- to upper-division physics and learn to “think like physicists.”

In addition to becoming a national leader in physics education, Manogue has made significant contributions to two areas of theoretical physics: the fundamental symmetries of physics using mathematical structures involving the octonions; and the properties of the vacuum in quantum field theory.

Manogue has authored more than 70 articles on student learning and on theoretical physics. With her husband, OSU mathematics professor Tevian Dray, she has co-authored *The Geometry of Vector Calculus* (2009-18) and *The Geometry of the Octonions* (2015).



In memoriam: Jim Ketter

Jim Ketter, who served as lab guru and instructor for many years, passed away in June. Jim joined our department in 2005 after a varied career as a geophysicist, high school teacher, graduate student and physics instructor at Linn Benton Community College and Oregon State. A warm and sensitive instructor, Jim was also the go-to gadget guy who kept our labs running and our department presentable. In addition to the considerable load of teaching and keeping our labs humming, he loved doing outreach — from Discovery Days to supervising the Society of Physics Students and generally bringing his enthusiasm for physics to everyone he met. We are devastated by losing Jim and send our sincere condolences to his family.



2017 and 2018 Yunker Lectures

Nigel Lockyer, director of the Fermi National Accelerator Laboratory (Fermilab), delivered the annual Yunker Lecture to a crowd of more than 200 on May 4, 2017, covering the history of Fermilab and particle physics over the past 50 years. At the end of the lecture, Lockyer gave a tantalizing overview of the big questions that remain unanswered and how scientists will tackle them in the years to come. During his two-day visit, he also tried out our new teaching facilities, gave a guest lecture in particle physics to 25 seniors and met with graduate students and faculty.

Lockyer received his doctorate from The Ohio State University and did his postdoctoral work at Stanford University's SLAC National Accelerator Laboratory on the Mark-II experiment, serving as spokesperson of the experiment. In 1984, he joined the faculty at the University of Pennsylvania, where his research focused on high-energy particles, fundamental symmetries, and quarks. From 2002-2004, Lockyer served as co-spokesperson for the Collider Detector at Fermilab, an experiment involving 600 scientists. From

2007-2013, he served as director of TRIUMF, Canada's national laboratory for particle and nuclear physics. He received the Panofsky Prize, the field's highest honor in experimental physics.

The Yunker Lecture continues to be the flagship event of the year for the department. This year we added a Department of Physics Open House with lab tours and a student poster show. Local alumni attended, including one who directs operations at Hewlett Packard after previously operating the Fermilab accelerator in the 1990's.

Laura Greene, director of the National Magnetic Field Laboratory and president of the American Physical Society, delivered the 2018 Yunker Lecture on April 20, 2018, "The Dark Energy of Quantum Materials."

In her talk, Greene explored superconductivity and the bizarre behaviors of quantum materials, showcasing some of the exciting applications from levitating trains, lossless power transmission and sensors that can detect the tiniest magnetic field change when a proton flips.



Dean Haggerty (L) at the Gilfillan Lecture social.



Congratulations to our 2017 Ph.D.s!

MINOT GROUP

Lee Aspitar. Now a postdoc at National Energy Technology Labs in Albany.

Morgan Brown. Now a postdoc at the University of Oregon Institute of Neuroscience in Eugene.

LAZZATI GROUP

Atul Chhotray. Now a postdoc at Anton Pannekoek Institute for Astronomy of the University of Amsterdam, Netherlands.

Christopher Mauney. Now a postdoc at Los Alamos National Lab in New Mexico.

OSTROVERKHOVA GROUP

Rebecca Grollman. Now a data scientist at Bsquare Corp. in Bellevue, Washington.

SUN GROUP

Christopher Jones. Now a senior scientist at Microsystems Engineering.

Garrett Potter. Now a postdoc at the Mayo Clinic.

GRAHAM GROUP

Hiral Patel

ZWOLAK GROUP

Joshua Kincaid

Subin Sahu

Now a postdoc at National Institute of Standards and Technology.

FANG GROUP

Liangdong Zhu

TAKING PHYSICS OUT THERE



Far-sighted generosity

The College of Science's Summer Undergraduate Research Experience (SURE) Scholarships support students so they can pursue engaging, hands-on learning experiences while earning summer income and up to \$500 for research expenses. The experience complements their classroom learning. The program relies on the generosity of friends and donors like Professor Emeritus **John Gardner**. He supports a SURE Scholar each summer.

What inspires his generosity? Like many donors, Gardner is moved by all of the institutions that have played a positive role in his own life, including OSU.

As part of OSU's Physics faculty from 1973-2001, Gardner established himself as a world leader in perturbed angular correlation spectroscopy, a discipline within the field of solid state physics. Afflicted with poor vision from birth, Gardner lost all sight in 1988, when surgery to stem glaucoma went

awry. Gardner's blindness led to a profound shift in his research from solid state physics to accessibility initiatives for low- or no-sight students and researchers in the sciences.

In 1996, he founded ViewPlus Technologies to develop and market products like embossed and Braille printing that support accessibility through tactile graphics and more. The company first broke even in 2003 and continues to succeed today despite competitors who have sprung up.

"I suppose imitation is a great compliment," says Gardner.

Gardner is grateful for a long and fruitful career at OSU and the support and encouragement he received from colleagues and students as he transitioned his research, teaching and life after he lost his vision. Thanks to the support of many and his own ingenuity and spirit, he not only continued his research and teaching, but also won several National Science Foundation grants to develop new technologies to make graphical information and math more accessible.

Each year many lives are transformed by Gardner's annual SURE Scholarship and his work to make science more accessible to the visually impaired. We are grateful for his generosity and inspired by his passion and tenacity.



Professor emeritus
Kenneth Krane

Retired but not at rest

Professor emeritus **Kenneth Krane** retired 15 years ago, but “most days I am still at my desk, working,” he muses. In addition to editing the 4th edition of his popular textbook, *Modern Physics*, Krane is writing the first scientific biography of Hans Geiger, the German inventor of the Geiger counter.

Krane is also engaged in ongoing service and philanthropy at Oregon State. He currently serves on the Honors College Board of Regents and is an enthusiastic supporter of both the arts and sciences. He generously funded undergraduate scholarships in theater and music in addition to science. The Kenneth S. Krane Scholarship Endowment Fund in physics supports up to three undergraduates every year.

During his 29-year career at Oregon State, Krane distinguished himself in four key areas: research, education, scholarly writing and administration. A nuclear physicist who explored nuclear structure through the analysis of complex gamma ray decay schemes, he mentored dozens of undergraduates and Ph.D.

students, published 120 papers and was elected a Fellow of the American Physical Society in 1990.

Krane also was a trailblazer in physics education research. He was one of the first at OSU to replace traditional lectures with workshop-style classes and, in the 1990s, pioneered the use of clickers, a device commonplace today. His three widely adopted physics textbooks have been translated into five languages. In recognition of his innovation, Krane was elected a Fellow of the American Association of Physics Teachers in 2014 and awarded their Distinguished Service Certificate in 2017, among many other honors.

Krane chaired OSU’s Department of Physics from 1984-98. He is most proud of the hiring and mentoring of seven tenure-track faculty, including the first tenure-track women: 2017 Gilfillan awardee Corinne Manogue and 2018 OSU Distinguished Professor Janet Tate. Recognizing early on how difficult it could be for women in physics, Krane encouraged the founding of the OSU Women in Physics organization to foster mentoring and networking among women faculty as well as graduate and undergraduate students. The group continues today.



In memoriam: Ben Whiteley

Ben Whiteley, a long-term supporter of physics at Oregon State, passed away in Portland on May 4, 2017. Ben was CEO of Standard Insurance from 1983-94 and a leader in Oregon business and philanthropy. Ben and his wife Elaine generously sponsored the Whiteley Materials Research Fund and the Yunker Lecture series, in memory of Elaine’s father – Edwin Yunker, long-serving professor (1925 – 1968) and Chair (1949-1966) of Physics. The lecture series brings renowned scientists to campus every year. Ben was also a long-serving OSU trustee. He and Elaine received the College of Science Distinguished Service Award in 2016.

After Ben passed away, the Ben & Elaine Whiteley Faculty Scholar Fund for Teaching Excellence was established through his estate to support great teachers who are advancing teaching and learning excellence in support of increased student success.

Ben and Elaine’s impact on Oregon State University and on the Department of Physics cannot be overstated. We miss Ben dearly.



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