WOOSTER PHYSICS

Wooster Physics majors Gabe Dale Gau ‘18, Avi Vajpeyi ‘18, and Haidar Esseili ‘19 play with “real” sand piles on a beach in Los Angeles just prior to presenting their research on the bead pile experiment in self-organized criticality at the March Meeting of the American Physical Society.

2017-2018 Annual Report

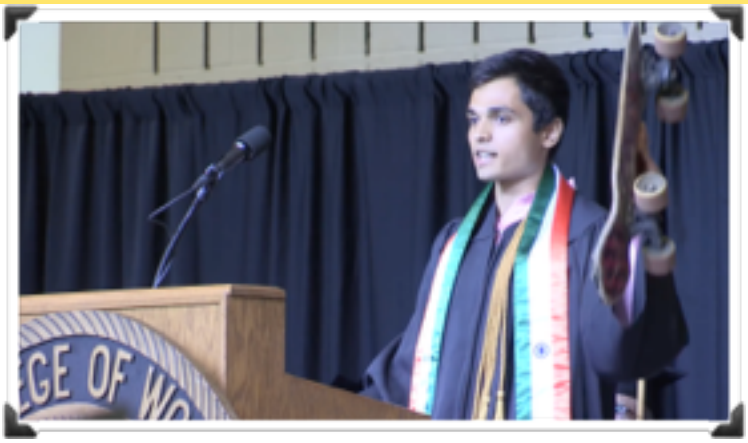
physics.wooster.edu

CLASS OF 2018

front: Nate Moore, Avi Vajpeyi, Gabe Dale-Gau, Emma Brinton

rear: Kyle McNickle, Nate Smith, Collin Hendershot, Justine Walker, Zane Thornburg, Jack Mershon

AVI'S COMMENCEMENT SPEECH



[Skate to stage]

As a boy who grew up in Kolkata, India, I would have never thought that I would have been able to do what I just did -- skating was only something for Marty McFly.

Coming to Wooster made me realize that EVEN I was capable of learning how to skate.

AND now my Independent Study has made me realize that even I, like all of you, am capable of contributing to humanity.

Before I begin, I'd like to thank my professors, coaches, friends, and family, especially my Ma – she is she has flown half-way across the world to celebrate this weekend :D Ma, I know I didn't call as often as I should have these past four years, but every morning, I thank you in my mind, because I know that I AM the person I AM -- because of you.

Well, Class of 2018, we've made it! We have survived:

the terrifying two minutes of power outage of 2017 (RIP squirrel),

the great floods of Andrews-Gault library,

the rise and fall of YikYak,

and even made it through I.S. orals, something that I had been nervous about ever since my first year at Wooster, when I heard about the grueling stories from upperclassmen.

Before I get into I.S. orals, Id like to talk a bit about our first year at Wooster–which is a bit like learning to ride a skateboard.

Initially, when you get on a skateboard, it can feel chaotic and somewhat terrifying -- the landscape around you seems to guide the skateboard rather than you steering it.

I remember the start of freshman year feeling like this: I had absolutely no idea what was going on.

In fact, during international orientation, I was so confused with everything, I managed to lose my way while walking from Bornhuetter to Lowry. Eventually, a kind Drug Mart cashier, who seemed very concerned, gave me some directions.

Yes, I was a confused individual my first year. I kind of had an idea that I wanted to study neuroscience -- but I wasn't sure.

But then at ARCH, a professor helped me pick classes: he mentioned that as a neuroscience major I would have to take physics at some point, so after talking to some people at ARCH, I registered for Physics 111.

Wooster's environment nudged me towards a path and this guidance ended up being exactly what I needed: I really loved the intro physics classes and labs. I also really struggled in them -- but that only made me like the subject even more!

Very quickly, these classes helped me realize that I wanted to study physics and computer science instead of neuroscience!

The hours I struggled with friends on HW sets eventually paid off -- I was able to get a summer research opportunity in the Physics Department here at the College!

I read the acceptance email during a sociology class and masked my whoop of excitement with a bout of coughing. I honestly thought I had been pretty slick at containing my happiness-- but right after class, a classmate asked me why I was grinning so much, in a class on gender inequality.

By the time our class reached sophomore year, we were all getting the hang of steering our skateboards and choosing the environments to roll towards. We got more involved with clubs, became better at getting ready for class in ten minutes, and found the best places to study on campus. And I am proud to say that I managed to memorize Lowry's location in the GPS of my brain.

What I also find amazing about Wooster is that it has exposed me to so much more than just academics. I had never run track before coming to college, yet the coaches and track team readily accepted me. I was able to join different clubs, and eat meals with people from all over the world—from Paraguay, Lebanon, Brazil and China, sometimes even at the same table! I have been so grateful for having the chance to speak to people from such diverse backgrounds on a daily basis these past four years.

By the end our sophomore year, each of us even figured out our majors! I think this was one of the most incredible steps in our journey here.

And just like that we became upperclassmen. At this point, we knew where we were going, and we began guiding our skateboards with complete control. We became such pros that we even knew when to avoid the long lines at Lowry during admissions events. The experience we gained and the courses we took helped us choose the area we felt passionately about for our junior and senior independent studies.

For me, the area I wanted to investigate was the study of criticality. I worked on creating a simulation of an avalanching system. What I find ridiculously awesome is that by studying this simple system, we can better understand much more complex phenomenon such as real sized avalanches, forest fires and even stock markets!

Through IS, all of us were able to take what we learned and direct our skateboards to previously unexplored areas, and push the boundaries of our fields just a little further.

And now back to I.S. orals. If we compare this to our skateboard analogy, orals are kind of like the X Games. None of us were too keen to participate, but we also wanted the opportunity to show what we had found and learned in our explorations to our mentors.

Before my orals, I was nervous. I thought about the stories I had heard about them from previous survivors. Then I complained to everyone how frustrating it was that the Physics Department was so extra -- orals for the Physics Department last for two HOURS and in addition to our first and second readers, the entire physics faculty is present! What the heck!?

All my physics professors were sitting in front of me, waiting for me to talk about my work… and they were all smiling. Immediately, I was at ease -- this was going to be fun!

Yes, I know that sounds weird, but yeah, I really enjoyed IS orals! I think it was my favorite experience at the college.

I could tell that all my professors were listening to me, and just by that itself, I felt that my work had value. I felt so energized and honored. Our professors at Wooster are amazing individuals, and they are willing to give us so much of their time. Not just during orals, but countless hours outside class, including playing in occasional intramural sports. I can say without hesitation that this is something unique to Wooster.

My professors of the Physics Department have not only helped me find my passion—they have helped me figure out the kind of person I aspire to be. I think Wooster does this for each and every one of us.

Whether it be a coach, a professor, a friend, or Al from dining services, each is helping guide us on our path. Due to this close environment here at Wooster, we have learned more about ourselves and how we aspire to grow and change…

Before I close, Id like us to reflect for a moment. If we look over the course of human existence, we see flash points of change driven by people who seek information and knowledge--challenging existing belief systems to further ethical and scientific progress.

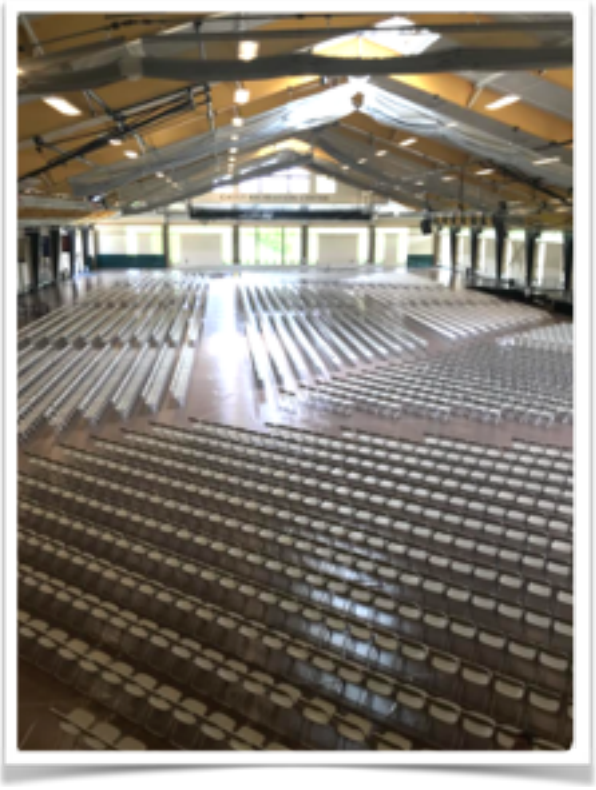
Class of 2018: the three hopes I have for our class are that…

First, that we be the flash points of change and continue to push the boundaries of knowledge like we did for I.S.;

Second, we impact the life of at least one person, like the professors and coaches have done for us.;

And finally, teach one person how to skate!

Thank you and CONGRATULATIONS TO THE CLASS OF 2018!



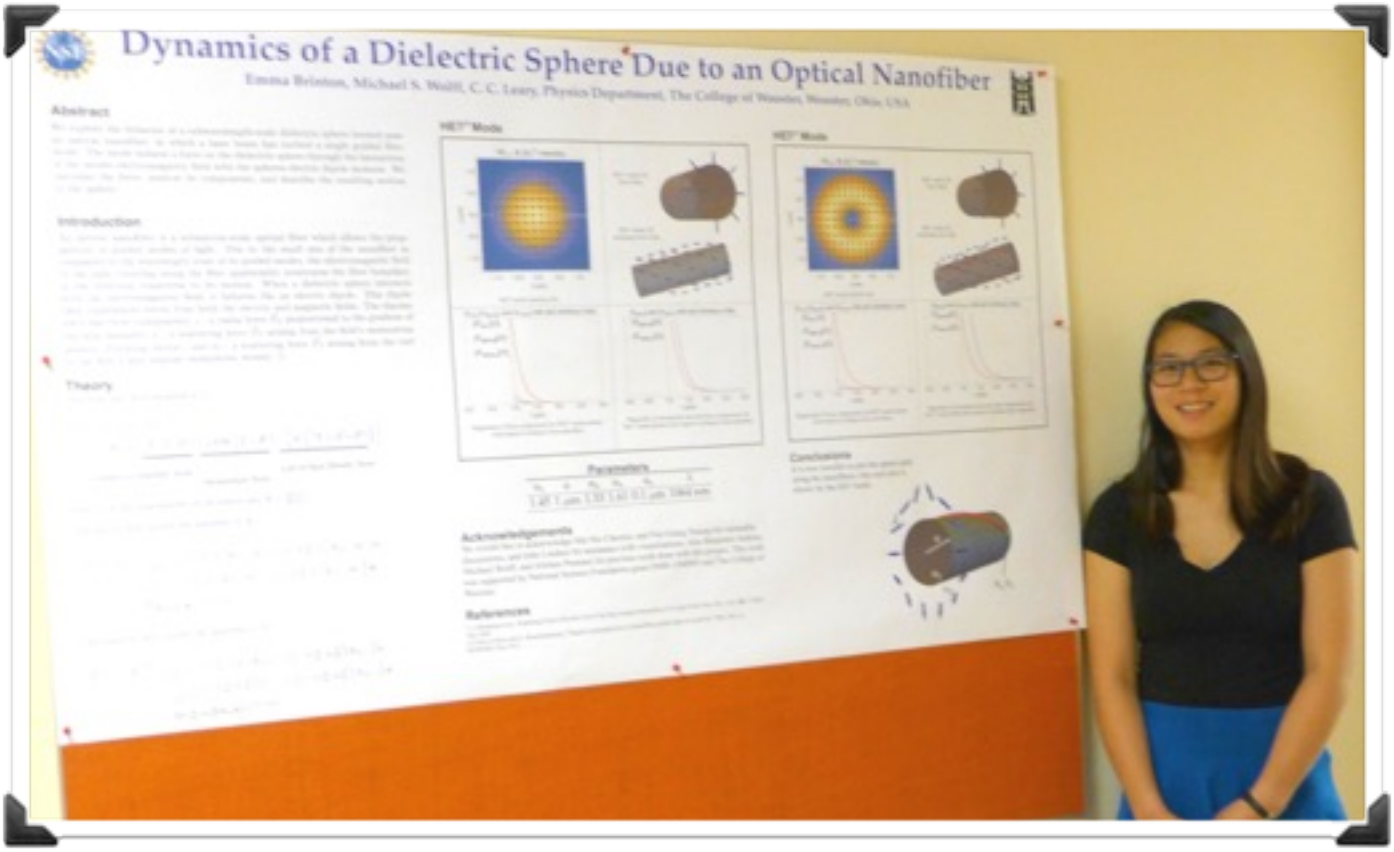
View from the mezzanine of the Scot Center indoor track, prior to commencement ceremonies.

SENIOR INDEPENDENT STUDY

Emma Brinton (Physics Major from Lexington MA)

Exploring the Dynamics of a Small Dielectric Sphere Due to the Higher-order Modes of an Optical Nanofiber (advised by Cody Leary)

This thesis explores the dynamics of a small dielectric sphere due to the higher-order modes of an optical nanofiber. The electromagnetic field created from a laser traveling down the nanofiber induces a force on a glass bead. This force is dependent on the electromagnetic field and the effective dipole moment of the sphere. The force is found to have three components: the intensity term, the spin density term, and the momentum density term. Each term is calculated to determine the motion of the bead due to both individual forces and the laser as a whole.

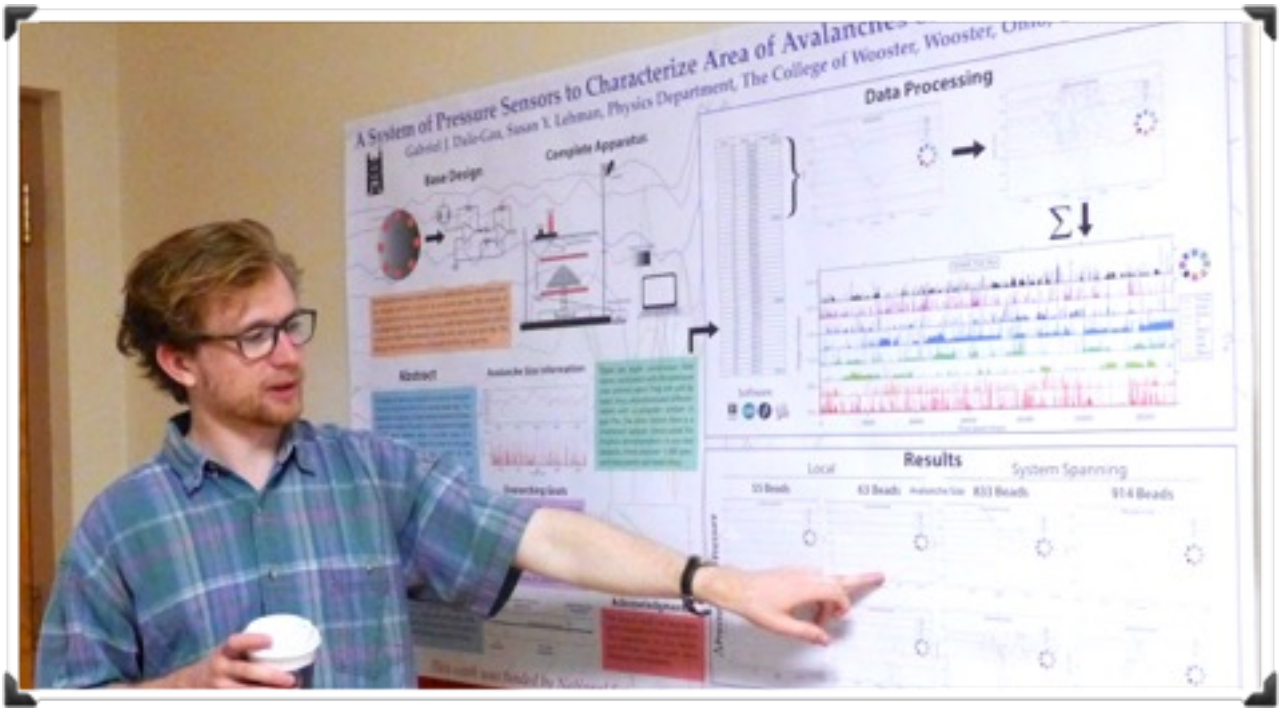


SENIOR INDEPENDENT STUDY

Gabriel Dale-Gau (Physics Major from St. Paul MN)

Employing a system of pressure sensors to characterize avalanche dynamics over a conical bead pile (advised by Susan Lehman)

A system of pressure sensors is used to measure the area of avalanches on a conical bead pile. The bead pile is a slowly driven critical system of 3 mm steel shot beads. The pile is composed of roughly 20,000 steel spheres atop a circular base; it is driven by adding one bead at a time to the apex of the pile. Avalanches are recorded by the change in mass as beads fall off the pile. To create cohesion between beads, a pair of Helmholtz coils is located around the pile to apply a uniform magnetic field and induce magnetization of the beads. As cohesion is added, the size and number of the largest avalanches in the system increase. To more fully compare the experiment to models, we want to characterize the fraction of the pile involved in a given avalanche to determine which avalanches are system-spanning. Thus we added a set of eight pressure sensors at the edge of the base of the pile to detect dynamic changes in the pile during an avalanche. The signals from the force-sensitive resistors are amplified though a custom circuit board and each signal is read via Arduino. The sensors provide a response to changes in the force chains within the pile, allowing us to characterize the fraction of the pile involved in an avalanche at any time during the avalanche.

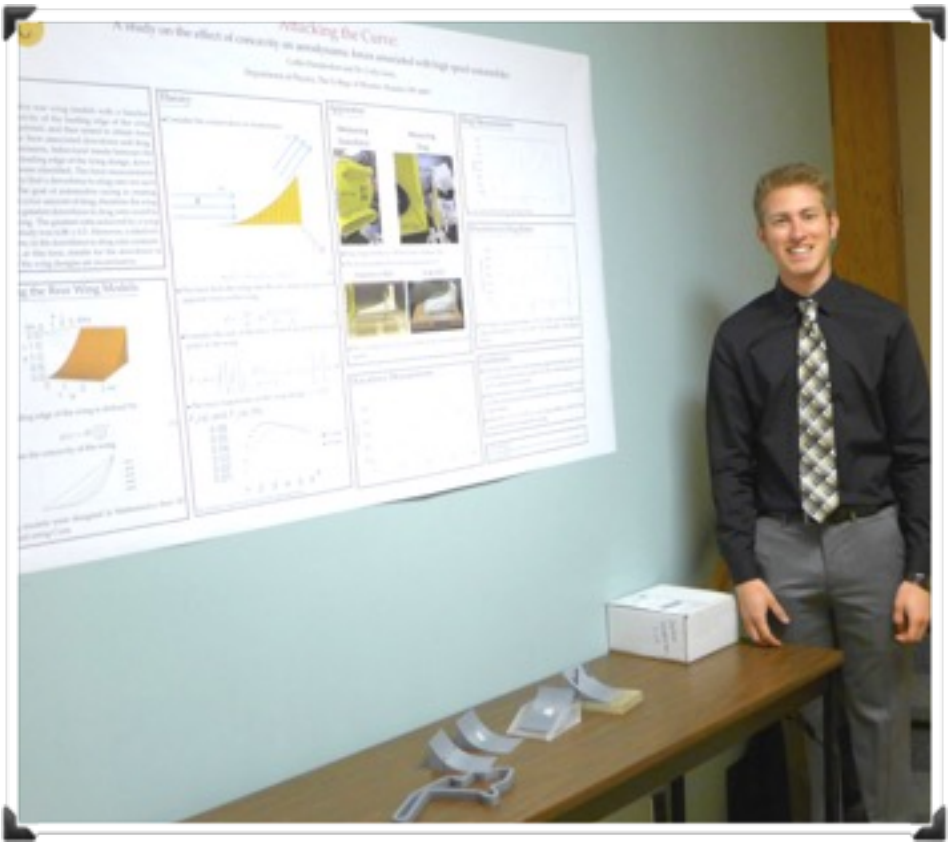


SENIOR INDEPENDENT STUDY

Collin Hendershot (Physics Major from Medina OH)

Attacking the Curve: A study of the effect of concavity on aerodynamic forces associated with high speed automobiles (advised by Cody Leary)

Multiple automotive rear wing models with a leading edge defined by the function $y(x) = H(x/L)^a$, where the variable a defines the concavity, H is the height of the wing, and L is the length of the wing, were 3D printed and then tested to obtain force measurements for their associated downforce and drag. From the measurements, behavioral trends between the concavity of the leading edge of the wing design, downforce, and drag were identified. The force measurements were then used to find a downforce-to-drag ratio for each wing design. The goal of automotive racing is creating downforce with a low amount of drag, therefore the wing design with the greatest downforce-to-drag ratio could be efficient for racing. Of the wings studied, the $a = 4$ wing design had the largest downforce-to-drag ratio, which was 4.08 ± 0.5. However, a relatively large uncertainty in the downforce-to-drag ratio measurements means at this time, results for the downforce-to-drag ratios of the wing designs are inconclusive.

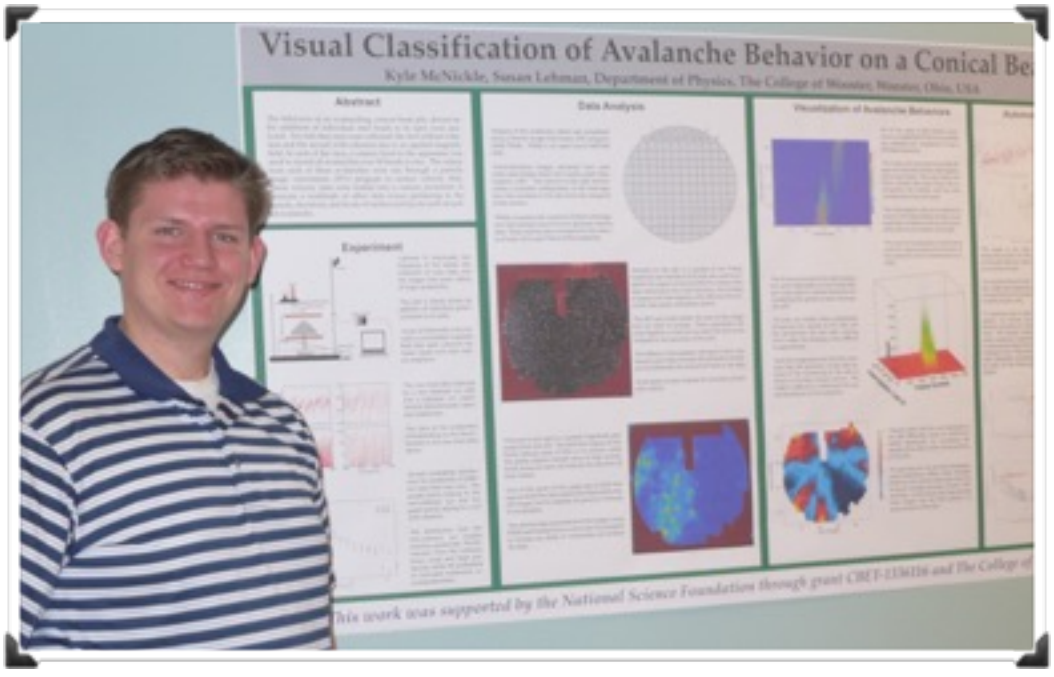


SENIOR INDEPENDENT STUDY

Kyle McNickle (Physics Major from Elyria OH)

A Visual Investigation of Criticality: Avalanche Classification on a Conical Bead Pile (advised by Susan Lehman)

The behaviors of an avalanching conical bead pile, driven by the additions of individual steel beads to its apex were analyzed. Two full data runs were collected, each containing about a week's worth of data. The first run was conducted without cohesion and the second run with cohesion. Cohesion was induced in the beads by subjecting them to a magnetic field produced by two Helmholtz coils centered around the pile. The current passing through the coils was set to 750 mA. In each of the runs, a camera fixed to the apparatus was used to record all avalanches over 50 beads in size. The videos from each of these avalanches were analyzed using a particle image velocimetry (PIV) program to extract velocity data from small cells overlaid on each frame. These velocity data were loaded into a custom *Igor* procedure to generate a multitude of other data waves for analysis. These waves contained information relating to the amount of activity on the surface of the pile, the durations, the speeds, and the total distance moved on the pile, for each avalanche. It was observed that the average sizes of the avalanches, the total distance moved by the pile, and the average activity of all of the cells on the pile were greater for the cohesion run. The automated duration calculations were only accurate for the non-cohesion run. Large cohesion avalanches and small non-cohesion avalanches had the most uniform levels of activity across the surface of the pile.

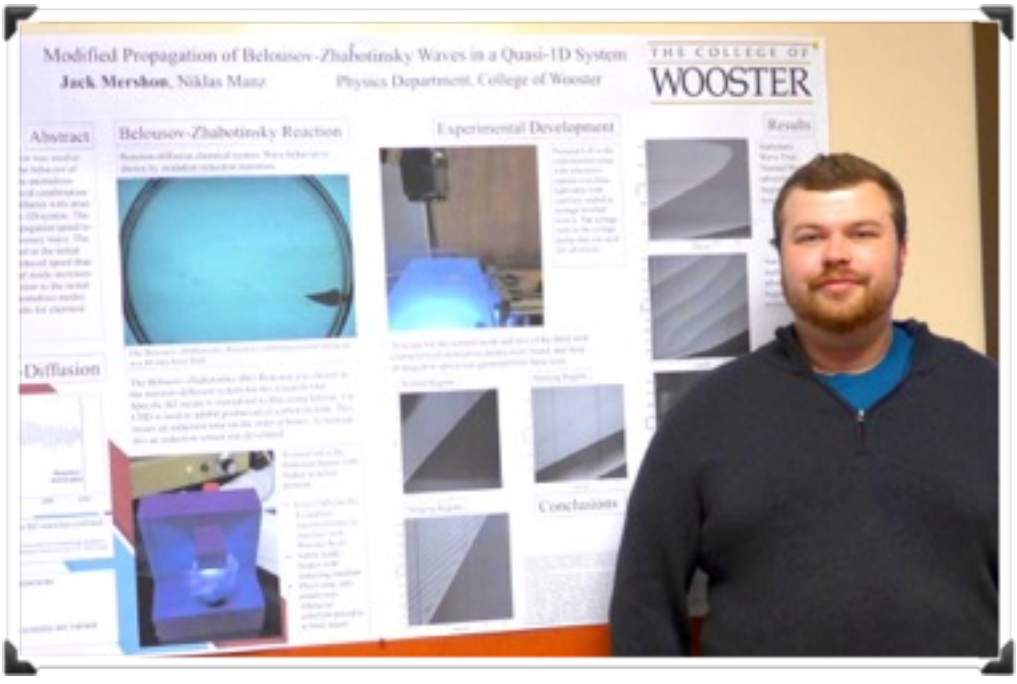


SENIOR INDEPENDENT STUDY

Jack Mershon (Physics Major from Carmel IN)

Modified Propagation of Anomalous Belousov-Zhabotinsky Waves in a Quasi-1D System (advised by Niklas Manz)

The Belousov-Zhabotinsky (BZ) reaction was used to investigate the effect of fluid flow on the propagation behavior of reaction-diffusion (RD) waves. Solutions were filled into glass capillaries to create quasi-1D systems. The normal regime was advected at its propagation speed to determine if this would produce a stationary wave. This did not work precisely and other speeds were tested. Two anomalous wave behaviors, named stacking and merging, were investigated as well. Stacking behavior is characterized by an initial wave front being tailed by faster waves that slow to the propagation speed of the first wave, producing a series of stacked waves. Merging is similar to stacking except the secondary waves die off as they approach the initial wave's inexcitable refractory tail. The anomalous mixtures were also subjected to advection at a speed equivalent to their nominal propagation speed. Other advection speeds were tested by not thoroughly. The advection of the normal regime resulted in the initial fronts propagating at a significantly reduced speed than normal, though some forward propagation was still observed suggesting that the flow was not sufficient to stop forward wave propagation. Higher speeds were attempted and it was shown that waves could be stopped but at a speed not its nominal propagation speed. Normal propagation was found to have the distance between wave fronts greatly increased by advection. The development of precise anomalous modes was not observed but compelling results for chemical gradience in anomalous regimes were seen during experimentation. That is, it would seem advection is causing different chemical concentrations to develop in different regions of the capillary.

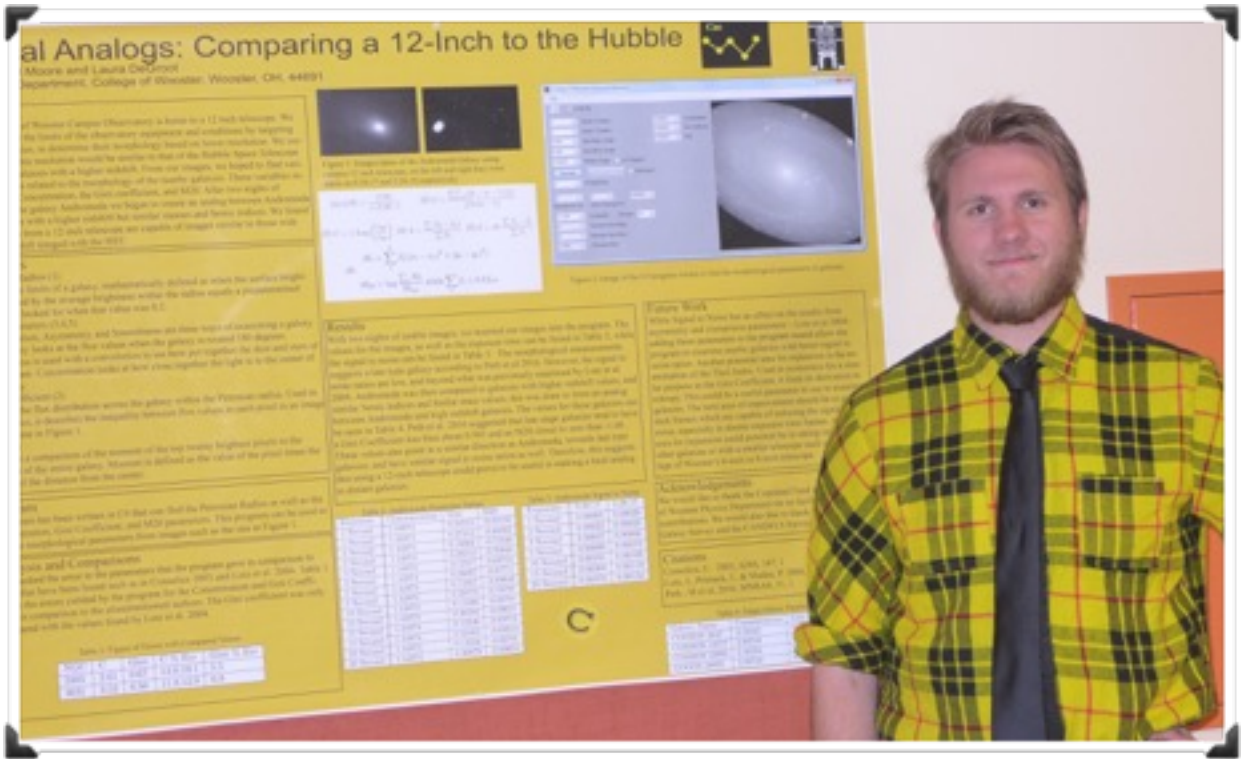


SENIOR INDEPENDENT STUDY

Nathaniel Moore (Physics & Political Science Major from Weare NH)

Local Analogues: Comparing a 12-inch Telescope to the Hubble (advised by Laura DeGroot)

The College of Wooster Campus Observatory is home to a 12-inch telescope. We aimed to test the limits of the observatory equipment and conditions by targeting nearby galaxies, to determine their morphology based on lower resolution. We suspected that this resolution would be similar to that of the Hubble Space Telescope (HST) for galaxies with a higher redshift. From our images, we hoped to find various variables related to the morphology of the nearby galaxies. These variables included the Concentration, the Gini coefficient, and M20. After two nights of data of the galaxy Andromeda, we began to create an analog between Andromeda and galaxies with a higher redshift but similar masses and Sérsic indices. We found that images from a 12-inch telescope are capable of images similar to those with higher redshift imaged with the Hubble Space Telescope.

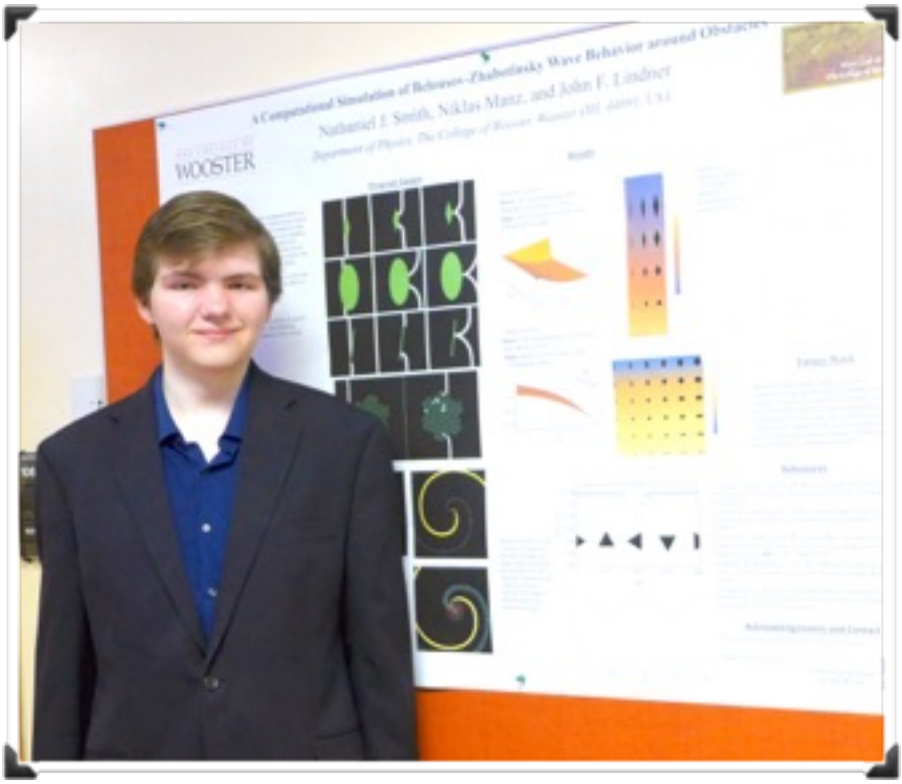


SENIOR INDEPENDENT STUDY

Nathaniel Smith (Physics Major from Medina OH)

A Computational Simulation of Belousov-Zhabotinsky Wave Behavior Around Obstacles (advised by Niklas Manz)

We developed an interactive multi-threaded Objective-C computer simulation, named BZP, to analyze the propagation behavior of reaction-diffusion waves around obstacles in a two-dimensional channel. By comparing the wave's behavior with experimental results and other computational models, under known conditions, BZP was verified to correctly simulate their propagation. Objects placed in the path of an initially planar propagating wave impeded the wave's movement due to the decreased speed of positively curved fronts in contact with them. We investigated the effect of various obstacle shapes (*n*-sided polygons, diamonds, ellipses) and extensions parallel and perpendicular to the channel and their influence on the total propagation time within the two-dimensional channel. We also studied the effect of location of different numbers of obstacles with the channel. In addition, work was done on the effects of obstacle rotation. Other more complicated obstacle configurations were also explored, including spirals, sinusoidal paths, and fractals. Although the wavefront straightens after the obstacle due to well known curvature effects, we typically observed a transient delay that increased with the projected size of the obstacle perpendicular to the flow.



SENIOR INDEPENDENT STUDY

Zane Thornburg (Physics & Chemistry Major from Bellaire OH)

An Investigation into the Lambert-Beer Law in Incoherent Broad-Band Cavity-Enhanced Absorption Spectroscopy (advised by Susan Lehman & Karl Feierabend)

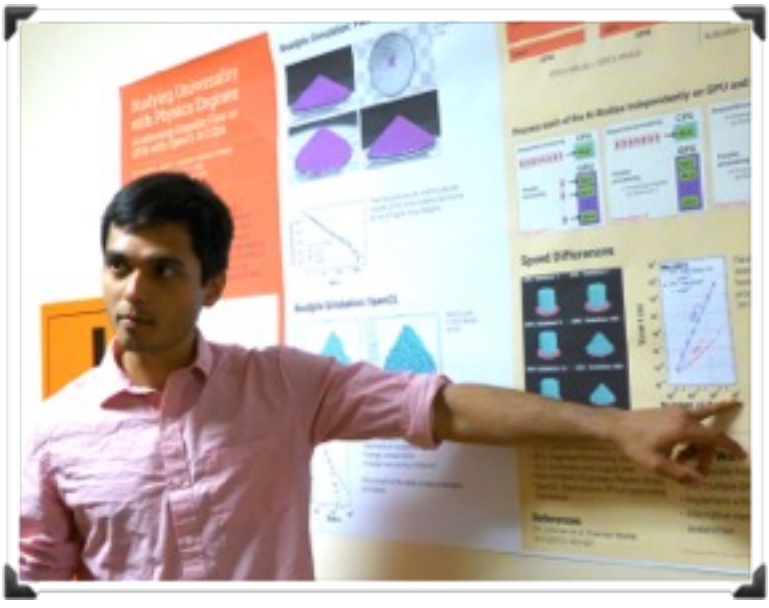
Absorbance values measured using incoherent broad-band cavity-enhance absorption spectroscopy (IBBCEAS) were confirmed to have a non-linear dependence on concentration in contrast to the expected linear dependence from Beer's Law. A liquid-phase sample in a cuvette is placed within an optical cavity created by two highly reflective mirrors to increase the number of optical passes through the sample, enhancing the sensitivity of absorption measurement. The nonlinear behavior was observed in absorbance measurements for both a weak absorber, toluene, and a strong absorber, the dye 1,1-diethyl-4,4-carbocyanine iodide. Tracking losses of intensity within the mirror cavity, models to describe the behavior in certain absorbance ranges were found. Two models were found that could be used to predict absorbance measurements made between 0 and 0.3. The first model predicts a finite number of passes within the mirror cavity, specifically around 60 passes, as a good fit to the experimental data in the range of 0 to 0.3. The second model predicts an infinite number of passes through the cuvette and incorporates a constant non-absorptive loss. The non-absorptive loss is difficult to predict, but can be empirically determined and used later for unknown samples to predict absorbance measurements. Above absorbance 0.3, the number of passes occurring appears to decrease for higher concentrations/absorbances. The effects causing the apparent fewer passes likely include factors such as reflection off the cuvette-air interface within the mirror cavity, complicating the equations needed to describe the behavior at higher absorbance values. While a complete model was not achieved, models that are good approximations for cavity-enhanced absorbance measurements between 0 and 0.3 were found.

SENIOR INDEPENDENT STUDY

Avi Vajpeyi (Physics & Computer Science Major from Kolkata INDIA)

Studying Universality with Physics Engines: Accelerating Granular Flow on GPU with OpenCL and CUDA (advised by John Lindner & Denise Byrnes)

Experiments with a granular beadpile have shown that the pile can model critical systems such as avalanches. In the experiments, a bead is dropped on the apex of the pile of beads. Eventually, one such bead causes several beads of the conical bead pile to avalanche. The experiments have studied the distribution of avalanches and how the distribution is affected by altering the bead type, bead cohesion, and bead drop height. In this study, two computational simulations of the experiment are presented. The simulations model each bead as an independent particle with their own position and velocity. Due to the independentness of the particles, we can use parallelism to thread various processes of the particles to a personal computer's graphical processing unit. This allows the simulations to run faster than real-time while still having more than 10 thousand particles on the pile.The first simulation's data matched the laboratory beadpile's data at the low drop height regime, but failed to do so at higher drop heights. The second simulation, made using a much simpler model, requires friction to be included in the model to make the simulated beadpile comparable to the laboratory beadpile. With these simulations it is possible to learn new information that may have been challenging to study with the actual experiment. For example, we can vary the shapes and numbers of the beads. With the simulation it is also possible to record the velocity of each particle both on the surface and inside the pile.

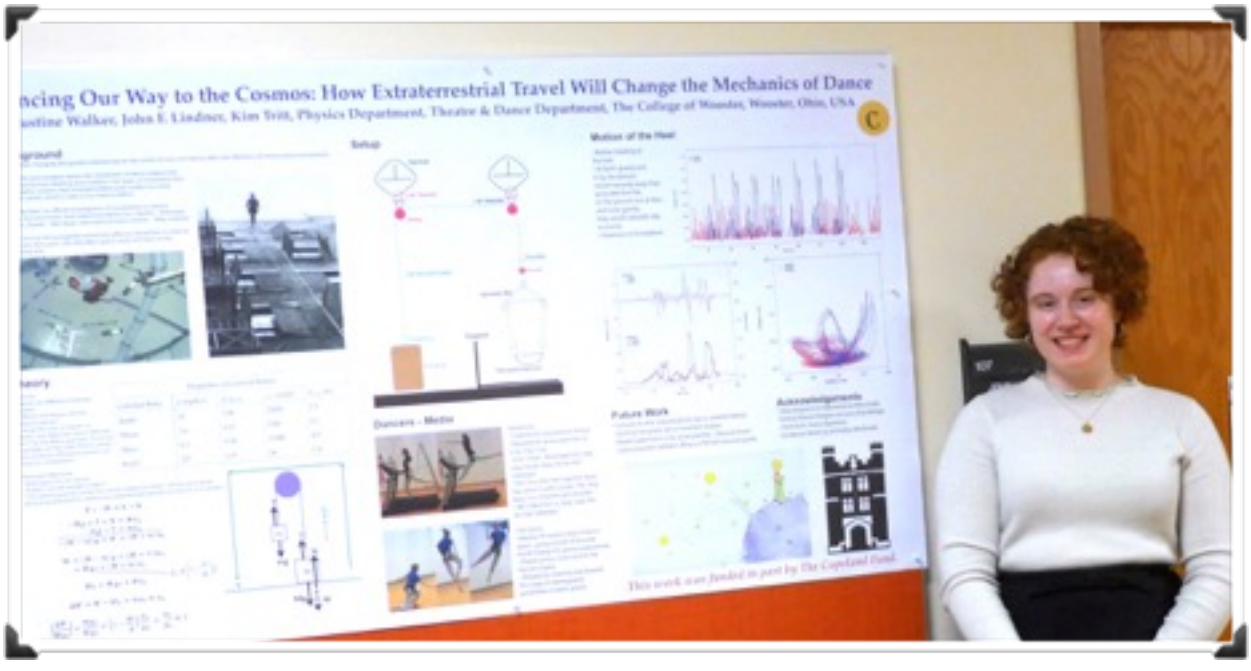


SENIOR INDEPENDENT STUDY

Justine Walker (Physics & Dance Major from Mahopac NY)

Dancing Our Way to the Cosmos: A Study in How Extraterrestrial Travel Will Change the Mechanics of Dance (advised by John Lindner & Kim Tritt)

How does gravity affect the efficiency of dance movements? We expect the fundamentals of various dance forms to change drastically at Earth, Mars, and lunar gravity. The efficacy of movements are altered in lower gravities by changes in natural oscillation frequencies and a dancer's kinesphere. We simulate lower gravities using a pulley counterweight system connected to a dancer in a two-point harness. The dancer moves on a treadmill (non-stationary movements) or a force mat (stationary movements). Quantitatively, we compare motion tracking data from a camera for each dancer and movement at the three gravities. Qualitatively, we consider the dancers' feedback and our choreographic experiences in relation to post-modern dance. As physicists we thereby better understand the mechanics of the human body in various gravities, beyond the walking-running transition. Engineers can incorporate our results when creating space habitats. Earth-based choreographers can create dances inspired by our lower gravity experiments. Our work highlights obstacles and opportunities for movement in space colonies, which will expand our understanding both of movement and of what it means to be human.



HONORS & AWARDS

Latin Honors

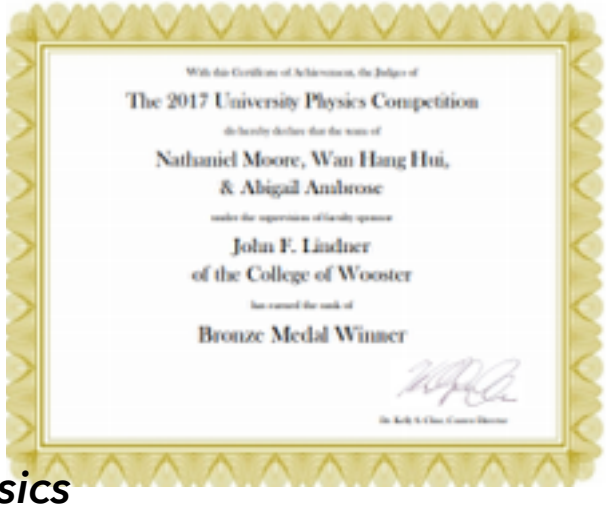
Summa cum laude
Avi Vajpeyi
Justine Walker

Magna cum laude
Emma Brinton
Gabriel Dale-Gau
Zane Thornburg

Cum laude
Jack Mershon

Phi Beta Kappa

Gabriel Dale-Gau
Zane Thornburg
Avi Vajpeyi
Justine Walker



The Jonas Notestein Prize

Avi Vajpeyi

The Arthur H. Compton Prize in Physics

Avi Vajpeyi

The Cummings-Rumbaugh Speech and Dramatics Prize

Justine Walker

The Joseph Albertus Culler Prize in Physics

Maya Lapp

The Mahesh K. Garg Prize in Physics

Zane Thornburg

Justine, Avi, and Zane with Dr. Leary

JUNIOR INDEPENDENT STUDY SELF-DESIGNED EXPERIMENTS

Michelle Bae
The Integer Quantum Hall Effect

Daniel Blaikie
Propagating BZ Waves Over Illuminated 2-D System

Carson Bullock
Space Debris

Haidar Esseili
All Paths Lead to Rome: Path Integration Route to Quantum Electrodynamics

Kenny Huang
How the Pendulum Tuned Mass Damper Affects Vibration with Different Viscosity and Mass

Vincent Hui
Properties of Traversable Wormholes in Spacetime

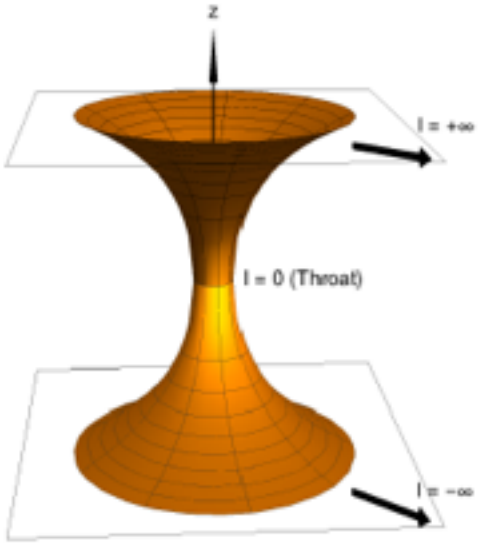


FIG. 1: The embedding diagram of the Morris-Thorne wormhole in cylindrical coordinates. Fixed $t = t_0$ and $\theta = \pi/2$. There are also 2 asymptotically flat regions on top and bottom.

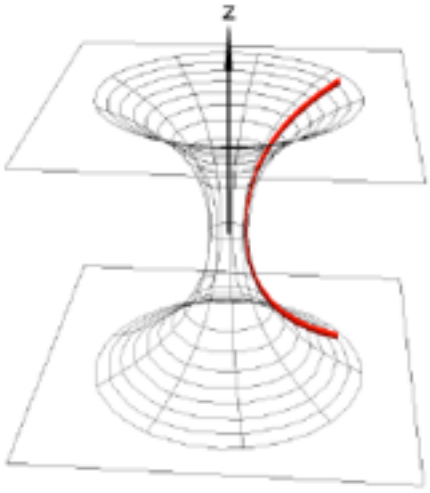
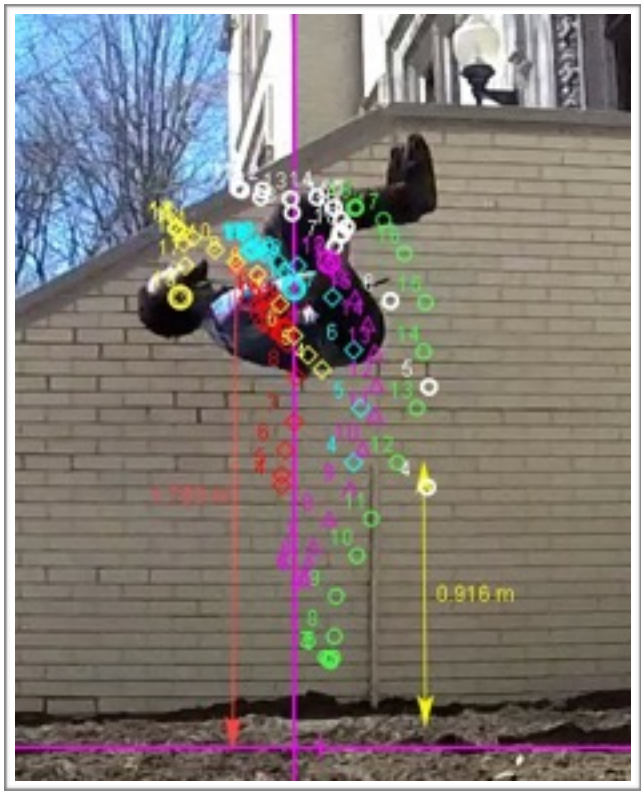


FIG. 2: The geodesic (red line) of the free-falling particle on the surface of the wormhole.

JUNIOR INDEPENDENT STUDY SELF-DESIGNED EXPERIMENTS

Chase Fuller
On Phase-induced Interference of Non-separable Spin-orbit Light Modes

Benjamin Jenkins
Flips are Fun: A Study in the Conservation of Angular Momentum of a Non-rigid Human Body



James McElroy
Definitive Frequencies of an Individual's Voice

David Morrow
Using Ferrofluid as a Field Magnet: A Ferrofluid Electromagnetic Generator

Asaki Takahashi
Sync Test of Non-cohesion Bead Piles

Joseph Theiss
Measuring Fluid Flow in a T-junction Pipe with Colored Dye

2017-2018 COLLOQUIUM SERIES

Physics Juniors, Junior I.S. Self-Designed Experiments, 1 May and 3 May

Mike Winters ‘10, Georgia Tech, Sonification for Science and Beyond,16 April

Thijs Heus, Cleveland State University, How big is a cloud? On the size, shape and organization of cumulus clouds, 5 April

Jutta Luettmer-Strathmann, University of Akron, Motor proteins: Designing a molecular walker, 29 March

Intro to the major, 22 February

Danielle Shepherd '14, From IS to IndyCar,15 February

Peter Hoekje, Baldwin Wallace University, The beauty of distortion: non-linear physics of music, 1 February

Research opportunities with CoW Physics faculty (Cody Leary, John Lindner, Laura DeGroot), 25 January

Research opportunities with CoW Physics faculty (Susan Lehman, Niklas Manz), 18 January

Senior I.S. progress reports by Avi Vajpeyi, Nate Moore, Collin Hendershot, Nate Smith, and Justine Walker, 5 December

Senior I.S. progress reports by Jack Mershon, Emma Brinton, Kyle McNickle, Gabe Dale-Gau, and Zane Thornburg, 28 November

Mark Foster, University of Akron, Very High Resolution Chemical Information About Polymer Surfaces Using Tip Enhanced Raman Spectroscopy, 14 November

Dan Gauthier, The Ohio State University, Securing the internet in the age of quantum computers, 9 November

Alexandria Volkening, The Ohio State University, How the zebrafish got its stripes, 24 October

Ali Khaledi-Nasab, Ohio University, Emergent stochastic oscillations and signal detection in tree networks of excitable elements , 3 October

Abigail Ambrose '20, Michelle Bae '19, Justine Walker '18, Benji Jenkins '19, Summer Research Experiences II , 5 September

Carson Bullock '19, Avi Vajpeyi '18, Jack Mershon '18, Chase Fuller '19, Summer Research Experiences I ,29 August

ALUMNI SPEAKERS

2017-2018 Department of Physics & Physics Club

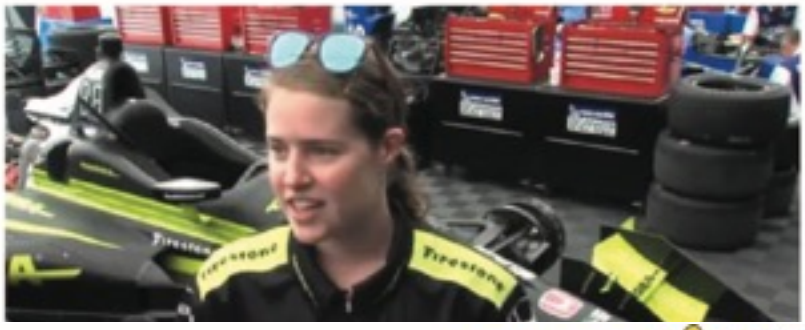
colloquium SERIES

From I.S. to IndyCar

INDY 500

Danielle Shepherd
Wooster Physics & Math '14

Thursday, February 15
11 am, Taylor 111



Hindsight is always 20/20, but sometimes, while you are on the journey, you don't realize the importance of the steps you are taking. When I started school at The College of Wooster, I never thought I would end up in the auto racing industry. After my first semester, my love for physics and math emerged and I decided to pursue racing. This is my journey from Wooster to IndyCar. I'll describe how Wooster helped me achieve my goals, how I first got into the racing industry, and how I use physics and math in my everyday work.

Sonification for Science and Beyond

Monday, April 16
1:00 pm, Taylor 111

R. Michael Winters
Georgia Tech Center for Music Technology
GVU Sonification Lab, BrainLab, Robotic Musicianship
Wooster Physics '10

Humans are multi-sensory organisms, relying on a complex web of information to make sense of the world. Yet, in scientific practice, knowledge is often driven by visualizations, graphs and PDFs. To open up science and scientists to non-visual forms of sense-making, sonification uses the evolved affordances of the human auditory system. By mapping data onto sound attributes, data can be represented objectively, systematically and reproducibly, and listeners may learn something they didn't know before. This application-driven talk will provide examples of sonification across the scientific, social and cultural spectrum including educational technologies, data-driven exploration, articulation of machine intelligence, and artistic pursuits. Listeners will leave with a new appreciation of listening and how sound can drive insights in a variety of data-domains.

FACULTY

Dr. Lindner, Dr. Manz, Dr. DeGroot, Dr. Lehman, Dr. Leary

Cody Leary, Associate Professor of Physics and Chairperson

TEACHING

Calculus Physics I + laboratory
Calculus Physics II (2 sections)
Electricity & Magnetism
Quantum Mechanics
2 Senior Independent Study advisees

****

Dr. Leary chaired the Physics Department this year and continued his research in quantum optics alongside undergraduate colleagues at Wooster and elsewhere. Along with collaborators from the University of Oregon, he coauthored an article in *Physical Review Letters*, entitled "Observation of Interaction of Spin and Intrinsic Orbital Angular Momentum of Light." He gave an invited seminar at The Ohio State University entitled "Encoding and manipulating information in single photon and two photon states." Dr. Leary looks forward to continuing collaboration with his Oregon colleagues during his upcoming Fall 2018 leave.

FACULTY

Wave lab researcher Abigail Ambrose and Dr. Manz visited the Missoula Fire Sciences Lab in Montana to take a tour and learn more about forest fire research.

Dr. Manz' I.S. students (aka the "Wave Lab bros" Jack Mershon and Nate Smith) celebrate I.S. Monday

Niklas Manz, Assistant Professor of Physics

TEACHING

First Year Seminar "Patterns Around You"
Algebra Physics I + Lab
Algebra Physics II
Calculus Physics II Lab
Thermal Physics
2 Senior Independent Study advisees

****

Niklas Manz' research interests are in the interdisciplinary feel of spatio-temporal pattern formation with a focus on reaction-diffusion (RD) systems. His projects include one- and two-dimensional chemical waves, fire fronts, and geographic tongue patterns on the human tongue.

Dr. Manz has been attending all spring and fall two-day meetings of the American Physical Society Ohio-Region with students. For some students, it's their only poster presentation while at Wooster; for some it's their first poster or oral presentation at a scientific conference. He is currently chairing the organizing committee to host the Joint Spring 2019 Meeting of the Ohio Sections of APS and AAPT at Wooster.

In March, Dr. Manz started a collaboration with a mathematician from Miami University in Oxford, OH to model the effect of fluid flow on reaction-diffusion waves in a capillary, with the plan to combine her numerical and Dr. Manz' experimental results into one strong project. In July, he attended the biannual Gordon Research Conference on Oscillations & Dynamic Instabilities in Chemical Systems in Geneva, Switzerland.

FACULTY

Dr. DeGroot helps position the 6" refractor telescope during the campus viewing event of last summer's eclipse. (photobomb by Dr. Lindner)

Laura DeGroot, Visiting Assistant Professor of Physics

TEACHING

Calculus Physics I + Lab
Calculus Physics II Lab
Mechanics
Astrophysics
Physics Revolutions
1 Senior Independent Study advisee

****

We welcomed Dr. Laura DeGroot to our department as a 3-year visiting assistant professor. She earned her Ph.D. from University of California Riverside in 2015 and her research interests are astrophysics and galaxy morphology. In January, Dr. DeGroot and her senior I.S. advisee Nate Moore attended the 231st Meeting of the American Astronomical Society in Washington DC where Nate presented "Local Analogs: Comparing a 12-inch to the Hubble".

FACULTY

Dr. Lindner assists dancer Kathlyn MacDonald with the harness used during Justine Walker's (senior physics and dance double major) low gravity experiment. They simulated lower gravities using a pulley counterweight system connected to the dancer in a two-point harness. The dancer moves on a treadmill (non-stationary movements) or a force mat (stationary movements).

John Lindner, Professor of Physics, Moore Professor of Astronomy

TEACHING

Astronomy of the Solar System
Astronomy of Stars and Galaxies
Modern Physics + Lab
Math Methods for Physical Sciences
2+1 Senior Independent Study advisees (1 from Wellesley College)

****

Dr. Lindner, along with Wooster physics major Hwan Bae and REU student from 2017 Norah Ali (Hiram College), have co-authored an article "Hannay's Hoop Beyond Asymptotics" in the journal *Chaos*, 28, 083107, August 2018. The article is being promoted as a feature article by the editors of the journal. It is also being reported by Physics Today as a news story: https://physicstoday.scitation.org/do/10.1063/PT.6.1.20180809a/full/
A brief summary of the article is "*Just as cats falling feet up twist their bodies to land feet down, rotating noncircular beaded hoops shifts the beads, as per a new analysis confirmed by ice cylinders sliding in 3D-printed channels".* Another of Dr. Lindner's students, senior Avi Vajpeyi, presented his work last fall at the MidStates Conference for Undergraduate Research in Math and Computer Science (MCURCSM) and was awarded "Best Paper" for "*Chaotic Scattering in Hill and Valley Systems".*

FACULTY

Dr. Lehman accompanied nine students to the March 2018 National Meeting of the American Physical Society in Los Angeles.

Susan Lehman, Victor J. Andrew Professor of Physics

TEACHING

Electronics for Scientists + Lab
Condensed Matter Physics
Calculus Physics Lab
Junior Independent Study
3 Senior Independent Study advisees

****

Dr. Lehman has been named the Victor J. Andrew Professor of Physics, a title previously held by Donald Jacobs, Emeritus, Professor of Physics from 1976-2012. Dr. Lehman taught the physics portion of the Expanding Your Horizons workshop, a huge event specifically for middle school girls that incorporates not just women science students and professors from the campus but also professional women from around the community whose job includes an aspect of science. In the "Humpty Dumpty" experiment, the girls have about 20 minutes with limited materials to create a container to try to protect an egg from breaking during a fall. They then drop the eggs from the 3rd floor of Taylor Hall. Dr. Lehman really enjoys seeing the creativity of the girls — not only in making their containers, but also in decorating and naming their eggs.

Dr. Lehman accompanied a record-number of Wooster students to the March Meeting of the American Physics Society in Los Angeles. While there, she presented "Effect of Cohesion on the Time between Avalanches On A Slowly-Driven Conical Bead Pile".

PHYSICS CLUB

OFFICERS

Zane Thornburg, Caesar / President
Nate Moore, Basileus / Vice President
Daniel Blaikie, Quaestor / Treasurer
Michelle Bae, Aedille, Secretary
John Lindner, Czar / Advisor

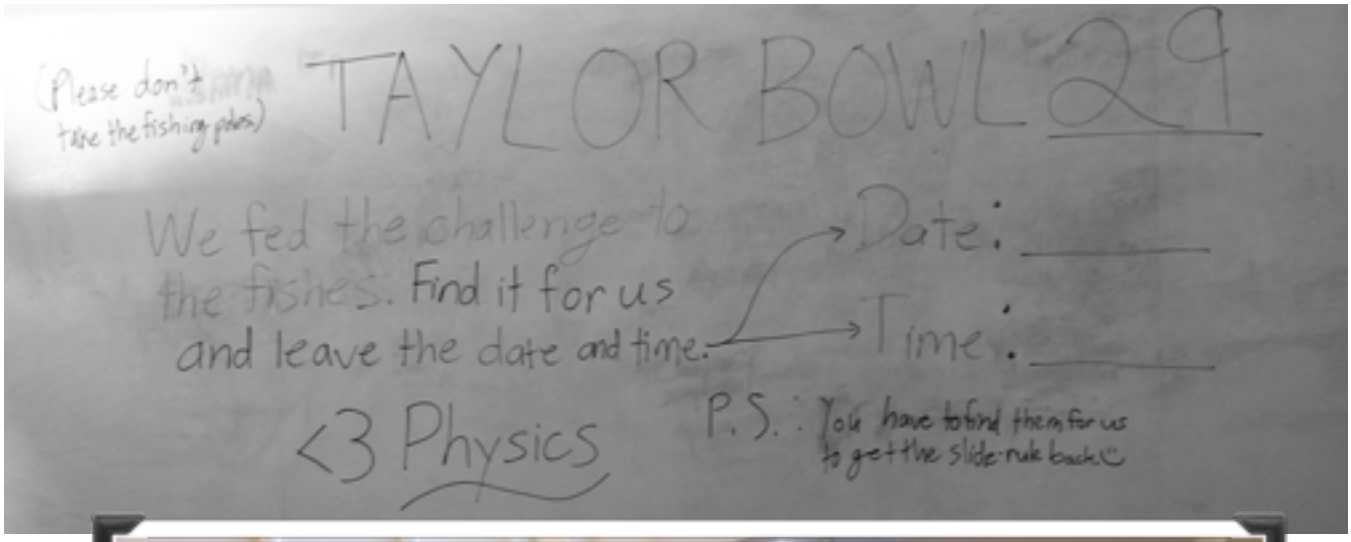
Taylor Bowl XXVIV marked the end of an era, since Scot Lanes has been demolished for the renovation of Lowry Center. The Physics team even donned faceprint for the occasion. The Math/CS Department retains the giant slide rule trophy for all eternity, but the enthusiasm and pride of Wooster Physics Club will carry on forever.

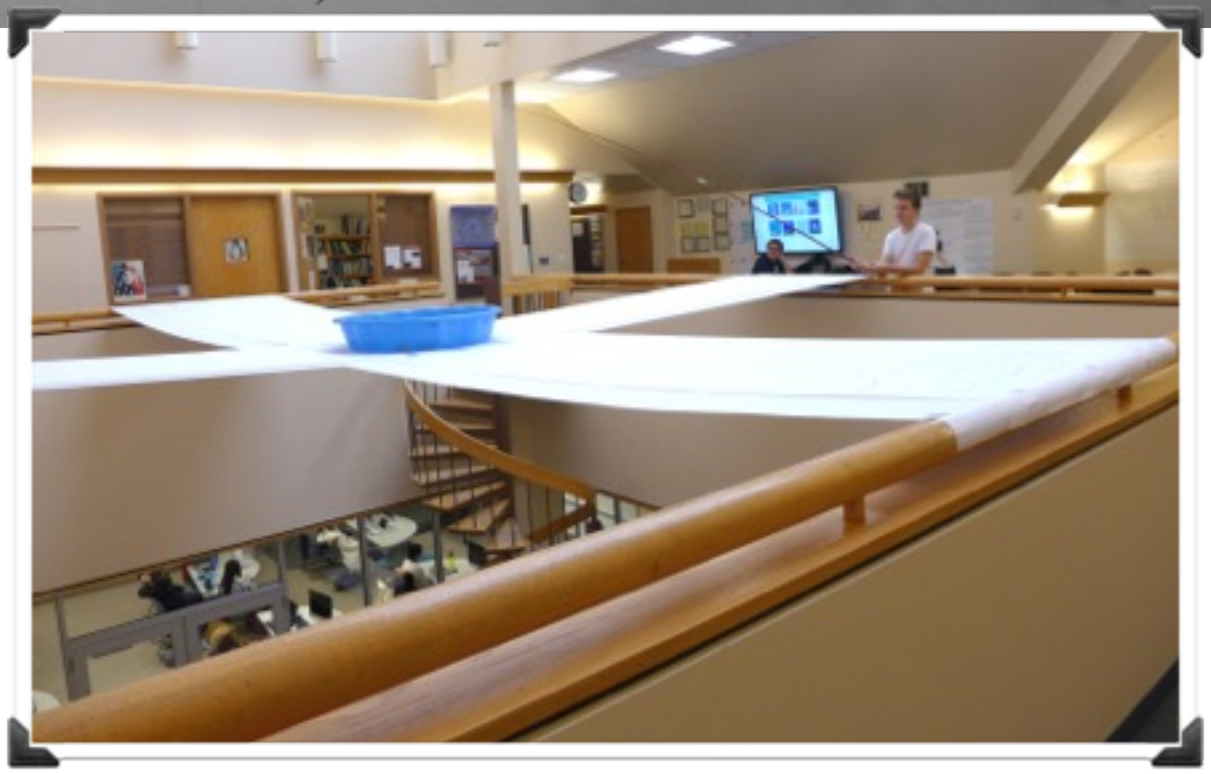
EVENTS

2017 August 21: Viewing Solar Eclipse
2017 August 25: Viewing stars & planets at the observatory
2017 September 1: Scot Spirit Day
2017 September 6: Luce Dinner - Pizza and Liquid Nitrogen Ice Cream
2017 September 28: General Meeting
2017 October 18: Viewing stars & planets at the observatory
2017 October 25: General Meeting
2017 November 17: Taylor Bowl Challenge Construction
2017 December 3: Taylor Bowl 29
2018 February 28: Star Wars: Rogue One
2018 March 7: Star Wars: The Force Awakens
2018 April 7: Science Day 10
2018 April 22: 50th anniversary SPS at Wooster picnic
2018 April 30: Observatory viewing of Jupiter and moon

PHYSICS CLUB

TAYLOR BOWL CHALLENGE



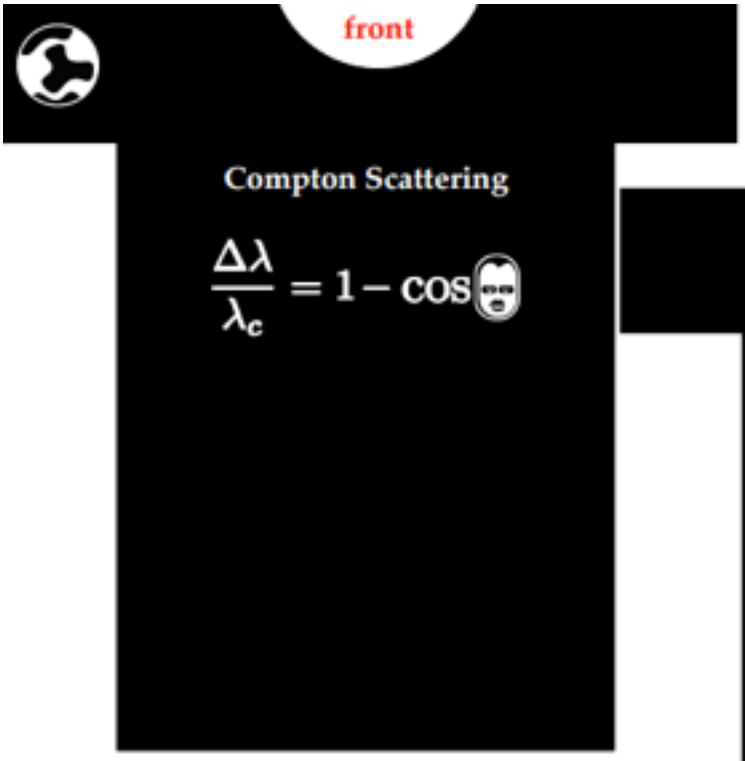


DR. STRANGELOVE

This year Physics Club collaborated with Political Science Club to watch the film "Dr. Strangelove: Or How I Learned to Stop Worrying and Love the Bomb" and afterwards had a panel session on nuclear weapons. The panelists were faculty who generously volunteered their time to speak on the panel, two from physics and two from political science, moderated by Carson Bullock, a double major in physics and political science.

PHYSICS CLUB

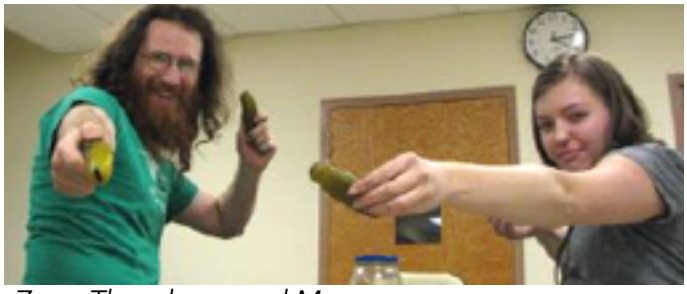
PHYSICS CLUB T-SHIRT



The front features the Compton scattering equation with an icon of Nobel Prize Winner and Wooster grad (1913) Arthur Compton. The back includes a map pointing out each of the locations where the Compton brothers became administrators after graduating from The College of Wooster. The sleeve features a spherical cow.

OUTREACH

Every year we offer five physics demos to the local elementary schools to teach simple physics concepts to children. Some teachers request all five demos each year! This year we went on about 20 different outreach visits.



Zqne Thornburg and Megan Fisher prepare to do the "glowing pickle" demo for Science Day.

We hosted and sponsored the 10th annual Community Science Day in April. We had a record-breaking number of clubs participate this year, including: archaeology, astronomy, biology, biochemistry, chemistry, geology, math, neuroscience, pre-dental, pre-health, robotics, and seven different physics demos. Our attendance this year was ~150 children and ~75 parents.

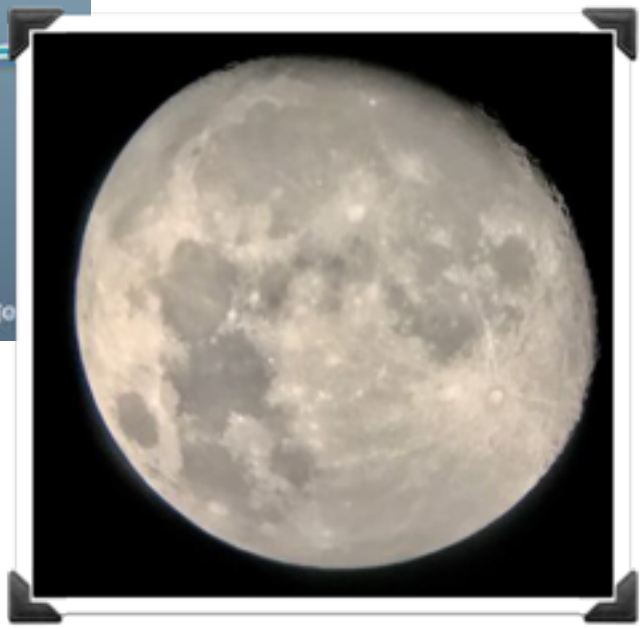
ASTRONOMY CLUB

Independent Eyes, Observing Together

ASTRONOMY CLUB T-SHIRT

OFFICERS

President: Zane Thornburg
Vice President: Nate Moore
Treasurer: Michelle Bae
Secretary: Abigail Ambrose



Winning submission
"Luna"
taken by
Sally Lorbach '20

CONFERENCES

This year, the students in our department became more active in presenting at conferences thanks to more opportunities being presented by faculty in our department. Our students presented at local APS meetings, the APS March Meeting, an American Astronomical Society national meeting, an Ohio Academy of Science meeting, CUR conferences, and even an American Chemical Society national meeting.

STUDENT PRESENTATIONS

** denotes Wooster student; † denotes summer research student*

• Abigail Ambrose* † and Niklas Manz. "Using Match Stick Arrays to Analyze Forest Fire Propagation Along a Slope." American Physical Society Ohio-Region Section, Michigan State University (March 2018) and The Ohio Academy of Science Annual Meeting, Bowling Green State University (April 2018).

• Jack Mershon*, Chase Fuller *†, and Niklas Manz. "Modified Propagation of Belousov Zhabotinsky Waves in a Quasi-1D System." American Physical Society Ohio-Region Section, Michigan State University (March 2018).

• Zane Thornburg*, Karl Feierabend, and Susan Lehman. "Investigating the Beer-Lambert Law in a Cavity-Enhanced Spectroscopic Method." 255th ACS National Meeting and Exposition, New Orleans, LA (March 2018).

•Gabriel Dale-Gau*†, Susan Y. Lehman, A System of Pressure Sensors to Characterize Duration and Area of Avalanches on a Conical Bead Pile, American Physical Society, Los Angeles, CA (March 2018).

•Emma Brinton*, Michael Wolff*, Benjamin Jenkins*†, Cody Leary, Dynamics of a Small Dielectric Sphere Due to the Higher-Order Modes of an Optical Nano Fiber, American Physical Society, Los Angeles, CA (March 2018).

• Haidar Esseili*†, Kyle McNickle*, Susan Y. Lehman, Use of Particle Image Velocimetry to Characterize the Dynamics of Avalanches on a Conical Bead Pile, American Physical Society, Los Angeles, CA (March 2018).

• Chase Fuller*†, Jack Mershon*, Niklas Manz, Effects of Fluid Flow on Chemical Excitation with Normal and Anomalous Dispersion Relations, American Physical Society, Los Angeles, CA (March 2018).

• Hannah Peltz Smalley†, John F. Lindner, Sliding on a Massive Spinning Asteroid, American Physical Society, Los Angeles, CA (March 2018).

• Avi Vajpeyi*, John F. Lindner, Susan Y. Lehman, Denise Byrnes, Simulation of a Granular Flow Experiment Using GPU Parallelism, American Physical Society, Los Angeles, CA (March 2018).

• Justine Walker*, John F. Lindner, Kim Tritt, Dancing Our Way to Mars Through Physics, American Physical Society, Los Angeles, CA (March 2018).

• Nathaniel Moore*, Laura DeGroot, Local Analogs: Comparing a 12-inch to the Hubble, American Astronomical Society, Washington, DC (January 2018).

CONFERENCES

STUDENT PRESENTATIONS

** denotes Wooster student; † denotes summer research student*

• Jack Mershon*, Nojan Aliahmed, Yadong Liu, Bhavya Sri Pakki, and Magilal Agarwal, Ultra-Thin Flexible Battery, CUR's Research Experiences for Undergraduates Symposium, Alexandria, VA (October 2017).

• Zane Thornburg*, Karl Feierabend, and Susan Lehman, Investigating the Beer-Lambert Law in a Cavity-Enhanced Spectroscopic Method, American Physical Society Ohio-Region Section, Oxford, OH (October 2017).

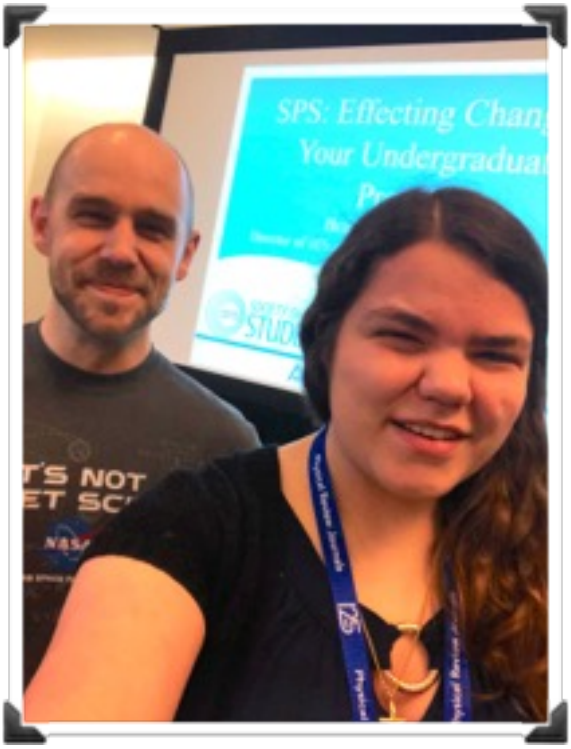
• Avi Vaipeyi*, Andrew Miller, Pia Astone, and Sergio Fransca, Enhancing Long Transient Gravitational Wave Power Spectra with Filters, American Physical Society Ohio-Region Section, Oxford, OH (October 2017).

• Hwan Bae*, Norah Ali†, and John F. Lindner, Hannay's Hoop Beyond Asymptotics, American Physical Society Ohio-Region Section, Oxford, OH (October 2017).

• Wan Hang Hui*, John F. Lindner, and Niklas Manz, The effect of obstacles on the propagation speed of Reaction-Diffusion waves, American Physical Society Ohio-Region Section, Oxford, OH (October 2017).

• Chase Fuller*† and Niklas Manz, Effects of advection on the Belousov-Zhabotinsky reaction: standing excitation waves in a quasi-1D system, American Physical Society Ohio-Region Section, Oxford, OH (October 2017).

• Abigail Ambrose*† and Niklas Manz, Using Matches to Investigate Forest Fire Propagation Along a Slope, American Physical Society Ohio-Region Section, Oxford, OH (October 2017).



Physics Club member Abigail Ambrose meeting the Director of SPS, Brad Conrad, at "SPS: Effecting Change on Your Undergraduate Program" at the April APS Meeting.

CONFERENCES

A group at the Ohio Section of APS in Fall 2017 at Miami University in Oxford, OH.

Back from Left: Vincent Hui '19, Zane Thornburg '18, Chase Fuller '19, and faculty Niklas Manz. Front from Left: Avi Vajpeyi '18, Hwan "Michelle" Bae '19, Megan Fisher '21, and Abigail Ambrose '20.

Part of the Wooster group at the Ohio Section of APS Spring 2018 meeting after the cyclotron tour.

Carlos Owusu-Ansah '21, Abigail Ambrose '20, Nate Smith '18, and Mili Barai '21.

SUMMER RESEARCH

WOOSTER NSF-REU

- Joshua Ballard-Myer (Georgia College '20) (Advised by Niklas Manz)

  "Analysis of an Experimental Setup for BZ Waves in a Quasi 1-D RDA System"

- Daniel Blaikie (Wooster '19) (Advised by Niklas Manz)

  "Propagating Excitation Waves Over an Illuminated Two Dimensional System"

- Duncan Crow (Wooster '19) (Advised by Paul Bonvallet)

  "Force Exertion and Spectroscopic Properties of Swellable Organically Modified Silica"

- Tanaka Chingonzo (Wooster '21) (Advised by Niklas Manz)

  "Digitizing the History of the BZ Reaction in HTML, CSS, JavaScript and LaTeX"

- Montana Ferita (Westminster '21) (Advised by Susan Lehman)

  "Characterizing System Spanning and Non-system Spanning Avalanches"

- Rebecca Glaser (SUNY Geneseo '19) (Advised by Niklas Manz)

  "Simulation of Reaction-Diffusion Waves Interacting with Convex Obstacles"

- Ben Hessman (Wooster '20) (Advised by John Lindner)

  "Sliding on a Spinning Asteroid"

- Carlos Owusu-Ansah (Wooster '21) (Advised by John Lindner)

  "Spectral Stability of Slash-Slash Equilibrium"

- Kimberly Patterson (Agnes Scott '20) (Advised by John Lindner)

  "Sliding on a Rotating Cuboid"

- Ryan Reffner (Lorain County Community College '19) (Advised by Paul Bonvallet)

  "Force Generation and Encapsulation of Fluorophores in Swellable Organically Modified Silica"

- Katie Shideler (Wooster '21) (Advised by Susan Lehman)

  "New Ways of Analyzing Pressure Sensor Data"

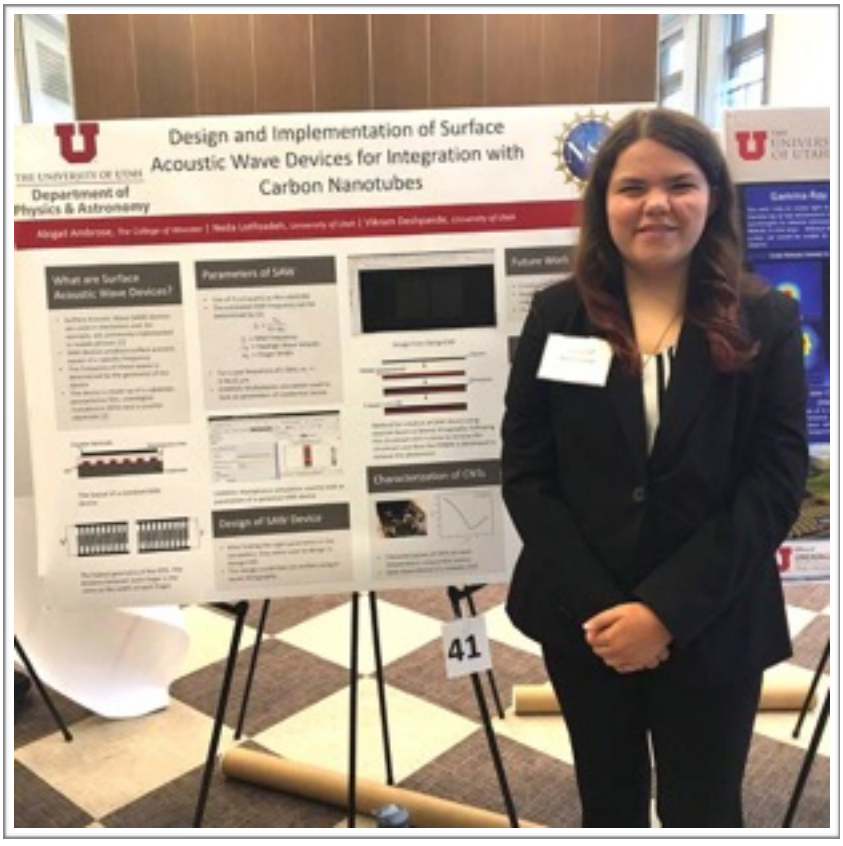
- Charles Walker (Haverford '20) (Advised by John Lindner)

  "GPU Accelerated Granular Flow Simulation"

SUMMER RESEARCH

OFF-CAMPUS

- Carson Bullock ‘19 was a Space Policy Intern at the National Academies of Sciences, Engineering and Medicine in Washington, DC. Carson worked as an editor on upcoming reports on Exoplanet Science and Astrobiology.
- Haidar Esseili ‘19 had an Internship at Kent Displays Inc., Kent OH.
- Megan Fisher ‘21 worked on improving the forecasting of space weather, specifically solar flares, by quantifying the improvements of forecasting curves made from vector magnetograms instead of line-of-sight magnetograms on currently one of the best forecasting techniques, MAG4 at The University of Alabama in Huntsville and NASA Marshall Space Flight Center Heliophysics Summer Research Opportunity for Undergraduates.



- Abigail Ambrose ‘20 worked on the design and implementation of surface acoustic wave devices for integration with carbon nanotubes” at The University of Utah.

ALUMNI TIDBITS

Saul Propp '15, a graduate student at University of Oregon, ran into '05 grad Nick Harmon, research scientists at University of Iowa, during a recent visit to NIST. Saul reports a very exciting visit at NIST and they even got to see the setup for the "loophole-free" Bell test.

Jackie Middleton, Department Administrative Coordinator, enjoyed running into Lily Christman '13, Elliot Wainwright '15 as well as Louisa Catalano '11 at Alumni Weekend activities.

Manon Grugel-Watson '99 was recently honored for her ten years of service as our Department's lab coordinator and instructor.

Roger France '73 wore the 2018 Physics Club "Compton scattering" t-shirt at Alumni Weekend and reports it inspired some good discussion! Roger says that his family is a pretty good example of "Compton scattering":

- *He met his wife of 42 years Mary Beth Aitchison France, '73 at Wooster, where she was living in Compton Hall.*
- *Their oldest son got his undergrad degree in physics from the school of engineering at Washington University in St. Louis! (one arrow)*
- *His son's wife got her PhD at MIT in biomechanical engineering. (another arrow)*
- *The only connection he has with Washington State University is that he's visited the state a couple of times (but, that counts, right?)*

photo credit: Connie Hoffman Storck '73