

The Dilated Times

The Newsletter of the Drew University Society of Physics Students

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Editor: Rachel Newburg

2016 Physics Congress in California



By Rachel Newburg '17, Jenny Soter '18 and
Natalya Scherban '19

Last November physics majors Natalya, Rachel, and Jenny travelled 3,000 miles to San Francisco, California to represent Drew's SPS chapter at the 2016 Quadrennial Physics Congress. Every 4 years the physics honor society, Sigma Pi Sigma, hosts a three-day conference to bring together undergraduate physics students, alumni, and faculty members to bond, inspire one another, and grow professionally. This year's theme was "Unifying Fields: Science Driving Innovation." From November 3 to November 6 our days were packed with talks, workshops, presentations, and some sightseeing.

We left campus around 4 AM to catch our flight to San Francisco. Sadly our flight was delayed and we missed the first event of the conference: a tour of Stanford's particle collider, SLAC, the longest linear accelerator ever built. We did arrive in time for the networking reception to enjoy some tacos while we talked with representatives from dozens of different graduate programs. Later that night, we listened to a talk given by the astrophysicist Dr. Jocelyn Bell-Burnell, the discoverer of the first pulsar. She talked about her work as the only woman on a team that won the Nobel Prize in Physics, though her contributions went unrecognized. Dr. Bell-Burnell has been a leader for women in science, and was inspirational in her discussion of the need to be more diverse and inclusive in the science, technology, engineering and mathematics (STEM) fields.

Bright and early Friday morning we had "Breakfast with the Scientists" where we sat down in small groups with a scientist whose field we were interested in and asked questions. Next was the first workshop of the conference, "Unifying Fields: Science Driving Technology." During this workshop we worked in groups to design a solution to a societal need by combining technology from several fields randomly assigned to the groups. It was a great opportunity to meet and work with other physics students, and to think about the various applications of physics and technology.



After lunch Jenny presented a poster on research she conducted during an independent study in Spring 2016 titled "Assessment of Temporal Features of Neural Circuitry in Primary Olfactory Regions." This was Jenny's fourth conference presentation. It was a unique experience for her because of the multidisciplinary nature of her research. The work was done through Drew's Neuroscience Department, but was largely a computer-programming project that had physical applications. This was her first opportunity to present this project at a physics conference, which allowed her the opportunity to discuss the math,

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UV Optics at Brigham Young

By Zoe Hughes '17

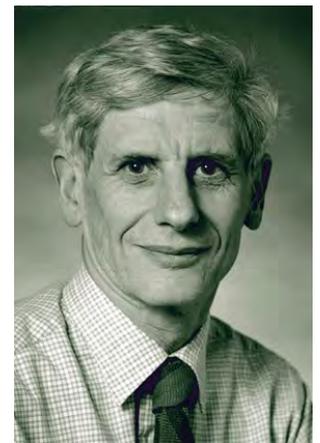
Last summer I had the privilege of doing research at Brigham Young University (BYU) in Provo, Utah as part of their Research Experience for Undergraduates (REU) program in the Physics and Astronomy Department. My project was in the field of extreme ultraviolet optics. I worked on determining the index of refraction of aluminum fluoride in the extreme ultraviolet spectrum, approximately from 6 nm to 50 nm. My project originated from NASA's new flagship telescope LUVOIR (Large UV/Optical/Near-Infrared Telescope). NASA hopes to use this telescope to explore new exoplanets and galaxies. A team at BYU is designing coatings for the mirror for this telescope. Aluminum is commonly used for this purpose. However when aluminum is exposed to the atmosphere it oxidizes, which affects the mirror's ability to reflect extreme ultraviolet (EUV) light; therefore, a coating is needed to protect the aluminum. One possible coating they tried was aluminum fluoride. My task was to find the index of refraction of this compound and determine if it would be the right fit for the LUVOIR telescope. Aluminum fluoride is especially interesting because its index of refraction is still experimentally unknown in the EUV spectrum. Overall, my project was successful because I was able to collect accurate data and calculate experimental values for the index of refraction. More data needs to be collected to clearly confirm if aluminum fluoride is the right coating for the LUVOIR telescope mirror. My REU experience was amazing and I definitely recommend physics students apply to them!



Famous Physicist: David James Thouless

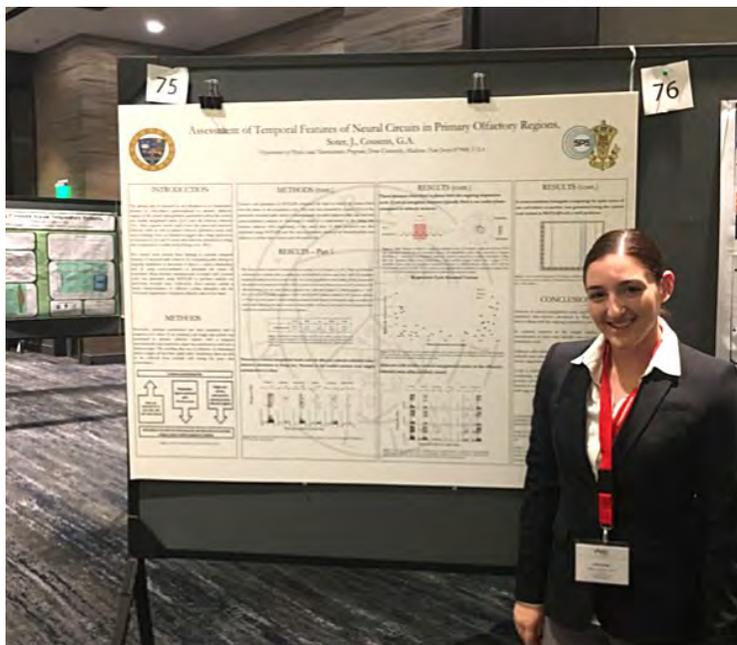
By Zoe Hughes '17

David James Thouless won the 2016 Nobel Prize in physics for “exploring exotic states of matter.” He shared the prize with two other physicists, F. Duncan M. Haldane and J. Michael Kosterlitz. Thouless’s research involves “superconductivity phenomena, properties of nuclear matter, and excited collective motions within nuclei.” He explored how matter interacts in flat two dimensional environments. In these environments, quantum mechanics is needed and the matter reaches exotic states beyond solid, liquid, and gas. His research opened up new fields of study that applies to superconductors and quantum computers. Thouless was born in Bearsden, Scotland in 1934 and attended Cambridge University for undergrad. He received his doctorate from Cornell University in 1958 and worked under Hans Bethe, also a Nobel laureate. After doing his postdoctoral research at University of California, Berkeley, he returned to the United Kingdom to work as a mathematical physics professor at the University Birmingham (1965-1978). In 1979, he accepted a position at Yale University as a professor of Applied Science. He did not stay long because he relocated to the University of Washington in Seattle in 1980. The Nobel Prize adds to Thouless’ long list of accolades. He was voted a fellow of the Royal Society (FRS), the American Physical Society, and the American Academy of Arts and Sciences.



programming, and physical properties in more detail with physicists.

After the first poster session, Natalya, Rachel, and Jenny broke off to attend different workshops. Jenny attended a workshop titled, "Taking Advantage of Physics Career Options," focusing on the types of jobs available to those with a Bachelor's degree in physics. Jenny was able to walk away with a long list of job opportunities, a résumé outline, and an elevator speech to practice during the remainder of PhysCon. Rachel attended a workshop titled "Taking Your Chapter to the Next Level" where she met with other SPS students to discuss what their chapters did well, and what they could do to attract



more members. Rachel learned that though our chapter might seem small or lacking in attendance there are plenty of other chapters out there that are even smaller. She also learned that there is no one successful way to grow a chapter, and that the best plan is to listen to the interests of your members.

On Saturday, Natalya presented a poster on her DSSI 2016 research she conducted in Dr. Larson's lab. Her poster was titled "Increasing Axial Resolution on a Line Scanning Confocal Microscope Through Tail Subtraction." This was her first time presenting at a conference. It was inspiring to see many different fields of research among the student presentations, from physics applications with human livers to black holes. Presenting for the first time was also an exciting experience and it helped Natalya learn how to properly present her information, especially with a focus on explaining the physics of the research. This was not featured when presenting at DSSI, where there are multiple scientific fields of research presenting to each other. Based on abstracts of their work, both Jenny and Natalya were awarded SPS Travel Grants by the American Institute of Physics to support their presentations at the meeting.

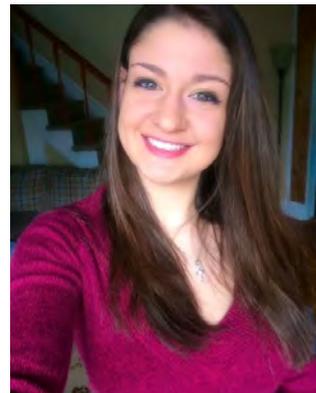
The conference finished Saturday night with a talk by Dr. Patrick Brady, a LIGO Team Member and the director of the Center for Gravitation, Cosmology & Astrophysics at University of Wisconsin. Many of the earlier speakers had some connection to gravitational waves, and all carried a common theme about the importance of unity and diversity in physics. Dr. Brady was an excellent final plenary speaker connecting everything that had been discussed at the conference. He discussed the history of gravitational wave theory, the timeline of the gravitational wave discovery of LIGO, and had a closing message about what he hoped the physics community will look like in the future. All of the Plenary Speakers were big supporters of encouraging students in physics, as shown by their presence at almost all of the other events and poster sessions. And they didn't keep to themselves, but constantly mingled with the students, asking and answering questions. This allowed for numerous opportunities to meet these physicists outside of a more formal environment, and it showed their great support of education.

Overall, we had an incredible conference experience with a jam-packed schedule of networking, representing Drew, and learning physics during the 2016 PhysCon.

Confocal Microscopy at DSSI

By Kelsey Oeler '17

For my second DSSI summer, I worked in Professor Larson's microscopy laboratory building a confocal microscope and observing the effects of scattering in turbid media. The first half of the summer consisted of working on the confocal microscope and aligning the system. The microscope was giving us some trouble over the last few months, and Professor Larson and I discussed how to tackle the issue often. While we worked on troubleshooting the microscope, the discussion began to shift towards designing a phantom tissue sample. The sample is for testing the microscope to understand the effects of scattering in turbid media. Therefore during the second half of DSSI I began focusing on creating an easily reproducible phantom tissue sample that replicates the optical properties of human tissue. The 2016 Robert L. Fenstermacher Research Fellowship funded my design for an automated optical system that tests each sample and outputs the resulting scattering coefficient value. Designing and building the system was difficult at first, but the challenge is always the best part.



One of my favorite parts of DSSI is the ability to interact with students and professors in different departments. Each week a different research group would present their work, many of which were in biology, chemistry, or computer science. The presentations were not only great practice for each group, but informational for the audience as well. In addition to the presentations, conversation about our research would flow over lunch or gym sessions. This was particularly helpful for my own project because I welcomed any advice that would help me better understand the biological and chemical aspects of my phantom tissue research.

My summer of 2016 was full of hard work and determination, as well as a lot of laughter and new friendships. The environment of Drew University and DSSI brings motivated students and encouraging professors together for a summer research experience. I am graduating in May, and when I look back at my time at Drew, I know that my time working in Professor Larson's laboratory will always bring back some of my favorite memories, especially this last summer at DSSI.

NEED A SCIENCE GIFT? DOES YOUR FRIEND OR FAMILY MEMBER LOVE SCIENCE? THESE \$10 GIFTS ARE FOR THEM!



Perpetual Motion Machine



Bare Conductive Electric Paint Pen 10ml



TEDCO Toys Light Crystal 2.5" Prism



Glantop® Magnetic Sculpture Desk Toy for Intelligence Development and Stress Relief

Investigating Kalman Filters

By Michael Clancy '18

Last spring I had the opportunity to work with RISE fellow Dr. John Eickmeyer on the applications of a Kalman filter in wireless signal processing. The research used MATLAB simulations of cellular signals and focused on being able to predict what a signal would look like in the future based on current data.

The goal in mind for predicting a cellular signal was the “handoff problem.” In cellular communications the receiver (cellphone) always communicates with the best transmitter (cell tower), given its location. It is not always the case that the best transmitter is simply the nearest one, and choosing the best transmitter relies on communicating with other nearby cell towers and seeing which one receives the best signal. When one transmitter becomes better than the current transmitter, the receiver switches to the new transmitter. The Kalman filter is very useful for this process because it is capable of both smoothing a noisy signal and predicting the future signal.

The research incorporated physics, statistics, and computer science, and the model of the simulation was based on the physics of wireless communications. The Kalman filter is a useful statistical tool across many disciplines for similar problems. It assumes there is a vector associated with the state of the system, and gives a very general framework for updating the state vector of that system via a set of matrix equations.

The application of the Kalman filter to our problem proved to be worthwhile. In our problem, we assume the signal we receive is some “mean signal” or “track signal” along with some noise on top of the track signal. Our hope was that the Kalman filter would perform nearly as well as the track signal, but at the end of our simulations we found that the Kalman filter performed as well as or even better than the track signal. We believe this was due to the asymmetric nature of the noisy component of the signal, and the Kalman filter’s success in being able to account for that is a testament to its versatility.

As of Fall 2016 we are working on preparing a paper based on the research for submission to an undergraduate journal, and in Spring 2017 we are planning to do more research on the applications of Kalman filters to problems in physics. I would like to thank the RISE program and the Drew University Physics Department for this opportunity. This research has been a great experience.

Astronomical Events: A Supermoon

By Ashley Bloodgood '17

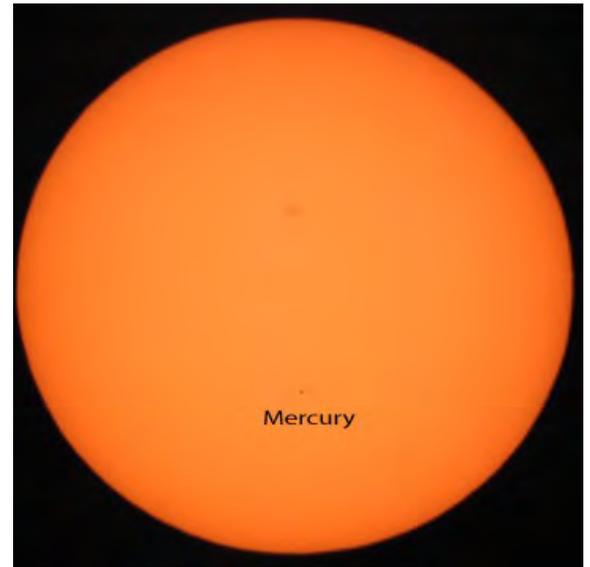
Early on November 14th a supermoon occurred. The supermoon happens when a full moon occurs on the same day that the moon in its orbit is closest to the earth, also known as perigee. This results in the moon being slightly larger and brighter in the sky. Supermoons are usually about 14% bigger and 30% brighter than a normal full moon. The next time you’ll be able to see the full moon appear this big is in 2034!



A Rare Transit of Mercury

By Ashley Bloodgood '17

On May 9, 2016, Mercury made a transit across the face of the sun. Largely unnoticed by the general public, it was not readily observable without a telescope and a solar filter to block most of the sun's bright light. Transits of the inner planets occur when Venus or Mercury pass exactly through the line between the Sun and Earth. On most orbital crossings they are above or below the Sun. Tiny mercury can be seen about halfway through its path across the sun's disk in this picture. It looks like a tiny pinprick on the face of the massive sun. This is because Mercury, at its distance from us, is only 1/158 of the sun's diameter. The transit took Mercury over seven hours to complete. Above Mercury, a sunspot can be seen. This photo was taken by Dr. Fenstermacher using a 3.5" Questar telescope and Nikon D70 digital camera. The next transit of Mercury will occur on November 11, 2019. You have time to prepare.



Nuclear Physics (and more) at Duke University

By Jenny Soter '18

Last summer, I had the opportunity to participate in an NSF-funded Research Experience for Undergraduates (REU) at Duke University and Triangle Universities Nuclear Laboratory (TUNL). TUNL is a research consortium located on the campus of Duke University in the research triangle funded by Duke University, University of North Carolina at Chapel Hill, and North Carolina State University. I worked under the direction of Dr. Megha Bhike, who is a post-doctoral associate working in a group led by Duke professor emeritus Dr. Werner Tornow. Dr. Bhike, Dr. Tornow, as well as the other two post-docs in the group, Dr. Finch and Dr. Krishicyan were incredible mentors. I am beyond grateful for not only participating in this REU, but also being matched with this group.

In simplest terms, my project over the summer was to measure the probability of two neutron-induced reactions. The official title of the experiment was, "Cross section measurements of $^{169}\text{Tm}(n,2n)^{168}\text{Tm}$ and $^{169}\text{Tm}(n,3n)^{167}\text{Tm}$ for the National Ignition Facility." When I first read the title, I was pretty overwhelmed to say the least – the only words I understood were the prepositions. Before participating in this REU, I had no knowledge of nuclear physics, but by the end of ten weeks, I was writing the draft of the publication and had just been invited to present the results at the American Physical Society Fall Meeting in Vancouver, Canada.

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For those ten weeks, I lived with 7 other students just as passionate about physics as me and was able to experience first hand what it takes to be a research physicist. During the first week, the REU program arranged for Duke graduate school professors to lecture us 8 hours a day on basic nuclear physics and radiation safety. For the next 9 weeks, all the REU students attended lectures every Tuesday and Wednesday afternoon. We had various group outings to local spots during the summer and we were also given tours of the physics graduate departments of all the universities in the research triangle.

Aside from the amazing resources Duke and the REU had to offer, getting this specific project and advisor was truly a once-in-a-lifetime experience. Dr. Bhike was extremely committed to my learning and giving me the full experience. She essentially gave me a one-on-one crash course in nuclear physics, about 2 hours a day for the first couple of weeks and we had meetings almost twice every single day for the remainder of the summer. I was involved in every part of the experiment, except for the initial experimental design (since the group had previously researched dozens of other similar reactions, the experimental set up was already set in stone). The first part of the experiment was related to causing the reaction. We used a particle accelerator and beam line to produce neutrons that we would use to induce the reaction we were interested in studying. Next, I used very sensitive detectors to measure the induced radiation. Then, I spent quite a bit of time analyzing all of the data and calculating the reaction probability (otherwise known as the “cross section”).

I had never worked so many long hours or had so many sleepless nights. Between learning nuclear physics, taking care of the detectors, running the particle accelerator overnight, and analyzing data, I had to spend close to 12-14 hours every day in the lab. Three times over the summer, we worked with the particle accelerator 20 hours a day four days in row because time was so limited. But, I felt such an intense sense of accomplishment at the end of the summer. I learned the neutron activation technique, how to care for HPGe detectors, a new programming language, the Linux operating system, and three nuclear softwares. Not only did I gain numerous practical laboratory skills and a great deal of physics and computer science knowledge, at the end of just ten weeks, I had more than enough results to publish in an academic journal.

I was later awarded a travel grant by both Duke University and the Conference Experience for Undergraduate (CEU) program to travel across the continent to Vancouver, CA to present my results at the APS – Division of Nuclear Physics Meeting in October 2016. That in itself was an amazing experience to reunite with some of the other REU students and experience a professional conference. Then, during January 2017, I was invited back for a two-week internship to take additional measurements. Still today, I analyze data remotely from my computer and do calculations. In a few months, after the group very carefully looks over my work, we will submit the work to the Physical Review C.

To say this was the summer of a lifetime would be an understatement. This REU truly changed my direction in life and opened up many more doors for me in the future. I am now 100% sure I want to get a Ph.D. and start a career as a research physicist. Because of this REU, I found my passion for nuclear physics research and ultimately gained a lot of confidence as a future physicist. So I highly recommend anyone interested in pursuing a Ph.D. to apply for REUs.

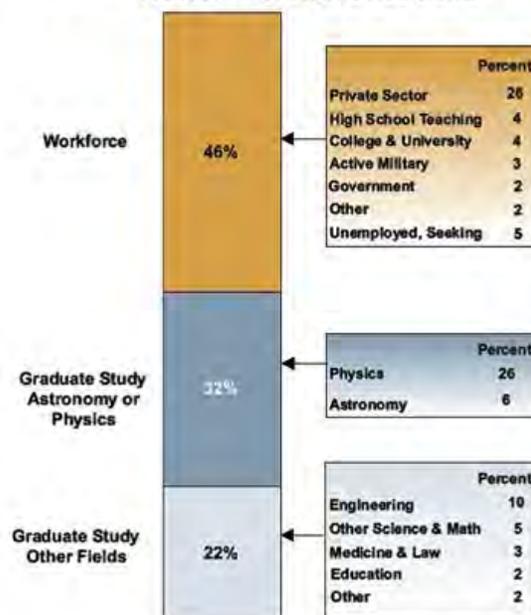
Career Corner

By Dr. Bob Fenstermacher

This issue of Career Corner focuses on some of the latest trends compiled by the American Institute of Physics Statistical Research Center, providing an update from a few years ago. Drew undergraduate physics majors are a diverse group and head into a wide variety of future careers upon leaving Drew. For many years Drew sent about half of its majors on to graduate work in physics, and a smaller fraction into graduate work in other related areas. Recent classes have shown broader interests using the physics major as a strong base for work in related areas including environmental topics and many engineering directions. Chart 1 gives us the most recent information on what physics majors are doing nationally. Drew's experience seems to be reflected nationally as shown where 54% still go on to some kind of graduate work, but only about 26% in physics. A full 22% are now pursuing related STEM fields. Clearly the physics bachelor's degree continues to provide an excellent background for many STEM interests.

Physics Bachelors 1 Year Later

7,430 Recent Degree Recipients



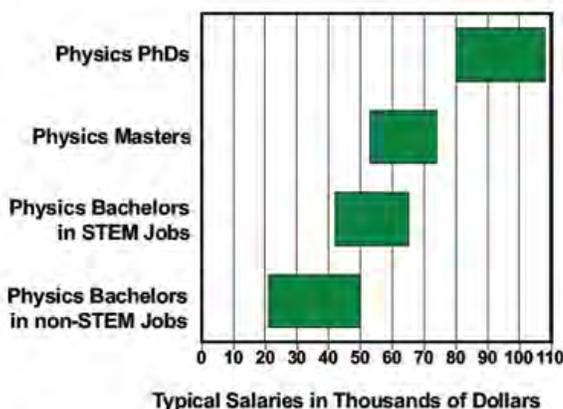
Note: Data in this figure are from the AIP Statistical Research Center's annual Bachelors Follow-up Survey, classes of 2013 & 2014 combined. The 7,430 degree recipients represent the average of these two classes. Four percent of respondents to the survey indicated that they had left the US to pursue employment or graduate study and were not included in the figure.

The chart shows the initial workforce sectors for physics bachelor degree holders from the classes of 2013 and 2014 combined.

The private sector is just over half of all employment. High school teaching comprises about 8.7% of all employment, down from 11% four years earlier. Some bachelor's degree holders continue on for Masters of Art in Teaching (MAT) degrees, something now available at Drew (in 1+ years of additional work leading to certification in NJ). Employment shown here at colleges and universities would likely be as technicians and support staff.

Starting Salaries in the Private Sector

Physics Degree Recipients, Classes of 2013 & 2014



Note: Typical salaries are the middle 50%, i.e. between the 25th and 75th percentiles. STEM refers to positions in Science, Technology, Engineering, and Math.

For those making career decisions based on future salaries, Chart 2 gives you a range of starting salaries in the private sector for all physics degree holders. These are numbers that AIP has been tracking for many years, showing results every five years. There is mostly good news here as all categories EXCEPT Bachelors in non-STEM Jobs have risen since the data five years ago. Physics PhD's are now earning \$8-10K more, and Masters and Bachelors about \$5K more. Physics Bachelors who leave the STEM world actually lost about \$3K in starting salary. STEM jobs continue to bring better salaries overall.

A final statistic for this report, while still not good enough, warrants our attention and approval. The number of physics bachelors earned by women continues to rise ...Continued on Page 9

significantly. An increase of 160% has occurred between 1982 and 2011. This has brought the percentage of women physics majors from about 12% in 1982 to about 23% in 2011. This is a very welcome trend that we are also experiencing at Drew albeit a very slow one. Keep spreading the good word – the positive slope for increasing numbers of women has to be even more positive!

More career guidance and information for all degree holders can be obtained at the American Institute of Physics website: <http://www.aip.org/statistics/trends/career.html>

Physics Comics

Oddbox by Bahb Gonzalez

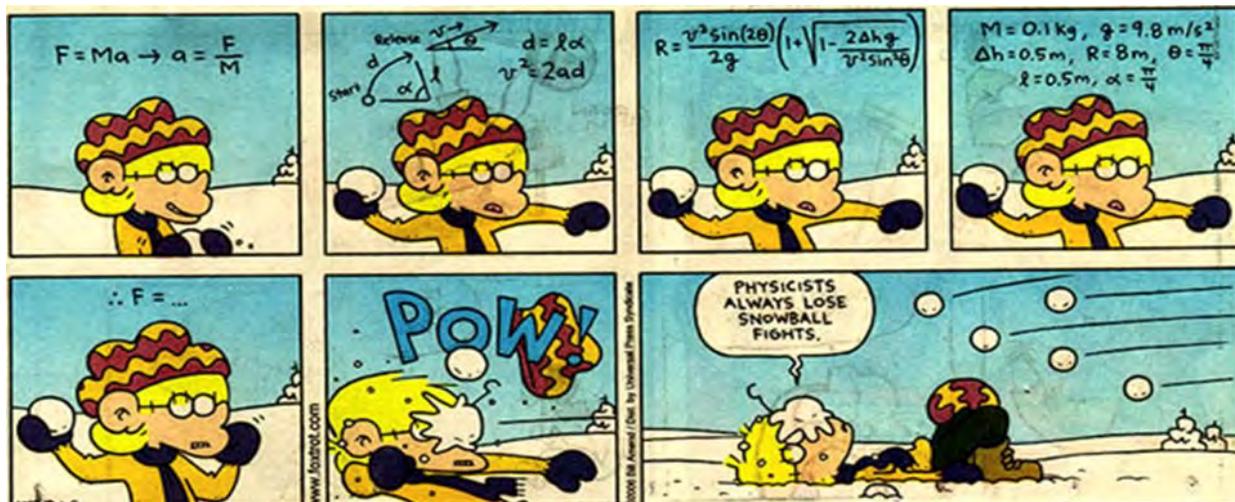


Figure Top: Gonzalez, Bahb. “Above the Law”. Oddbox Comics. July 1, 2011. <https://oddboxcomics.com/2011/07/01/above-the-law/>

Figure Bottom: Amend, Bill. “FoxTrot”. GoComics. January 8, 2006. <http://www.gocomics.com/foxtrot/2006/01/08/>

Rare Opportunity to Observe a U.S. Total Solar Eclipse

By Dr. Bob Fenstermacher



This summer, on Monday August 21, you have a chance to see one of nature’s most beautiful and awe-some sights, a total eclipse of the Sun. And you don’t have to leave the United States to participate. If perhaps you have seen a more common partial solar eclipse somewhere and think you’ve “been there, done that,” put aside those thoughts. You haven’t seen anything yet!

A total solar eclipse occurs when the Moon moves for a short time exactly in line between the Earth and the Sun. Because of the accidental relative sizes of these three bodies and the distances between them, the Moon is just able to fully block the entire disk of the Sun casting a near circular shadow on the surface of the Earth about 100 miles in diameter. And because of the rotation of the Earth and motion of the Moon, this 100 mile-wide shadow races across the surface from west to east at over 1000 miles an hour. The triumph of Newtonian mechanics and knowledge of the solar and lunar orbits allows such eclipse alignments to be predicted hundreds of years in the future as to time and location of the moving shadow – quite a powerful tool for impressing the populace. For those wondering why we don’t have a solar eclipse every month at new moon, it’s because the Moon’s orbit is inclined about 3 degrees to the Earth’s orbit around the Sun. Thus the shadow of the Moon at new moon is usually just above or below the Earth, and we see no blockage of the Sun.

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So why is a total solar eclipse so spectacular? First of all it may be something that you will see once in a lifetime. While not exactly a super rare event (77 in the 21st century), many total eclipses occur in locations not easily accessible - over oceans, deserts, inaccessible countries, etc. This year that small 100 mile wide shadow will move diagonally across the United States beginning in the morning in Oregon and ending late in the afternoon in South Carolina. The next total eclipse with a shadow on this country will occur in 2024.

The 100 mile diameter shadow dashes across the surface along the “line of totality,” and should you be on that line, the Sun will be totally blocked for about 2.5 minutes for this eclipse. The exact locations and distances of the three bodies dictate the size of the shadow, and thus the duration of totality could, in a particular eclipse, be as long as 7.5 minutes. In any partial solar eclipse a portion of the blazing disk of the Sun is still visible, and many people may not even be aware that an eclipse is in progress due to the enormous brightness of even a small sliver of visible sun. But in a total eclipse, at the instant of totality, the Sun goes out! In the next few minutes of totality it will be as dark as night with the glowing white corona or outer atmosphere of the sun in full view (a part of the Sun never seen). If you’re really lucky a number of pink solar prominences may reveal themselves, huge solar outbursts rising high above the solar disk into the corona. It’s an extraordinarily beautiful sight. It’s not hard to believe how terrifying this must have been to our early ancestors, to see the Sun disappear during the day.

During totality a number of interesting terrestrial effects occur. The surface covered by the moving shadow becomes cooler, with the temperature falling by as much as 10 degrees F in a few minutes. This cooling causes the wind to pick up as warmer outside air moves into the cooler region. Birds begin to sing as they do at the end of the day at sunset. And dogs may begin to bark. Too quickly for most people it’s over. The Sun winks back on as the fast moving shadow leaves us on its path eastward. It’s not uncommon for the local crowd of observers to burst into applause. Let’s do it again!

There are many web sources of information (<https://eclipse2017.nasa.gov/>) about locations, durations, and weather prospects (did I mention you need a clear sky?). Before and after totality you get the bonus of several hours of a partial solar eclipse, and you’re sure to meet lots of fellow enthusiastic observers. Viewing the partial phase of the eclipse requires appropriate eye protection (<https://eclipse2017.nasa.gov/safety>), but the brief total phase can be viewed safely with the naked eye. While all of North America will experience a partial eclipse on this day, consider a grand adventure to somewhere on the line of totality this summer. You won’t regret the experience and will likely remember it for the rest of your life.

Send The Physics Department Your Business Card!

We’re very proud of our alums and want to share your paths with current students. Let us know what you are up to and where you are working. Send us your business card for our display. Please send your card or cards to Dr. Robert Murawski, Department of Physics, Drew University, Madison, NJ 07940.

Things to look for *this semester...*

- *Weekly SPS Pizza Lunches - Thursdays at Noon, S-244*
- *SPS Bowling, April 11, 9 pm, East Hanover Lanes*
- *Annual Wiffleball Game, April 20, 3:30 pm*
- *Annual SPS/Physics Awards Banquet, April 24, 5 pm*
- *Sigma Pi Sigma Induction (at Banquet), April 24*

Remember:

The observatory is open to the public on clear Friday nights!

Visit the *physics department* website at:

<https://www.drew.edu/physics/>

The Dilated Times

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Madison, NJ,
07940

Address Correction Requested

Inside...

PhysCon 2016, DSSI and REU Summer Research, Cool Astronomical Events, Famous Physicist, Career Corner, Physics Cartoons, Physics Gift Ideas!

Contributors...

Rachel Newburg, Kelsey Oeler, Zoe Hughes, Nicole Jackson, Jenny Soter, Natalya Scherban, Ashley Bloodgood, Michael Clancy, and Dr. Fenstermacher!

