THE PHYSICS MAJOR

Department of Physics and Astronomy

First Ongaro Family Scholarship Award:

By Prof. Scott Severson

The Department of Physics & Astronomy is pleased to announce the first ever Ongaro Family Scholarship award. The $4750 scholarship, is awarded to physics student Natalie Sanborn. Natalie is pursuing a B.S. in Physics with a concentration in Astrophysics. The Ongaro Family Scholarship Fund has been founded under the direction of recent Sonoma State University graduate, Ernest J. "Ejay" Ongaro (B.S. Physics 2019). The Fund is part of the charitable works of the Ongaro Family, known locally for their successful plumbing, heating and cooling business, Ongaro & Sons. Ernest is the company's Administrative Manager, and is excited by the prospect of their giving having transformative impacts on the lives of students at Sonoma State.

An excellent student, Natalie began her studies as an undeclared student determined to narrow down the array of options. "I declared a Physics BS major with a concentration in Astrophysics, fueled by my curiosity to understand how the universe works." As a student completing her second year at Sonoma State, Natalie has pursued communities to join and ways to contribute. She serves as Treasurer of both the Performing Arts Club, and of her sorority, Lambda Kappa Pi. Thrilled with the experiences of her studies and interests, she is looking toward the future, "I am excited for what the future holds beyond my time at Sonoma State University." Aided by the Ongaro Family Scholarship, Natalie Sanborn is sure to make the most of what the SSU and the Department of Physics and Astronomy has to offer to prepare her for her future.

Scholarship recipient Natalie Sanborn:
I'm very honored and thankful. I was working 30 hour weeks this past semester and it's definitely not fun. Everyone, all the faculty in the department is so supportive. The fact that an alum wants to give back directly to the Physics & Astronomy students at Sonoma State, that's really great. I'm very thankful because it is a big award and it will be very helpful.

Ongaro & Sons Administrative Manager, Ernest J. Ongaro:
"Congratulations to Natalie! I really hope that our scholarship makes a difference and helps with the financial burden that comes along with seeking higher education. Watching this scholarship come to fruition has been a wonderful experience. Ongaro and Sons was founded by my great-grandfather in 1932 and we feel deeply rooted in our community. By supporting our local university, we hope to foster academic success in our community and encourage the growth of Sonoma County's higher education."

Cominsky Named Legacy Fellow by the American Astronomical Society

Professor and former Chair Lynn Cominsky was named one of the 200 initial "Legacy Fellows" by the American Astronomical Society (AAS). The AAS Fellows program was established in 2019 to recognize AAS members for their contributions toward the Society's mission of enhancing and sharing humanity's scientific understanding of the universe. Fellows may be cited for original research and publication, innovative contributions to astronomical techniques or instrumentation, significant contributions to education and public outreach, and noteworthy service to astronomy and to the Society itself. The initial group of Legacy Fellows were designated by the AAS Board of Trustees, and include past recipients of certain awards from the AAS or its topical Divisions, distinguished AAS elected leaders and volunteer committee members, and previously unrecognized individuals with long histories of outstanding research, teaching, mentoring, and service. During her career, Prof. Cominsky has served on many AAS committees, including: Executive Committee of AAS High Energy Astrophysics Division (HEAD, 1995 – 1997), HEAD Press Officer (1996 – 2002), and AAS Deputy Press Officer (1998 – 2008). In January 2017, she was honored with the 2016 AAS Education Prize.

Cominsky receives the AAS Education prize in 2017 from AAS President Christine Jones

SONOMA STATE UNIVERSITY

Capstone Research:

Visualizing Special Relativity

By Christopher Sellite

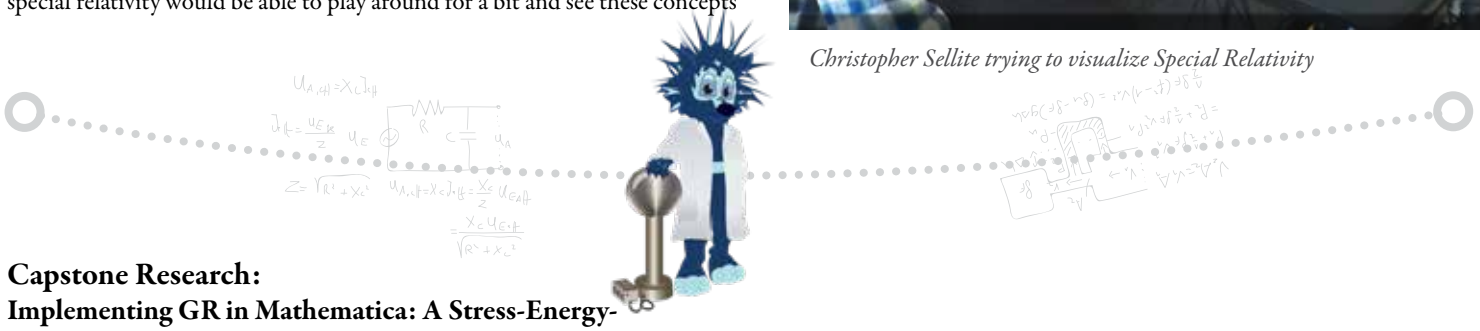
Special Relativity is usually a difficult topic to fully understand by undergraduate physics students. Like many other difficult physics topics, the inability to visualize and imagine is what makes these topics so hard to tackle. The goal of my project is to give students an interactive environment to play around and experiment with special relativity concepts like length contraction, time dilation and the doppler shift. To accomplish this task, I used the game development software, Unreal Engine, in order to build a game that included these concepts.

In the game, as you move around at speeds comparable to the speed of light you can see your relative time diverging from the proper time (time experienced by someone moving at speeds not comparable to the speed of light). Length contraction is shown by objects contracting in length as you walk past them due to your high speeds. On the objects, you can see the apparent length to you compared to the proper length seen by someone again not moving at speeds comparable to the speed of light. Lastly, the concept of the Doppler shift is shown by the differing in time of objects that you are walking away or towards.

During development, I was compelled to search for a better way of showing a concept or fixing some bug. I found myself rewriting the same code over and over in order to improve not only the functionality but the efficiency as well. I found the more I refined my code the game ran much smoother and my experience as a player became increasingly better. I was able to see my vision coming to light. I could see how someone that was new to the topic of special relativity would be able to play around for a bit and see these concepts become more easily understood. Now that everything has started to come together and the game is very playable, I feel a sense of pride and accomplishment.

As of right now my hope is to join the work force after my graduation from Sonoma State. Recently, I have applied and been interviewed at few local companies including Alluxa and Micro-Vu for positions in thin film coating, fabrication and metrology. I would like to get some work experience before furthering my education so I have a better idea of what I would like to specialize in. For now, my long-term goal is to go to graduate school and get a Master's in Mechanical Engineering. In addition, I may also pursue physics programming. I really enjoyed my senior research project and find it fascinating how programming and physics intertwine.

Christopher Sellite trying to visualize Special Relativity



Capstone Research:

Implementing GR in Mathematica: A Stress-Energy-Momentum Tensor with Metric Inputs

By Earl Powell

In this capstone project, I attempted to implement the Einstein field equations into Mathematica by creating a set of tensor calculators based on using the metric tensor as an input. I thought a list/array-based environment would prove quite suitable for adapting a representation of the tensor structure of the field equations, based on its covariant representation in natural units where the speed of light is set equal to one for ease of calculation.

My interest in the project is based on considerations regarding the difficulty of directly computing the Einstein field equations, even after taking thorough symmetry considerations designed to reduce the intensity of calculation. When considering applications of the field equations, we tend to start with a particular distribution of matter, using whatever symmetry considerations are appropriate, to attempt to solve for the metric tensor of the space-time. In my project, instead we start from a given metric tensor and then use a composition of tensor calculators to generate the appropriate stress-energy-momentum tensor. The idea, based on a great deal of prior works, is that we can create toy metrics and then, using the Einstein field equations, derive a stress-energy tensor to determine whether or not the energy and momentum configurations conform to our expectations of a physically admissible system.

The project was composed from a set of called functions, each of which generates an appropriate tensor taking a metric input. The first called function created is equivalent to the Christoffel symbol, which in is called by other functions necessary for calculating the Covariant Derivative and the Riemann Tensor. Using contractions and sums of these components lastly allows for the construction of the Einstein Tensor, which is directly proportional to the Stress-Energy Tensor.

To test the validity of the formulation in Mathematica, I entered the metrics associated with certain solved systems for the GR equations in the vacuum, such as the original Schwarzschild metric in order to test the accuracy of the calculator by recovering the appropriate stress-energy tensor. Thankfully, after several revisions, the calculators recovered the appropriate covariant representation of the stress-energy tensor.

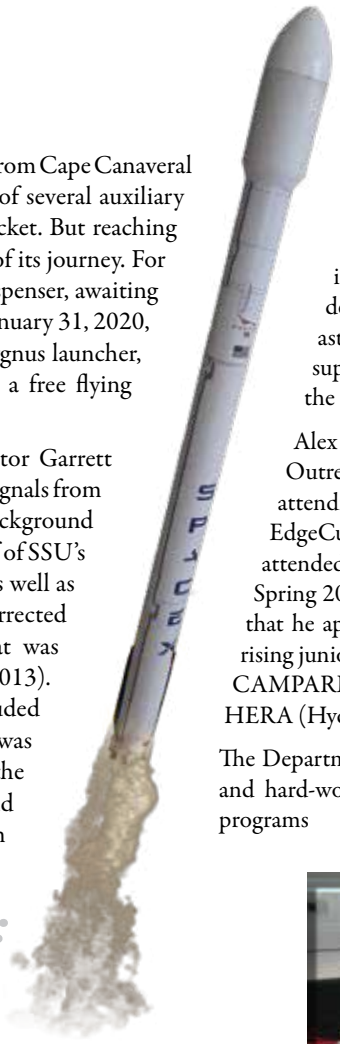
It is my hope to later consider a more thorough-going models based on numerical relativity that can be implemented, potentially with an interest of pursuing research into this field. I would likewise streamline the tensor calculators to avoid calculating certain values identically equivalent to zero in order to save on computing power.

EdgeCube Update

By Prof. Lynn Cominsky

EdgeCube, SSU's second small satellite, was launched from Cape Canaveral Air Force Station on December 5, 2019. It was one of several auxiliary payloads carried into space by a Space X Falcon 9 rocket. But reaching the International Space Station was only the first leg of its journey. For the next month, EdgeCube remained in its launch dispenser, awaiting a boost to 500 km (from the 400 km ISS orbit). On January 31, 2020, EdgeCube departed the ISS on the SS Alan Bean Cygnus launcher, and on Feb. 1, it was finally released into space as a free flying satellite, along with several other small satellites.

For more than six weeks, EdgeCube technical mentor Garrett Jernigan and others worked tirelessly trying to detect signals from EdgeCube. However, unexpected high levels of RF background noise in the ground station antenna system on the roof of SSU's Student Center precluded contact with EdgeCube, as well as any other amateur radio satellites. Jernigan then resurrected the ground station at the Little H-bar Ranch that was successful in communicating with T-LogoQube (in 2013). However, after several weeks of work that included confirming signals from other satellites, EdgeCube was not detectable. So we sadly have had to conclude that the mission failed. We hope to build future CubeSats and will take into account the many lessons learned from this project.

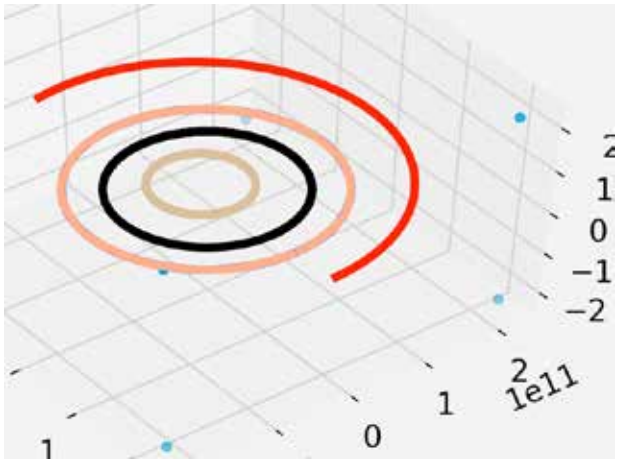


Newkirk Award:

From Classroom to Solar System

By Andrew Evans

What began as a seemingly simple question about how long it would take the Earth to fall into the Sun if stopped in its orbit, has become a (hopefully) valuable classroom exercise thanks to the Department of Physics and Astronomy's Newkirk Award. I have been working to creating new course material for PHYS-381: Computational Methods for Scientists, under the supervision of Dr. Targett. The material was based around the idea of using python code to create a working solar system model that could be generalized and applied to a variety of problems. It focuses heavily on use of recursion and pythons' ability to be interpreted line by line. The course begins with the question "how long would it take for the earth to fall into the sun?" and slowly generalizes that into a 3D orbital simulator. This project was very fun to watch develop as correct solutions resulted in the mimicry of a complex natural system using only introductory physic. The highlight of this was when the Moon-Earth-Sun system had been implemented and I could accurately predict the position, velocity, and acceleration of the moon. After generalizing the program, it became simple to "play around" with, which allowed me to do things such as create a binary star system, and add new objects into our own solar system to test that effects.



This project not only taught me how to use and apply python, but also how to approach larger scale physics problems that don't have clean mathematical solutions. Before I began work on this award I assumed that all physics has a clean mathematical solution. After completing this award, I can confidently say there is a mathematical solution, but programming an approximation was much more efficient and practical, and provides far greater utility. As a first physics research opportunity, it has greatly helped widen my horizon, and I am very grateful to have received the Newkirk award.

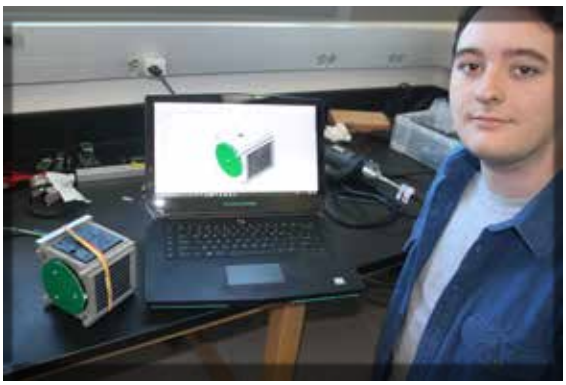
Department's first Cal-Bridge Scholar: Alex Vasquez

By Profs. Lynn Cominsky and Alexandra Miller

In Fall 2019, the Department received news that Alex Vasquez will be SSU's first Cal-Bridge scholar! Cal-Bridge is program funded by the National Science Foundation that aims to increase the number of CSU students completing their bachelor's degrees and successfully entering PhD programs to study physics, astronomy, or a closely related field. The program offers financial support, as well as grad school preparation workshops and help with the grad school application process.

Alex Vasquez began working with SSU's Education and Public Outreach group when he was still a high school student. While attending Santa Rosa Junior College, Alex began working on the EdgeCube satellite mission, mentored by Dr. J. Garrett Jernigan. He also attended the Sci 220 Maker class taught by Prof. Lynn Cominsky during Spring 2019 before transferring to SSU this past fall. She recommended that he apply for CAMPARE, a summer internship program that places rising juniors in research groups at research-intensive universities. Through CAMPARE, Alex spent Summer 2019 at UC Berkeley, working on the HERA (Hydrogen Epoch of Reionization Array) project.

The Department is working to ensure that Alex is the first of many talented and hard-working students recruited for the CAMPARE and Cal-Bridge programs



Alex Vasquez, SSU's first Cal-Bridge scholar

Capstone Research & Hichwa Award:
Impact of Gold Nanoparticles on ZnO Nanowires

By Kyle Johnson

I wanted experience in a lab where I could conduct experiments, analyze results and build solutions. The Hichwa award granted me that opportunity in the summer of 2019 when I gained access to the Physics Department Laboratory in Darwin Hall and the Keck Microanalysis Lab in Salazar Hall to engage in experimental research. Under the guidance of Dr. Hongtao Shi, I began growing wide bandgap semiconductor zinc oxide (ZnO) crystals on substrates such as tin doped indium oxide (ITO), through a process known as electrochemical deposition (ECD). While the ITO substrates performed as a cathode to attract Zn^{2+}, a platinum wire was used as an inert anode. The importance of this research lies in the demand for semiconductors in fields such as telecommunications, integrated circuits, lasers and light emitting diodes (LED).

Our goal was to construct uniform and ordered ZnO nanowires perpendicular to the substrate, at temperatures below 100°C, with as few defects as possible, in solutions containing Zn^{2+} ions and a buffer called HMT. While I tried many parameters to optimize the deposition process, the majority of my research focused on the cause and effect of gold nanoparticles on the quality of ZnO nanowires. The ITO substrates were either spin-coated with gold nanoparticles (average size about 5 nanometers) or left bare before the ECD process started. The hypothesis was that gold nanoparticles would increase the availability and uniformity of nucleation sites on ITO for the creation of better ZnO nanowires, while the bare ITO substrate would act as the control sample.

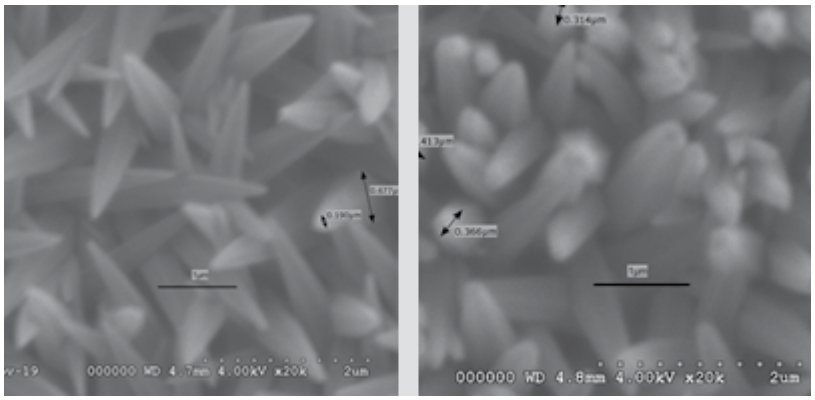


Figure 1. SEM micrographs of ZnO nanowires grown on gold nanoparticles (left) and bare ITO substrate (right).

Figure 1 shows the scanning electron microscopy (SEM) images of two samples prepared under the same conditions except that sample A had gold nanoparticles on the ITO substrate prior to the deposition process and sample B did not, serving as a control sample. These images were taken at the nanometer scale in the Keck lab in Salazar, and we can actually see the nanowires!

It did not end there; while comparing the SEM images could give us visual indicators of the surface morphology, which did not vary greatly for these two samples, laser induced photoluminescence (PL) could give us information on the semiconductor's optical properties, which certainly depend on the quality of the crystal. As we are bombarding the semiconductor with ultraviolet photons, excited electrons fall back to recombine with holes in the material to emit photons, which is characteristic of the band gap of the semiconductor. Figure 2 shows the PL spectra of these two samples at room temperature. The sample grown on spin-coated gold nanoparticles emits a lot more photons with a much narrower peak width than the control sample. Such a dramatic difference was due to the enhancement of the crystal quality, resulting in fewer defects in the ZnO nanowires when the gold nanoparticles were used as a seed layer between the ITO substrate and these nanowires. Such a sample also showed a typical rectifying current-voltage behavior when a thin metal layer was deposited on top of the ZnO nanowires (see the inset of Figure 2), forming a Schottky diode. On the contrary, the control sample did not show this rectifying behavior at all.

The Hichwa award presented me a rare opportunity to pursue research. It was a tremendously hands-on and rewarding experience. Trouble-shooting failed samples was a step into the reality of science, where things do not always work out. Where you have to extrapolate new hypotheses, get a better grasp of the basics, or read articles that may or may not pertain to your research. It is stepping into the void of what you do not know and challenging yourself to adapt and understand. The research was not easy and there were days when I struggled a lot. Through these struggles, I expanded my knowledge, and the void of the unknown started to illuminate. For this, I could not be more grateful.

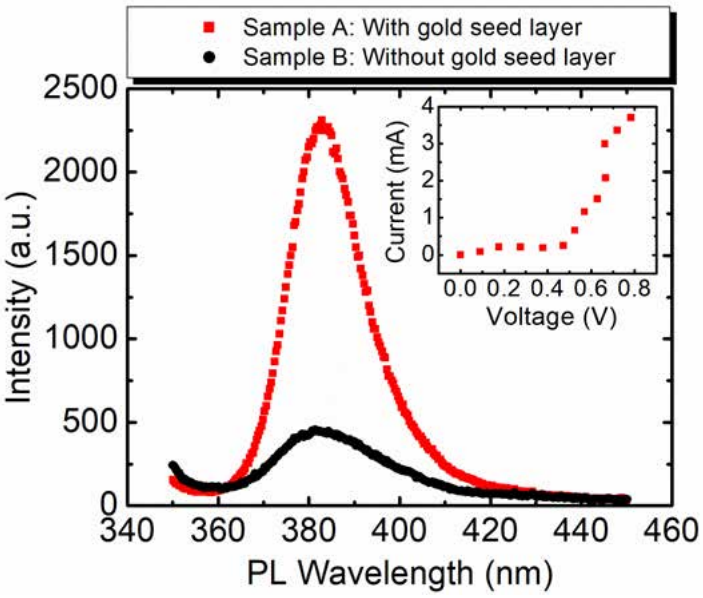


Figure 2. Room temperature light emission spectra from sample A and sample B described in Figure 1. The inset shows the rectifying behavior of sample A after a thin metal layer was deposited on top of the ZnO nanowires to form a Schottky diode.

Innovating Introductory Astronomy Education with Virtual Reality:

By Prof. Scott Severson

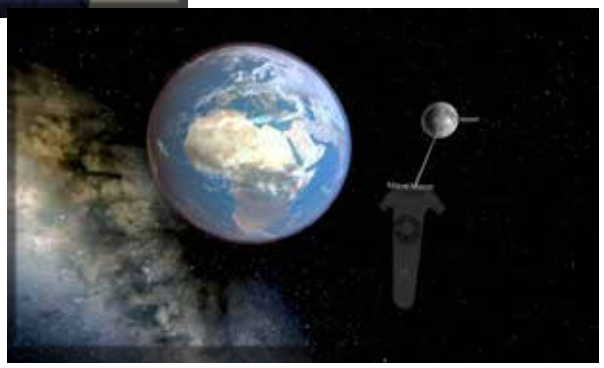
Professor Scott Severson has been awarded a CSU Lab Innovations with Technology (LIT) award to develop virtual reality educational experiences for astronomy students. CSU LIT is part of a systemwide Academic Technology initiative aimed to reduce bottleneck courses for students using innovative online, remote web-based, and lab kit technologies.

Student using Virtual Reality to explore Phases of the Moon

Dr. Severson is focusing his efforts on addressing key conceptual hurdles facing ASTR 100 students, in partnership with Dr. Justin Lipp, Director of the Faculty Center and Educational Technology, as well as Dr. Sara Kassis, Faculty Fellow of Immersive Learning, and adjunct faculty in the Department of Physics & Astronomy. One exercise, addressing the spatial origins of the phases of the moon, has already been designed and implemented in the course. The LIT award will support the assessment of the impact of VR activities in the classroom and the development of more exercises that will address the fundamental difficulty students have with relative size scales in astronomy and the revolution in observing and characterizing planetary systems outside our solar system through the use of planetary transits.

The hope is that these interactive VR activities will both improve student engagement with the course and break through student misconceptions by making explicit the conceptual leaps of modern astronomical discovery. "The increased engagement and support on difficult topics are important components of supporting student success and improving D, F, and W rates", says Dr. Severson. "Our initial work in-progress with the existing activity shows 90% of students either agree or strongly agree that the immersive experience stimulated their curiosity, and that student assessment shows a near 10% increase in correct responses over non-VR instructed students."

The additional VR exercises are implemented in one section of ASTR 100. With the expected addition of more VR compatible hardware, these exercises can roll out to the other sections of the course, benefitting the entire ASTR 100 course population. Dr. Severson expects to use his experience to guide others in the Department who wish to innovate other courses, and help the Department adapt to recent campus-wide changes to general education standards.



Screenshot showing VR controller being used to move the Moon around the Earth

AlumNotes

Steve Jilka ('71) *is a senior project manager with Teradata in San Diego. He earned an M.S. in physics at San Francisco State University in 1972 and another, in systems management, at the University of Southern California in 1978.*

Zee Betty Hakimoglu ('75) *is President and CEO of ClearOne Communications. In 2007 she won Frost & Sullivan's 2007 Audio Conferencing CEO of the Year award. Formerly vice president for product line management of Oplink Communications in San Jose, she earned an M.S. in physics at Drexel University in 1979. She was chosen as one of SSU's Distinguished Alumni in 2011.*

Jon M. Jurgovan ('85) *is an administrative patent Judge in the Dallas area. He was formerly a senior patent attorney with BlackBerry in Texas and with Alston & Bird LLP in Atlanta. He earned an M.S. in electronic engineering at California State University, Fullerton and a J.D. at Washington & Lee University in Virginia.*

David E. Marshall ('88) *an information technology consultant, private pilot, and aircraft owner. He currently manages the IT support group in the College of Natural Resources and Sciences at Humboldt State University, where he earned an M.S. in mathematical modeling in 1998.*

Department of Physics and Astronomy Wins Teagle Grant

By Prof. Alexandra Miller

The Faculty-Led Curriculum Redesign for Student Success Program, generously funded by the Teagle Foundation and College Futures, is a six-campus CSU collaboration that will bring faculty from across the campuses together to share ideas aimed at furthering Graduation Initiative 2025, as well as general student success. Ultimately, fifteen projects at SSU will be funded as a part of this project. Led by Profs. Alexandra Miller, Scott Severson, and Tom Targett, the SSU Department of Physics and Astronomy has been awarded one of these grants. This award will provide support to the department in their efforts to develop a new Bachelor of Arts degree in Physical Science. This will be a STEM degree with a strong Liberal Arts basis. Its primary focus will be in the fields of Physics, Astronomy, Chemistry, and Geology, but it will also be quite flexible, allowing students to follow their individual interests via intentional pathways. This will include an optional concentration in Teaching aimed at students who ultimately wish to teach Foundational General Science. The new BA in Physical Science will become available to students starting in the Fall of 2021.

Education & Public Outreach Department Announces a New Name: EdEon

By Dr. Laura Peticolas

edeon.sonoma.edu

What is in a name? When we are born, we are often given a name which can stay with us for our whole lives. Sometimes we change our name, whether it is our first name because it just doesn't seem to suit us or our last name if we want to share a last name with a partner. Organizations go through similar processes.

Our grant-funded Science, Technology, Engineering, and Mathematics (STEM) group, founded by Prof. Lynn Cominsky with NASA funding in 1999, started with the name NASA Education and Public Outreach (NASA E/PO). The group's STEM education work continued to be exclusively funded by NASA until 2015, when the NASA funding for education within the Science Mission Directorate changed. Together with Susan Wandling, who runs the Academic Talent Search program, Prof. Cominsky was able to secure funding from the Department of Education. This meant large changes in skill sets within the team as well as a different type of focus in the STEM education work done within the group. As Prof. Cominsky was able to diversify the group's funding, keeping NASA in the name no longer made sense. The group needed a new name and SSU Education & Public Outreach, or SSU E/PO for short, seemed to better represent the new funding portfolio. It didn't stop people from still calling us NASA, however, and the confusion with SSU's EOP (Equal Opportunity Program) worsened.

In 2017, I joined the E/PO group as the Associate Director. Almost immediately, staff began to ask for a new name. Since I had gone through the rebranding process in my previous STEM education job at UC Berkeley, I was excited to do this work at SSU too. In my previous work, I discovered that group and organization names are most effective if they are just a single word, or two at the most. Think of Apple, Nike, Microsoft, Clover Sonoma as examples of successful names. Just as people know me as Laura, they have to get to know me to really know what does Laura mean? The same is true for brand names. It is through interactions with these brands that we come to know and love them for what they provide. The same is true for STEM education organization names.

As the group separated from the Physics & Astronomy Department into our own Department, we spent time discussing possible names, building them from pieces of words that represent what we do, who we are and what we value. After pages of names, we finally landed on EdEon. Our tag line is "A STEM Learning Center" and the "Eon" part of the name implies education forever, or at least for all ages.

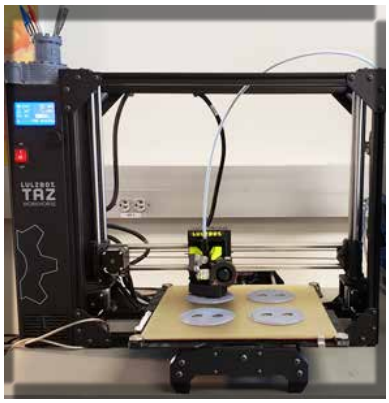
What can you expect from EdEon as we move into the future? We will be developing our own strategic plan to ensure our activities are aligned with those of both SST and SSU, and we are working on becoming an official SSU Center. We are also developing a new website to reflect what we do and what we want to do. As a fully grant-funded department, we already work across schools, supporting a wide variety of students doing STEM internships. In the future, we aim to support other groups and projects that may have administration or staffing needs for their own grant-funded work. We look forward to engaging more SSU students in real-life applications that provide them opportunities for employment in fields they are passionate about.

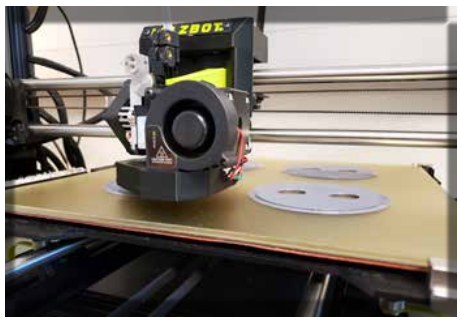
If you are interested in learning more or seeing how your own work can be supported by EdEon, please email me for more information at : *laurap@universe.sonoma.edu.*

Physics & Astronomy Student Success Display

By Ryan Brown

The SSU Physics and Astronomy Department has created a "Student Success Display" in Spring of 2020, created using SST Innovation and Strategic Priorities funds. Here, you will see all of the accomplishments from past and present physics, astrophysics, and astronomy students, in an ever-changing slide show of research summaries, photos, and short biographies. These include student research into nanotechnology, Capstone senior projects, and live data from projects such as the SSU EdgeCube Satellite program. Artifacts from past research are also featured. Stop by the South-East corridor on the third floor of Darwin to explore what SSU Physics & Astronomy students are working on!





Prototype, Program, Print

The SSU Physics and Astronomy department introduced a new 3-D printing station in January of 2020 called "Prototype, Program, Print" enabled by the SST Innovation and Strategic Priorities funding program. With the introduction of this 3-D printing station, physics, astrophysics, and astronomy students now have modern 3-D printing technology at their fingertips. These students now have a clear avenue to engage in 3-D fabrication and design through various CAD platforms available on all Physics and Astronomy Laboratory computers. With this technology, students can now design prototypes and print them for their research or for limited personal use.

Capstone Research:
Developing a High School STEM Curriculum

By Courtney McNatt

Courtney and baby Ryan

Working with the EdEon group has given me the opportunity to gain professional experience with secondary education. Being involved with helping to develop the Learning by Making (LbyM) high school curriculum grew my passion for science education. My senior capstone project goal was to collect survey response data from students who have been taught the material from LbyM by both our outreach workshops and classes taught at local high schools. While I was able to lead a few student workshops and get some data responses I was not able get data from the high schools due to the Shelter in Place orders. From the data I collected it is evident that this program helps students to feel more confident learning difficult science concepts and they are having fun while learning. My main task with LbyM was editing material by reading it with first a student mindset and then as an educator. The most important thing in curriculum development is clarity in instructions and diagrams. A lot of work has been put into developing this material over the years and I feel my contributions have made a positive impact. I am excited for the students who have, or will have, the opportunity to be taught this curriculum as it is a very different way of learning compared to the traditional way of teaching science with textbooks, lectures, etc.

Trying to make science class fun is not a new concept and the only person who even came close in my opinion to succeeding is Bill Nye. Learning by Making is revolutionary by bringing computer science into the classroom and integrating multiple science disciplines into all experiments. It allows teachers a convenient way to teach more effectively while still fulfilling Next Generation Science Standards. Students are engaged and excited to learn which is the most important part. It is my hope that more students will continue their science education because of Learning by Making and we can help the world by growing the number of professionals in STEM careers. I believe science is for everyone and I hope to see LbyM be the new standard of what a science class should be.

Capstone Research:
Investigating the Origins of Structural Color and Iridescence in Blue Morpho Butterflies

By Logan Hofer

Color in nature comes mostly from inherent colors of pigmented materials, though it sometimes has a purely physical origin that is produced by light reflecting, diffracting, and interfering with structures. The goal of my Capstone project was to explore this phenomenon, known as structural coloration, that gives the wings of the Blue Morpho Butterfly its beautiful iridescent blue color. Essentially, the structural color and iridescence is a product of visible light interacting with rows of Christmas tree-shaped nanostructures on the scales of these butterfly wings. These Christmas trees have anywhere from 6-10 alternating branches, which cause light to constructively interfere between 400-500nm in wavelength (blue and purple) when you factor in the following variables: phase shift, branch thickness, air's refractive index, branch's refractive index, diffraction integer, and observation angle. The Blue Morpho is just one example of a biologically induced structural color but scientists have begun studying other similar nanostructures with the goal of manipulating light to create anti-counterfeit currency, biometric fabrics, multilayer solar innovations, and thermal detecting mechanisms.

Blue Morpho Butterfly wings

In many ways, this Capstone project challenged my ability to learn quickly and adapt to the unforeseen circumstances that often wreak havoc on our structured lives. My favorite part of this project was learning to use the Keck Lab's Scanning Electron Microscope to capture some amazing images of the butterfly wings. I'm sure that I share the same thoughts as many of my fellow graduates regarding the timing of this global pandemic, but I'm currently helping out at my family's aerospace manufacturing business with the goal of one day running the business. I also would like to give a quick shout out to Dr. James Lee for all his help!

Capstone Research:
Infrared Scanning, Object Classification, and Safety Screening: Thermographic photography from theoretical concepts to real world applications

By Michael Stephens

Initially, my project was intended to use an infrared camera to characterize the unique exhaust signature of vehicles and identify them through image recognition. Things do not always go as planned, and, in the process of data collection the COVID-19 outbreak occurred. For a period of two months most of my efforts ended up being refocused to effectively screening personnel as an essential employee for a large manufacturer and resulted in efficient checks for our staff. Between working with people and vehicles and seeing the variance in temperature between samples and ambient conditions I collected data that are being processed to determine the viability of my original idea that will hopefully be done prior to presentation. After graduation I intend to return to the United States Marine Corps and apply my education toward the continued defense of our nation.

Michael Stephens next to his personnel screening equipment in various states of PPE coverage. The author found that he had to apply his image recognition skills in industry far sooner than expected!

AlumNotes

Lauren J. Novatne ('89) *is the physics instructor at Reedley College. She earned her M.S. in physics at California State University, Fresno in 1999.*

Daniel Swearingen ('91) *is the Director of Studio Operations of Autistry Studios, a non-profit organization to help teens and young adults with social, communication, and learning differences become successful independent adults, in Marin County. A long-time programmer, webmaster, and businessman, he earned a master's degree in physics at California State University, Northridge in 1991, and a second master's in astronomy at Indiana University in 1997.*

Monika Ivancic ('93) *is the manager of the NMR Facility of the University of Vermont. She was formerly associate director of the Magnetic Resonance Facility in the Chemistry Department of the University of Wisconsin-Madison. She did postdoctoral research in biochemistry at the University of Vermont after earning her Ph.D. in Biochemistry and Biophysics at Oregon State University in 2001.*

Jeff Kavanaugh ('94) *is an associate professor of earth and atmospheric sciences at the University of Alberta. Formerly a postdoctoral researcher in the department of geography at the University of California at Berkeley, he earned his Ph.D. in earth and ocean sciences at the University of British Columbia in 2000. His research in glacier dynamics has taken him to the Yukon, Antarctica, and points in between.*

David J. Lamb ('94) *is an advanced physics research specialist in the Display Materials and Systems Division of 3M in St. Paul, MN, where he is currently working on automotive sensor applications as well as displays. He received his Ph.D. in physics at the University of Alabama in Huntsville in 1999, where he worked on the use of Fresnel lenses in a proposed space-based extensive air shower observatory called the Orbiting Wide-angle Light-collector (OWL).*

Scott Fraser ('95) *is teaching physics at Cal Poly San Luis Obispo. He earned a Ph.D. in physics, with a dissertation on black holes and extra dimensions, at the University of California, Santa Barbara in 2010. Previously he earned a certificate of advanced study in theoretical physics at the University of Cambridge after spending a year at the University of Heidelberg on a Barry Goldwater Scholarship.*

Bill Oakes ('96) *is currently an Operations Management Consultant at Sonoma Lean Solutions. He formerly worked at Medtronic, JDSU (now Viavi Solutions), and TriVascular Technologies, Inc. (now part of Endologix) in Santa Rosa. A specialist in machining, he has recently provided advice to SSU seniors doing capstone projects.*

Barnell Hampton ('98) *is a program analyst with E&J Gallo Winery in Modesto.*

Tim Graves ('01) *is director of special projects and data management at Telecare Corp. in Alameda. He was formerly a business analyst with Pacific Pulmonary Services in Novato. For ten years he was an educational developer and information technology consultant on the NASA Education and Public Outreach team at Sonoma State University.*

Mark Loguillo ('03) *is a high pressure team lead for sample environment within the Neutron Sciences Directorate at the Oak Ridge National Laboratory. He was formerly a systems engineer with United Space Alliance working with hazardous gas detection systems in and around the space shuttle at the Kennedy Space Center. He earned an M.S. in industrial engineering from the University of Tennessee Knoxville in 2015.*

Ryan McDaniel ('07) *is an engineer at Deposition Sciences , Inc., a wholly owned subsidiary of Lockheed Martin Corporation in Santa Rosa. For many years, he has been a dedicated volunteer at the SSU Observatory.*

Orion Leland ('08) *is an automation engineer at Alluxa, Inc. in Santa Rosa. He formerly worked at Twin Creeks Technologies in San Jose and RETECH Systems LLC in Ukiah. He earned a master's degree in electrical and electronic engineering at California State University, Sacramento in 2014.*

Luke Haley ('11) *is an industrial engineer at Keysight Technologies in Santa Rosa. He earned an MBA at California Southern University in 2018.*

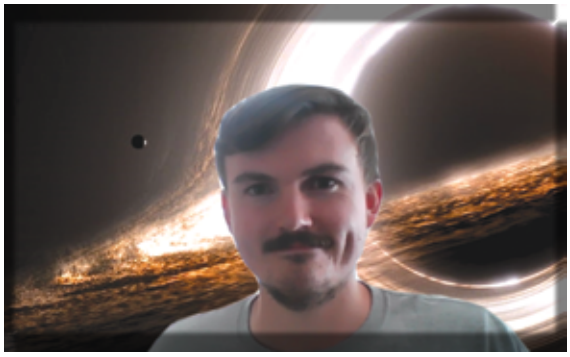
Katie Badham ('13) *is an electro-optical engineer at Lockheed Martin Space in Palo Alto. She earned an M.S. in physics at San Diego State University. Formerly an optical engineering intern at Cymer in San Diego, she also interned at Raydiance in Petaluma.*

Kevin Zack ('14) *is an Electrical Engineer at Applied Physics Laboratory at the University of Washington in Seattle. Previously, he received an M.S.E.E. and worked as a Research Engineer at Montana State University, and at L3 Wescam/Sonoma Operations. While at SSU, Kevin was the student leader for the successful T-LogoQube small satellite project.*

Capstone Research:

General Relativity: Motion in Black Hole Spacetimes

By Joseph McGuire



When it comes to black holes there is still a lot we have to learn. But, one thing that we understand well is how things move around black holes. My project focuses on simulating the kinematics and orbital mechanics of bodies near black holes, particularly the motion near stationary and rotating black holes. To describe this motion with any degree of accuracy, I had to first learn the language of general relativity with the help of Dr. Alexandra Miller. The major differences between Newtonian gravity and Einsteinian gravity lead to a real abundance of interesting phenomena to investigate. Notably there is the precession of orbits near large bodies, which was used as a first major test for General Relativity in our own solar system with the orbit of Mercury. There's also gravitational time dilation, the bending of light due to gravity, the stable orbits of photons near a black hole, and even the possibility of wormholes. Using numerical methods with the help of Mathematica and Matlab, I simulated some of these occurrences near these strangest bodies in the universe, black holes. These simulations are necessary for those working in the area of astronomy. Especially when dealing with accurately modeling the orbit of celestial bodies or even finding the next black hole candidate.

The reason why I chose this project and the area of general relativity in the first place was partly as a learning opportunity for myself and partly as an opportunity to model some of the strangest behaviors that we see in the observable universe. As a mathematician, part physicist, the area of general relativity offers a beautiful intersection between the two areas. The pure abstract language of mathematics is employed to tell us how the geometry of the universe dictates motion. As someone who loves to work in the intersection between different fields, this project has been immensely enriching.

For my future plans, this fall I'll be attending the M.S program in mathematics at Cal Poly, San Luis Obispo. My career plans are working in research in the area of applied mathematics, using the language of mathematics to connect and collaborate in many different disciplines.

Black Holes and Zombie Cats: Prof. Miller attracts new students to physics

by Profs. James Lee and Alexandra Miller

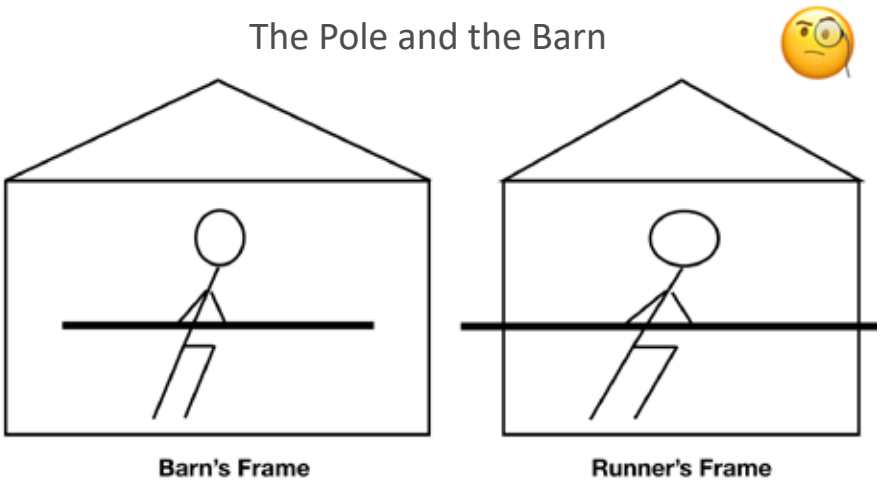
Prof. Alexandra Miller has developed an innovative new course to attract students to physics and introduce curious minds to our field's most exciting ideas. Called "20th Century Physics: From Black Holes to Zombie Cats (PHYS 100)", the course introduces the core concepts of Special Relativity, General Relativity, and Quantum Mechanics to freshman and sophomores with knowledge of high school-level algebra and no prior physics experience.

Tackling these topics can be daunting for physics majors, who are equipped with calculus and prior physics classes. Generations of physics majors have spent evenings debating with study partners how time can tick by at different speeds for different observers. Long nights are often required to work out what it means for objects to simultaneously exist in multiple places at once. How would non-science majors, with minimal mathematical tools, handle it?

Prof. Miller's experience indicates that students can handle it just fine: "One of my proudest moments involved the pole-in-the-barn paradox", a familiar problem for many physics majors learning about length contraction and the meaning of simultaneity in relativity. While it took a little longer than she anticipated, Prof. Miller remembers "when it finally clicked for the students, and they all went 'What? This is crazy!'" (As physics professors, we agree and we love it!)

As the class concluded, one student told Prof. Miller that "she never really liked science but she really enjoyed [the] class". Another student was moved enough to contemplate switching majors, and approached her to ask about the process during office hours.

Relativity and quantum phenomena seem so strange because they are mainly noticeable in conditions outside the realm of everyday human experience. Prof. Miller looks forward to revising her class and putting these fascinating ideas within the reach of more SSU students.



Adapting to the Pandemic with Technological Know-How, Heart, and Grit

By Prof. James Lee

In response to the emerging COVID-19 pandemic, on March 11, SSU President Judy Sakaki announced the suspension of face-to-face classes and a period of preparation for "remote, virtual, or alternative assignment modality" instruction.

About a week ahead of the announcement, junior and senior faculty, tenured and adjunct, met nearly daily to discuss how to maintain the quality of our lecture and laboratory courses. In informal hallway conversations and scheduled conferences, we brainstormed ideas about translating classroom practices to online experiences. We decided that lab classes would go ahead as a mix of externally-created software simulations and faculty-made videos. Lectures would be enriched with self-guided worksheets for students from field-tested sources. We learned about online collaboration tools and shared whatever we found useful with each other.

Interactions became more remote with mandated social distancing: group discussions became one-on-one chats across six foot distances. We worked in pairs or individually with smartphone cameras to record ourselves doing experiments, making videos that would have to substitute for hands-on work. In time, we came in alone, an hour at a time, to gather whatever we needed before Darwin Hall was closed and on-line instruction began on March 24.

Courses have wrapped up and final exams graded: how did things turn out? While it's fair to say that no one is satisfied, we learned a good deal. Ryan Brown came to appreciate "the importance of on-line backups [of course materials]", whose well-organized physical copies of which were cut off from him when Darwin closed. Prof. Targett found the period "a chance to try a bunch of things I wouldn't normally have tried" in a regular semester. Along these lines, Prof. Severson is thinking of developing and using asynchronous on-line learning modules in even his face-to-face classes, once they restart.

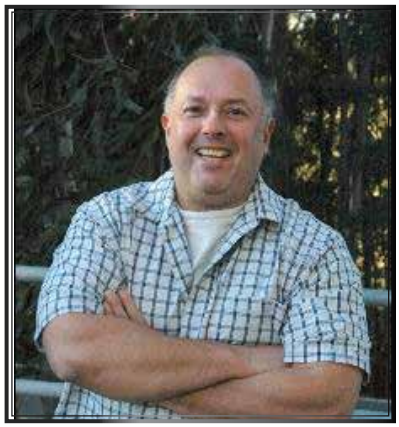
Though separated, we found ways to reconnect: in addition to virtual weekly department meetings, we arranged regular, informal "watercooler discussions" on Zoom (see picture) to celebrate successes, commiserate setbacks, and to shoot the digital breeze. The on-line tools we used in our courses also kept the department together through the semester.

The CSU system plans an entirely virtual Fall semester. After this trial by ordeal, the department is now much better positioned to tackle that challenge.

Mario Marckwordt 1957–2020

By Joe Tenn, Professor Emeritus

In 1991 I was advisor to all physics majors, and one of them stood out a bit. He was 34 and had been working as a furniture mover. A back injury had persuaded him to heed his wife's counsel that he should rely on his intelligence rather than his strong back for his career. The son of immigrants from Guatemala, he had never been studious, but she saw his capacity and urged him to go back to school. At SSU he chose physics because it was challenging, even though he had to start with algebra and trigonometry. He became so fascinated by the subject that he gave his first son the middle name Fermi, in honor of the great 20th century physicist.



He worked hard and quickly made up for his poor scholastic background. As I wrote in a letter of recommendation for a summer research program in 1994, "Mario is that rare student who continues thinking about what he has studied even after the final exam is over. He often comes by my office to discuss questions regarding material from the mathematical physics course. He finds electricity and magnetism so fascinating that he is auditing the course this year to get more insight and the perspective of a different teacher despite the fact that he earned an A- in the course last year."

A year later he graduated and entered the master's degree program at San Francisco State University. At about this time he gave his second son the middle name Tenn in my honor. I was astonished when he told me. I think it tells us something about Annette Marckwordt that she went along with this. But there is more. About the time he completed his M.S. in physics his daughter was born, and she was given the middle name Lea in honor of his graduate advisor, Dr. Susan Lea.

Mario then went to work at the University of California, Berkeley's Space Sciences Laboratory. I recall the time a few years later when he told me how proud he was that an instrument he had built was operating on a satellite in space. He worked at the SSL for more than twenty years as a highly successful aerospace engineer. His colleagues appreciated his perseverance, capability, and good humor. All three of his children went to college, a source of great joy to him. One, Mario Tenn Marckwordt, just graduated from UC Berkeley as a physics major.

When I retired the Department held a graduate reunion that doubled as a retirement party. Two weeks later Mario made the trip to SSU and walked into my office to apologize for missing it. His reason: he had had a heart attack. That was eleven years ago. Tragically, he had a second heart attack on April 22, and this one was fatal. He is greatly missed by his family, his colleagues, and all who knew him. Tributes from others may be found at:

www.ssl.berkeley.edu/mario-marckwordt-1957-2020/#comments.

Thank You for Your Support!

This has been a year to remember, with the addition of two new faculty, James Lee and Alexandra Miller; a new lab manager, Ryan Brown; the start of a new student award, the Ongaro Family Scholarship; wildfires and mass evacuations in the Fall, and the challenge of delivering high quality education under a pandemic in the Spring. Our academic programs rely heavily on the generous support of donors and your contributions help advance science and learning in our student-centered model.

We have three ongoing student research assistantships: The Horace L. Newkirk Endowed Assistantship and the Mike & Sheila McQuillen and Bryant & Diane Hichwa Summer Research Awards. Research is thriving within the Department, and funded research experiences have provided our students with incredible opportunities. Other scholarship funds, such as the Duncan E. Poland Physics and Astronomy Scholarship, the Sol and Edith Tenn Scholarship, and the Joseph S. Tenn Scholarship, also support and provide students with opportunities they would not have if not for the generosity of donors.

Our public programs remain vital, including the "What Physicists Do" lecture series and the Public Viewing Nights at the SSU Observatory. These are partially supported through donations and grants from SSU's Instructional Related Activities Fund. WPD remains the longest-lived public lecture series on campus, and was hosted this year by Prof. Tom Targett. This fall the series will celebrate its 100th semester and include some live-stream events, so be sure to subscribe to the Public Email List (public-phys-astr): *http://www.phys-astro.sonoma.edu/mailinglist.shtml.* If you would like to support our program and students please see:

http://www.phys-astro.sonoma.edu/publicSupport.shtml,

or contact the SSU Development Office at (707) 664-2712 or contact the Department.

Current Funds:

#C0141 Public Programs
Robert A. Fisher

#C0142 Physics & Astronomy Equipment and Supplies
Charles A. Bullen ('75) & JoAnne Etheridge, Anonymous

#C0144 Student Development Program
Dr. Bryant P. and Diane Hichwa, Michael T. & Sheila McQuillen, Lauren Novatne ('89)

Endowment Funds:

#E0185 Charles and Norma McKinney Fund
The Charles and Norma McKinney fund supports public programs.

#E0208 Horace L. Newkirk Memorial Student Assistanship
Established by Nadenia Newkirk in memory of her father to support student research.

#E0231 Duncan E. Poland Physics & Astronomy Scholarship
Lynn Cominsky and Garrett Jernigan, Paul Shaffer

#E0269 Science at Work Fund
Established by John Max to support What Physicists Do.

#E0304 Sol and Edith Tenn Scholarship
Established by Joe Tenn to honor his parents.

#E0305 Joseph S. Tenn Scholarship
Dr. Richard De Freez ('80) and Ms. Toni Kristensen

Cominsky to Serve as STEM-Net Faculty Fellow at SSU

Professor Lynn Cominsky was recently selected to serve as SSU's first STEM-Net Faculty Fellow. The appointment begins in the summer of 2020 and will extend through the next academic year. The role of the STEM-Net Fellow is to: i. Work with key faculty to develop and submit targeted STEM-based proposals, ii. Develop collaborative grants (research and educational-based) with faculty; iii. Help promote a culture of scholarship on campus, and; iv. Take on new initiatives as directed by the SST Dean, and CSU STEM-Net Director. Cominsky has an unparalleled record in obtaining grants at SSU: to date she has brought in over $28 million in funding from agencies including NASA, NSF and the US Department of Education.

Generous Donation of Scientific Equipment:

By Prof. James Lee

The Department of Physics and Astronomy has received a generous donation of scientific equipment from a regional corporate donor. Zygo Corporation, a unit of AMETEK Inc. based in Richmond, has contributed a vibration dampening optical table top (shown in picture) and table legs. If newly purchased, this equipment would cost approximately $25,000. The table top and legs isolate finely-aligned optical apparatus from vibration sources, such as the footfalls of passersby or the hum of air conditioning. Free from such disturbances, students will be able to use optical equipment mounted on the table to study subtle changes in material properties—shape, density, or even magnetization—that occur over microseconds to hours. The donated equipment is being set up in Darwin Hall and will be ready soon after pandemic-related restrictions are lifted (hopefully, early Summer).

Vibration dampening optical table top

Microsoft Donates VR Equipment Used By Physics Department

By Dr. Sara Kassis

Microsoft has donated 22 Mixed Reality Headsets to Sonoma State University's Immersive Learning@SSU Program for the purposes of faculty and students to develop mixed reality applications. Dr. Sara Kassis, Faculty Fellow of Immersive learning, and adjunct faculty member in the Departments of Engineering Science and Physics & Astronomy, accepted the donation from Jo Ryall, head of Marketing for the SF Academy at Microsoft Reactor. Some of the headsets will be used for coursework in classes such as ASTR 100, while a limited number of headsets are to be available on short-term loan at the SSU Library.

To the Graduates

By Joe Tenn, Professor Emeritus

In 1974, as I prepared the first issue of The Physics Major, I went over to the campus computer center and keypunched a card for each of the Department's 22 graduates. It contained name, address, phone, and type of degree. I then sent letters to the grads and used the replies in the newsletter. For the next 45 years I continued to query the graduates about their careers and further education, and the results may be seen in the 46 newsletters available for download from the Department website. In addition, we have a list of graduate achievements at *http://www.phys-astro.sonoma.edu/gradsAchievements.shtml* which is the envy of other departments at SSU and other universities as well.

Nothing lasts forever, and I am now spending most of my time on the Astronomy Genealogy Project (AstroGen: *http://astrogen.aas.org/*), which will soon be online. Fortunately, Dr. James Lee has volunteered to take over maintaining relations between the Department and its graduates. If you are one of them, please keep in touch with him and share your achievements with your fellow alumni and the faculty.

AlumNotes

Demitri Call ('16) *is a graduate student and teaching assistant in physics at the University of Nevada, Reno, where he is also the Vice President of Internal Affairs for the Graduate Student Association. He served as an intern with the Committee on Science and Technology of the U.S. House of Representatives during the summer of 2016.*

Michael Dobbs ('17) *is an associate at Sage Renewable Energy Consulting in San Rafael. He previously conducted research at the Wolfram Summer School and at CERN.*

Zachary Kurland ('18) *is enrolled in a Physics Ph.D. program at the University of Massachusetts, Lowell.*

Scott Allred ('19) *is an equipment engineer at Keysight in Santa Rosa, CA. Before graduation, he worked as a peer mentor for SSU's Sci 220: Dream, Make and Innovate, and also played an important role on the EdgeCube satellite project.*

Shannon Lessard ('19) *is enrolled in a teacher credential program at a satellite campus of the University of San Francisco. She worked extensively with Petaluma High School students building a 3D sandbox as part of her senior capstone in instructional design.*

Ernest "EJay" Ongaro ('19) *is the Administrative Manager of his family's business, Ongaro & Sons, who recently established a new scholarship program for SSU physics majors, the Ongaro Family Scholarship Fund (see article).*

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