WOOSTER PHYSICS

2020–2021 Annual Report

physics.wooster.edu

A NOTE FROM DR. CODY LEARY, DEPARTMENT CHAIR

Greetings from Cody Leary, Chair of Physics.

This year held a number of changes for the physics department, from new modes of hybrid teaching to the retirement of John Lindner after 33 years at the College!

Before Dr. Lindner left Wooster to continue pursuing his research interests, the department presented him with a poster containing a selection of physics club T-shirts over the years (see photo to the right with Dr Lindner with our Lab Instructor and Coordinator Manon Grugel-Watson). Among my favorite recollections in my ten years at the College is great conversations with students and colleagues at our weekly Physics Table lunches, put on by the physics club which Dr. Lindner so often advised. Thanks, John, for all the great memories!

Other highlights included a senior graduation celebration late in the spring semester, and catching 10 of our 15 seniors on graduation day for a group photo with faculty. After an academic year with fewer in-person extra-curricular activities, it was especially meaningful to be able to connect with students.

We also celebrate the tenure of Dr. Niklas Manz, who will become department chair effective summer 2021, and Dr. Susan Lehman, who was granted a research leave for this coming academic year. We are excited to announce that Dr. Laura DeGroot will be rejoining the physics faculty next year, and Dr. Robin Bjorkquist will be joining us for the first time, both as visiting faculty.

Wishing each of you well this year and hoping that we can continue to stay in touch!

FALL 2020

Many changes were implemented to keep students, faculty and staff healthy and safe during the Covid-19 Pandemic. Tents were set up across campus to allow for outdoor classes and social distancing.

2021 COMMENCEMENT

The graduating Class of 2021 was able to participate in person.

453 students celebrated their accomplishments at Wooster.

CLASS OF 2021

Matt Klonowski, Megan Fisher, Fish Yu, Craig Klumpp, Andrew Kunkel, Mili Barai, Henry Whyte, Katie Shideler, Ariel Xie, Dani Halbing, Carlos Owusu-Ansah

Not pictured:
Yuchen Gan, Gentaro Nakata, Handeul Son, Niall Qian

3/2 Engineering Dual Degree Program

Huikang (Niall) Qian

SENIOR INDEPENDENT STUDY

Mili Barai (Physics Major from Rajkot, India)

Measuring properties of entangled photons using the Hong-Ou-Mandel effect

Advised by Dr. Cody Leary (Physics) & Dr. John Lindner (Physics)

We model Joint Spectral Intensities of two entangled photons created by spontaneous parametric down conversion using three crystals, beta-Barium Borate, Calcium Carbonate and Lithium Iodate. For an entangled photon pair, by changing the property of one photon, one can also change the property of the other photon in the pair. We can model Joint Spectral Intensities by considering the effect of crystal length and the angle at which the crystal is oriented with respect to the pump laser polarization. We learn that on increasing length of the crystal, peaks of Joint Spectral Intensities get narrower. On increasing the angle of tilt of the crystal, the singular probability peak divides into two peaks and moves out of the visible range. We then model the Hong-Ou-Mandel effect to measure properties of the two photons by modelling the photons passing through a beam splitter after going through two separate paths, with one path having a time delay and getting detected by the detectors at the beam splitter outputs. We model the rate of coincidence, or number of times both photons are detected at different ports simultaneously for different lengths of crystals. We find that on increasing the length of the crystal, the width of the Hong-Ou-Mandel dip increases as well. This project is important because it helps us learn about the properties of entangled photons, which have numerous applications such as quantum computing, quantum cryptography, and secure communications.

SENIOR INDEPENDENT STUDY

Megan Fisher (Physics Major from Sheffield Village, Ohio)

Creating an Event Horizon Analogue with the Belousov-Zabotinsky Reaction

Advised by Dr. Niklas Manz (Physics)

Second Reader Dr. John Lindner (Physics)

The purpose of this thesis was to create a tabletop analogue for the event horizon of a black hole using the Belousov-Zhabotinsky (BZ) reaction. To create this analogue, we aim to fill a channel with a BZ solution, initiate a wave, and pump the fluid at a velocity to exactly oppose the BZ wave to create a standing wave. We redesigned the reaction container for the experimental setup to create sections of varying height to create a velocity gradient as the fluid was pumped. The experimental set up was transitioned from the previously used NE-9000G Peristaltic Pump to the Gilson Minipuls 3 Peristaltic Pump, funded by the College of Wooster's Copeland fund. We also found a set of BZ solution concentrations to create low excitability for controllable wave production. Once all elements were tested, we performed final testing to observe and create a time-space plot to visualize the analogue.

SENIOR INDEPENDENT STUDY

Yuchen Gan (Physics Major from Chengdu, China)

Free-Fall Spinning-Planet Tunnel Transportation Network

Advised by Dr. John Lindner (Physics) & Dr. Niklas Manz (Physics)

Transportation is a very general and important thing. We have airplanes and trains for long distance traveling now. It would be really interesting to have a new transportation tool which is much faster than these transportation tools. Free-fall tunnel transportation network is such a tool. If Earth is not rotating, it takes only 42 minutes for any object to travel from one side of Earth to the other side in an evacuated tunnel powered by gravity alone. We do not need to do anything except to put the object or yourself at the entrance of the tunnel. This research studies this new transportation system in a spinning Earth in detail. It shows that curved periodic free-fall tunnels can connect multiple points on the surface of a planet at any latitude. Theory and computation will help to elucidate the tunnel system in both inertial reference frame and rotating reference frame.

SENIOR INDEPENDENT STUDY

Daniel (Dani) Halbing (Physics Major from Charlotte, N. Carolina)

The Effect of Varied Paneling Characteristics on the Predictability of Soccer Ball Flight

Advised by Dr. Susan Lehman (Physics)

The predictability of flight of the Adidas Conext15, Adidas Jabulani, Adidas UEFA Nations League, Nike Incyte, Nike Flight, Nike Ordem, and Wilson NCAA Forte match balls were analyzed. Six to nine shots of each match ball were recorded from two angles, a rear angle and a side angle, for this investigation. Each of the videos were uploaded to Tracker in order to collect data on the spin, velocity, initial position, and final position of each of the trials in both the x-and y-directions. The data from the initial 20 frames of each trial was then used to create a theoretical final position of the ball using a radius of curvature of the flight path equation for the x-direction and a differential projectile motion equation for the y-direction. These theoretical final positions were then compared to the measured final positions of the ball in order to see how much the ball had deviated from the theoretical flight path based on the initial flight data. This deviation was then used as the metric for unpredictability in the scope of this investigation. For a soccer ball in general, it was found that a higher spin rate in the x-direction made the ball less predictable when compared to other low spin curved shots. However, in the y-direction, it was found that there was no relationship between the predictability of a ball and the spin rate. As the initial velocity in the y-direction increased, the predictability of the shot decreases. Of the seven balls that were tested, the most predictable ball in the x-direction was the adidas UEFA Nations League which deviated from the theoretical final x-position by an average of 0.78±0.67 m. The most predictable ball in the y-direction was the Wilson NCAA Forte which deviated by an average of 0.2±0.25 m. The most predictable ball overall was the Adidas UEFA Nations League as it deviated from the theoretical final x-position by an average of 0.78±0.67 m and deviated from the theoretical final y-position by an average of 0.29±0.15 m.

SENIOR INDEPENDENT STUDY

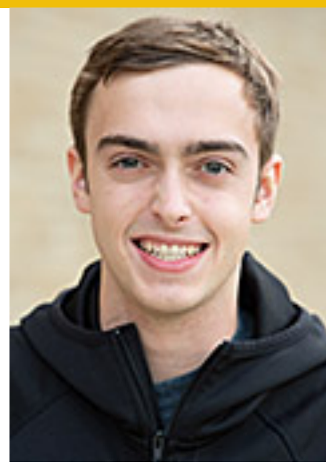
Mattaeus (Matt) Klonowski
(Physics Major from Lincolnshire, Illinois)

Comparative Study of Swellable Materials: Superabsorbent Polymers versus Swellable Organically Modified Silica

Advised by Dr. Cody Leary (Physics) & Dr. Paul Edmiston (Chemistry)

Stimuli-responsive polymers (SRPs) are materials which exhibit a change in physical properties upon a change in local environment. Some SRPs can expand in volume upon absorption of liquid, and are referred to as swellable materials. The two swellable materials studied in this project were sodium polyacrylate (SPA) and swellable organically-modified silica (SOMS). SPA swells only upon absorption of water, whereas SOMS can swell upon the absorption of a variety of organic solvents. Both SPA and SOMS generate a pressure when swollen within a confined volume. Although SPA generates greater swelling pressure than SOMS, SOMS takes significantly less time to reach maximum swelling pressure. SOMS exhibits immediate pressure generation upon contact with solvent, whereas SPA has an initially slow buildup in pressure generation. The different behaviors of SPA and SOMS are due to the different solvent-network interactions driving the swelling of each material. SOMS was swollen with different solvents, and maximum swelling pressure was found to have minimal dependence on absorbed solvent. However, the time it took for SOMS to reach maximum swelling pressure varied significantly with absorbed solvent, and may correlate to the viscosity of the solvent. Modeling SOMS as an exponential spring revealed a difference in the elasticity of SOMS for different amounts of absorbed solvent. Swelling mechanisms governing the pressure generation of SOMS remain unknown. However, progress was made by fitting relevant models to the swelling of SOMS. The next step in determining the swelling mechanism of SOMSwill be correlating physical processes to the models used.

SENIOR INDEPENDENT STUDY



Craig Klumpp (Physics Major from Delaware, Ohio)

A Case of Heartburn; Replicating the Heart's Electrical Signals with Fire

Advised by Dr. Niklas Manz (Physics)

Second Reader Dr. Susan Lehman

Typically, when someone mentions fire, a person's first thought is that of a blazing inferno. However, humanity has learned to somewhat tame flame over the millennia and it has been used greatly in our progress as a species. My research set out to use fire as a tool to replicate one of the most delicate systems found within the human body. This system is the heart's electrical conduction system which is responsible for the heartbeat. By using fire, behaviors of this system can be replicated in an easy to visualize manner. A few heart behaviors observed over the course of this research include: oscillatory pulses similar to those produced by the sinus node, pulses that matched heart arrhythmias, and blockages of pulses similar to conduction blocks. What was found in this research can be used to further understand how excitation pulses travel within the heart and how certain heart conditions may arise.

SENIOR INDEPENDENT STUDY

Andrew Kunkel (Physics Major from Charlottesville, Virginia)

Examining Light-Matter Interactions Through Two Photon Entanglement

Advised by Dr. Cody Leary (Physics)

In this thesis we model two-photon interference with a nonlinear sample in a Mach Zehnder interferometer to calculate a coincidence signal that can be compared with ongoing experimentation. Specifically, we use entangled biphoton states created by Type I collinear spontaneous parametric down conversion that give valuable symmetries that simplify the formalism. The interferometer constrains the input state to enter the apparatus through one entrance of a beam splitter allowing for a more intuitive model for the sample interaction. The experiment is first modeled using a black box method, with the techniques used then applied to each part of the interferometer one by one. We complete the model with an expression for a particular coincidence signal Rcc that is constructed from three terms, one for the linear interaction contribution to the signal denoted R0 and two for the nonlinear parts R1 and R2. In this analysis, only the R2 contribution was successfully evaluated. We implemented a second order Taylor expansion to approximate the unknown nonlinear susceptibility of the sample $\chi(3)$ to evaluate R2. The evaluation of R1 and the quantitative com- parison of both R1 and R2 to ongoing experiment is left to future researchers.

SENIOR INDEPENDENT STUDY

Gentaro Nakata (Physics Major from Azumino, Japan)

Propellant-less Space Travel with Tethers:Swimming in Space using an Asteroid's Gravity Gradient.

Advised by Dr. John Lindner (Physics)

Second Reader Dr. Susan Lehman

The thesis demonstrates the possibility of propellant-less space travel with a tether, two masses separated by a variable length. By computer simulations, we show how to lengthen and shorten the tether to swim in space using the gravity gradient of a nearby asteroid, moon, or planet.

SENIOR INDEPENDENT STUDY

Carlos Owusu-Ansah (Physics Major from Accra, Ghana)

Trajectory of an Anisotropic Particle Near a Light-Transmitting Optical Nanofiber

Advised by Dr. Cody Leary (Physics) & Dr. Rob Kelvey (Mathematics)

We present the general expressions force and torque on a dipolar particle of arbitrary linear birefringence. We use the derived equations to model the behavior of the anisotropic particle kyanite in the field of a light-transmitting optical nanofiber submerged in water. We examine the qualitative and quantitative features of the motion of the particle. We find that the steady-state orientation of the particle has one of its body-frame axes fixed perpendicular to the plane of the electric field while the other two rotate without stopping in the plane of the electric field. The rate at which the particle spins is nearly fixed but has small oscillations which represent less than 2% of its magnitude. This causes the force on the particle to oscillate, giving rise to vibration modes in the particle as it transverses its helical trajectory around the nanofiber.

SENIOR INDEPENDENT STUDY

Katherine (Katie) Shideler
(Physics Major from Gibsonia, Pennsylvania)

Energy Conservation: Harnessing Excess Thermal Energy and Converting to Electricity

Advised by Dr. Susan Lehman (Physics) & Dr. R. Drew Pasteur (Mathematics)

The dynamics of thermoelectric energy were studied throughout this experi- mental research. With the goal of energy recycling and conservation in mind, a device comprised of thermoelectric generators (TEGs) was placed onto various heat sources across the College of Wooster campus. The TEGs could harness the wasted heat given off by the heat source and convert the temperature gradient created on the TEGs into a usable voltage. With this voltage, we can calculate the amount of power and energy that can be recycled with our device. The amount of energy collected is analyzed to see if it is large enough to complete various possible tasks. Scenarios such as charging a cell phone or powering the lights are investigated. The energy recycled from our prototype device proved to be insignificant. The cost of making a device to power these tasks was far greater than the cost of electricity as to equate the cost of the device with the cost of electricity per year when both are supplying equal amounts of energy was determined 30 years minimum with our current device. Improvements must be made to our model to increase the efficiency and energy recycled. We must increase the current supplied by the TEGs or add to the number of operating TEGs on our device to make reasonable adjustments to recycle a significant amount of energy. Adjustments could also be made to the design of the device in an effort to maintain the temperature gradient for a longer period of time. The duration of our large temperature gradient directly affects the energy re- cycled. With these adjustments, thermoelectric materials have the potential to greatly increase energy conservation on the college campus.

SENIOR INDEPENDENT STUDY

Handeul Son (Physics Major from JeJu-Si, Republic of Korea)

Investigation of Fire Propagation using Discrete Tree Simulations.

Advised by Dr. Niklas Manz (Physics)

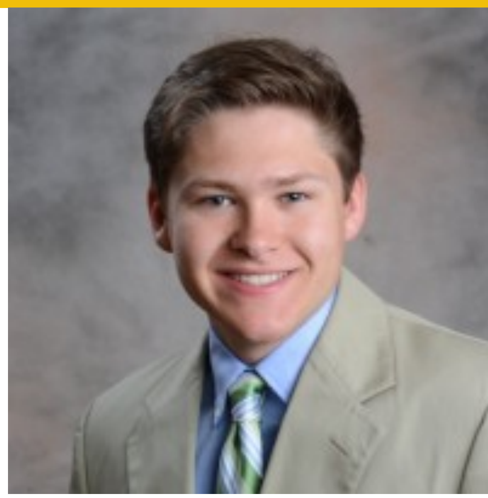
Second Reader Dr. Cody Leary

Joe Theiss '19 simulated the fire propagation with discrete trees using Python and determined vxincreases if Th and Sl increases but decreases if Td increases. Since the Python code made by Joe Theiss '19 was difficult to use due to the lack of explanations, annotations in the whole code were made.

The values of vx were computed in the range of 1 pixel ≤ Td ≤ 8 pixels, 20 pixels ≤ Th ≤50 pixels, and −45° ≤ Sl ≤ 45° to examine how Sl, Th, and Td affect vx and which factor alters vx the most. Td was identified to be the most important variable, with a clear inverse relationship following vx=(35.9±0.1) ⋅ Td(−1.055±0.003) pixels/second. Th and Sl were identified to affect the acceleration, while Td was identified to affect the initial speed. Since the effect on initial speed varied vx from 3 pixels/second to 33 pixels/second while the effect on acceleration varied vx from 4 pixels/second to 8 pixels/second, the effect on initial speed was stronger and it was the reason why Td was the most important variable.

It was exciting to investigate large amount of vxvalues and determine the relationship with a specific equation. The wind effect on vx can be simulated in the further research because wind strongly affects vx in nature.

SENIOR INDEPENDENT STUDY



Henry Whyte (Physics Major from Irwin, Pennsylvania)

An Investigation of PIVlab and Avalanches on a Conical Bead Pile

Advised by Dr. Susan Lehman (Physics) & Dr. Niklas Manz (Physics)

Avalanches are one of the most destructive forces in nature, a dangerous natural phenomenon that pose a risk to snowboarders, skiers and winter outdoor enthusiasts. Under the right environmental conditions, an avalanche can tear trees from its roots, flatten buildings, and consume anything before it, leaving a trail of destruction. At the College of Wooster with the help of a conical pile of steel-shot beads we can now investigate the conditions that may contribute to avalanches. The pile is driven through the autonomous dropping of beads onto the apex one at a time. Environmental conditions that facilitate an avalanche may change with time. Similarly, conditions in the lab change, which can effect the bead pile and subsequently experimental outcomes. The previous steel-shot beads used for this experiment were replaced this year with new beads of the same kind. To ensure the use of these new beads were not drastically changing the results of the experiment, an investigation of the mass data was completed. This investigation included comparing sets of data from the old beads and the new ones. Two runs were completed at different iii iv cohesion levels, where cohesion between the beads on the pile was created using the magnetic field due to a set of Helmholtz coils. From the probability distribution of avalanche sizes, I suggest that the amount of oil used to cover the older beads is greater than the amount on the newer set of beads. We also examined the use of video analysis and the software program PIVlab, which is used to analyze our avalanche videos. This program determines the velocity of small areas of the pile, and the magnitude of this velocity data was compared to that of a program called Tracker. Tracker is another video analysis tool which is well suited to track single particles, whereas PIVlab is better suited for analyzing the motion of whole systems. We found that the average velocity output from PIVlab was of the same order of magnitude as the calculated velocity from Tracker, which provides reassurance of our past and continued use of PIVlab.

SENIOR INDEPENDENT STUDY

Xinchen (Ariel) Xie (Physics Major from Beijing, China)

Exoplanets Sunsets

Advised by Dr. John Linder (Physics) & Dr. Robert Kelvey (Mathematics/CS)

For some eccentric planetary orbits, the host star appears to move backwards in the sky as the orbital speed momentarily exceeds the rotation speed near the periapsis, when the planet is nearest to its star. This necessitates a new definition of a day. Thus, a new definition "Apoday" is defined as the time between two consecutive noons in the dominant direction of motion of the host star, excluding the noons caused by its reversal and recovery. This thesis begins with an exploration of conditions necessary for apoday to happen.

Over the past decade, NASA's Kepler and K2 missions have discovered thou- sands of planetary candidates for human settlement, of which 2000 have been confirmed. If humans settle on the moon, planets, or exoplanets, how sunset looks like on exoplanet? This thesis examines the apparent motion of the host star as viewed from exoplanets. Mathematica simulations model the motion of the host star. The simulations involve numerical integration of orbital equations of motion and analytic computation of the altitude of the sun observed from the planet. For the special case of zero obliquity(tilt), an exact nonlinear equations delimiting apodays in the space of orbital eccentricity and spin-orbit (day-year) ratio is derived, confirmed by numerical simulations.

SENIOR INDEPENDENT STUDY

Yang (Fish) Yu (Physics Major from Beijing, China)

Alien Sunsets on Tumbling Asteroid

Advised by Dr. John Lindner (Physics)

Second Reader Dr. Cody Leary

We simulated Sol's apparent motion as observed from tumbling asteroids. If all the mass of the asteroid is concentrated at a point, it will move in an elliptical orbit, like Earth. To account for the tumbling of the asteroid, we extend the point into a dumbbell. We forced the center of mass to move elliptically, and then the asteroid itself tumbled, according to Newton's second law.

We calculated Sol's apparent motion by numerical integration of Kepler and dumbbell's orbital equations and changeable parameters. Our system is very sensitive to initial conditions, and hence is chaotic.

We simulated Sol's movement in skies under different conditions from observer's perspective. Sol is able to move irregularly in the skies; it may move back and forth in the sky or stay below the horizon for days.

2020-2021 COLLOQUIUM SERIES

- Junior IS Oral Presentations, Tuesday 20 April 2021, via Teams
- Dr. Matteo Luisi, Presentation of Research, "The Impact of High-Mass Stars on their Environment," Wednesday 3 March 2021, via Teams
- Dr. Robin Bjorkquist, Presentation of Research,"How to Build a Virtual Calorimeter," Monday 1 March 2021, via Teams
- Sophomore Majors Departmental Information Session, Thursday 11 February 2021, via Teams
- Senior IS Fall Semester Presentations, Session 2, Thursday 19 November 2020, via Teams
- Senior IS Fall Semester Presentations, Session 1, Tuesday 17 November 2020, via Teams
- CoW students, I don't know what you did last summer: Physics majors share **summer research experiences**, Monday 7 September 2020, via Teams

HONORS & AWARDS

FOR PHYSICS MAJORS

The Arthur H. Compton Prize in Physics
Carlos Owusu-Ansah
Xinchen (Ariel) Xie

The Mahesh K. Garg Prize in Physics
Megan Anne Fisher

Ann C. Mowery Endowed Scholarship
Katherine (Katie) Shideler
Yang (Fish) Yu

The William A. Galpin Award for General Excellence in College Work
Katherine (Katie) Shideler, 2nd place

The William H. Wilson Prize in Mathematics
Xinchen (Ariel) Xie

Karl T. Compton Scholarship
Raisa Raofa

Summa cum laude
Carlos Owusu-Ansah

Magna cum laude
Katherine (Katie) Shideler
Handeul Son

Cum laude
Megan Anne Fisher
Daniel (Dani) Halbing
Mattaeus Klonowski
Andrew Michael Kunkel
Yang (Fish) Yu

JUNIOR INDEPENDENT STUDY SELF-DESIGNED EXPERIMENTS

Bennett Anderson '22
The Compression of Soccer Balls

Shivam Bhasin '22
There are Probably No Figure-8 Orbits in the Universe

Teague Curless '22
To Flip or Not to Flip? That is the Question

Luke Eisnaugle '22
Small-Scale Percolation in a Physical Experiment

William Hilbert '22
Light in Non-Uniform Mixtures

Jonathan Logan '22
"In Thrust We Trust": A Galilean Moon Braking System

Lillian Miller '22
Oh What a Drag

Benjamin Stern '22
What's the Deal with Friction Anyway?

Melita Wiles '22
Investigating the Fractal Dimension of Clouds to Minimize Uncertainty in Climate Models

Haoge Yan '22
Rolling Bottle Experiment

FACULTY

Cody Leary, Associate Professor of Physics

TEACHING

Thermal Physics
Algebra Physics II
Electricity & Magnetism
Calculus Physics I Lab
Calculus Physics II Lab
4 Senior IS Advisees

****

Dr. Leary finished out his third year as department chair in the 2020-21 academic year. In between juggling the new responsibilities of teaching hybrid classes, he enjoyed working with 4 senior IS students and one sophomore researcher, making progress on a number of research projects in the areas of nonlinear quantum optics, optical nanofibers, and geometric phases of light.

FACULTY

Niklas Manz, Assistant Professor of Physics

TEACHING

Environmental Physics
Calculus Physics I
Calculus Physics II
Calculus Physics II Lab
Modern Physics Lab
Mechanics
4 Senior IS Advisees

****

Two articles, which Dr. Manz submitted during the summer, got published: https://wavelab.spaces.wooster.edu/publications/rd-systems/ One on the geographic tongue with Margaret McGuire '20 as the first author and one with Fish Yu '21 as the first author. Both were results from the Sherman-Fairchild grant during the summer 2019.

Dr. Manz was elected on a four-year term into the Executive board of the, now renamed, Eastern Great Lakes Section of APS. He received tenure and takes on the roll of Department Chair beginning in July 2021.

He also created his new website during leave (spring 2020 and the summer) and is now online. https://wavelab.spaces.wooster.edu/

FACULTY

Wooster women in physics pictured on graduation day (from left to right: Katie Shideler '21, Dr. DeGroot, Dr, Lehman, Mili Barai '21, Megan Fisher '21, and Fish Yu '21)

Laura DeGroot, Visiting Assistant Professor of Physics

TEACHING

Calculus Physics I Lab
Astronomy of Stars and Galaxies
Algebra Physics I
****

Dr. DeGroot taught during the Fall 2020 semester. She taught at Oberlin College during the Spring and Summer of 2021 and looks forward to returning to Wooster in the fall of 2021.

FACULTY

John Lindner, Professor of Physics, Moore Professor of Astronomy

TEACHING

Math Methods for Physical Sciences
Computational Physics
Nonlinear Dynamics
Modern Physics
Computational Physics Lab
Senior Independent Study advisor

"This summer after 33 years at Wooster I transitioned to emeritus status. I am thankful for the freedom I've had to design my own courses, including eight first-year seminars; for the flexibility to explore a wide range of research topics, from celestial mechanics to biophysics to dancing in reduced gravity; and for six wonderful yearlong sabbaticals in Atlanta, Portland, Honolulu, and Raleigh. I remember most the many wonderful undergraduates I've worked with, including the 73 senior thesis students. Of the 61 peer-reviewed science articles I wrote while at Wooster, 30 of them include 77 undergraduate co-authors (so far).

I expect to be doing research at NCSU for the next few years and I plan to continue regularly contributing to the Physics Blog https://woosterphysicists.scotblogs.wooster.edu . Please keep in touch!"

FACULTY

Susan Lehman, Victor J. Andrew Professor of Physics

TEACHING

Calculus Physics I + Lab
Calculus Physics II
Condensed Matter Physics
3 Senior Independent Study advisees
****

Like everyone, Dr. Lehman had a number of challenges with adapting her teaching during the pandemic. Coming back to teaching in the classroom with an actual chalkboard in the spring semester was so refreshing after trying to push all her teaching energy through the screen of an iPad to the students. One wonderful positive from the year was teaching Condensed Matter to a really engaged group of students while being able to use so many examples of how Condensed Matter Physics was helping us all cope during the pandemic (from our semiconductor-based devices to the liquid crystal screens we all used to view each other). Another positive was that we were able to be in person for almost all of Junior Independent Study, an advanced lab course for which there really is no good remote alternative.

Dr Lehman was awarded a research leave for 2021-2022, so she is looking forward to having that year to focus on her ongoing beadpile research, particularly on improving the video analysis of avalanches. She and students Bennett Anderson and Melita Wiles participated in the virtual 2021 March Meeting to share the results they have gotten recently. Dr Lehman also was an author with several students, John Lindner, and chemistry colleagues Paul Edmiston and Paul Bonvallet on a paper reporting on the forces resulting during the expansion of swellable organically modified silica.

FACULTY/STAFF

Manon Grugel-Watson '99, Physics Laboratory Coordinator & Instructor

TEACHING

Algebra Physics Lab
Algebra Physics II Lab
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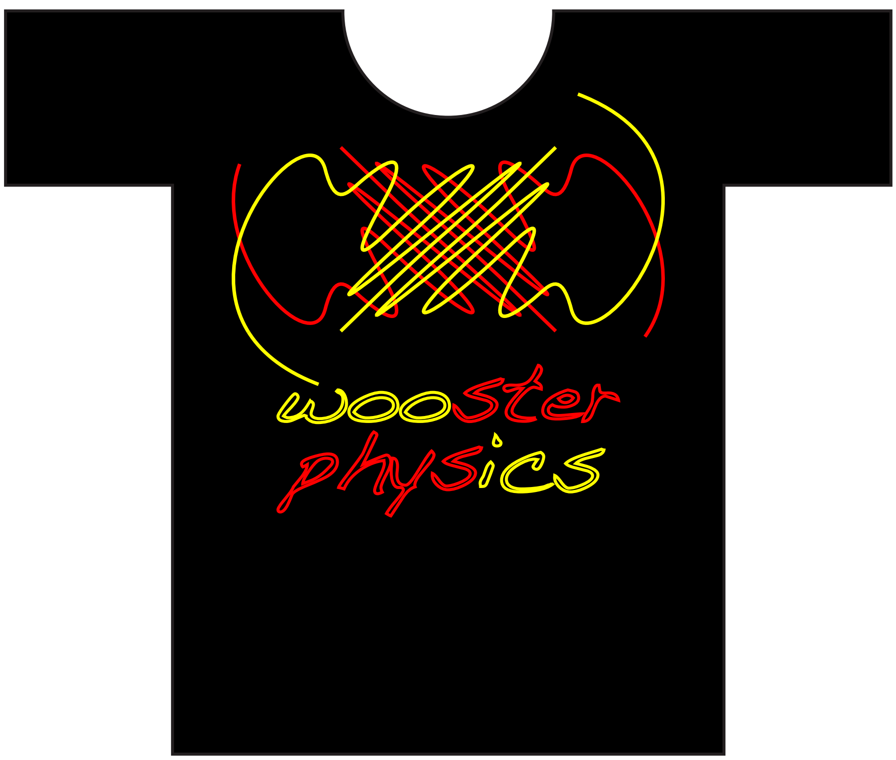
Professor Grugel-Watson manages the intro lab and demo equipment and also instructs some lab sections. This academic year, Professor Grugel taught the Algebra Physics Introductory labs and worked to provide her students with flexible options during this trying year. The lab course was offered as a "hybrid" option, allowing both on-campus and remote students to participate. Consequently, Professor Grugel redesigned the experiments in order to provide all students with a meaningful and worthwhile hands-on laboratory experience. And in order to reduce the density of students in the lab room, about half of the students would attend in-person on alternating weeks, completing an online experimental component on the other weeks. Experiments were adapted to use simple supplies, with a goal of consistency between the remote and in-person versions of the labs. Some specialized equipment was also provided to all students so that any student would be able to work remotely as needed. The online exercises often involved working with a variety of computer simulations. This year Professor Grugel had a few international students who were studying in their home countries and numerous students who preferred not to attend in-person for various reasons, so the new remote-versions of the experiments were heavily used. She looks forward to returning to a more normal semester with a fuller in-lab experience.

PHYSICS CLUB

OFFICERS

President: Megan Fisher
Vice-President: Matt Klonowski
Treasurer: Shivam Bhasin
Secretary: Andrew Kunkel
Faculty Advisor: Dr. John Lindner

PHYSICS CLUB T-SHIRT



The 2020-2021 T-shirt was Tangles!

ASTRONOMY CLUB

Independent Eyes, Observing Together

OFFICERS

President: Mili Barai
Vice President: Megan Fisher
Treasurer: Raisa Tasnim Raofa
Secretary: Melita Wiles
Faculty Advisor: Dr. John Lindner

ASTRONOMY CLUB T-SHIRT

Graphics designed by Andrew Kunkel '21

CONFERENCES

STUDENT PRESENTATIONS

** denotes Wooster student: † denotes summer research student*

- Melita Wiles*, Susan Lehman, Adjusting Images of a Conical Bead Pile through Linear Transformations (oral presentation), American Physical Society – Ohio-Region Section, virtual (April 2021).

- Margaret McGuire*†, Chase Fuller*†, John F. Lindner, Niklas Manz, Geographic Tongue as a Reaction-Diffusion System, American Physical Society – Ohio-Region Section, virtual (April 2021).

- Margaret McGuire*†, Chase Fuller*†, John F. Lindner, Niklas Manz, Geographic Tongue as a Reaction-Diffusion System, Annual Research Day, UNC Adams School of Dentistry, Chapel Hill, NC (March 2021).

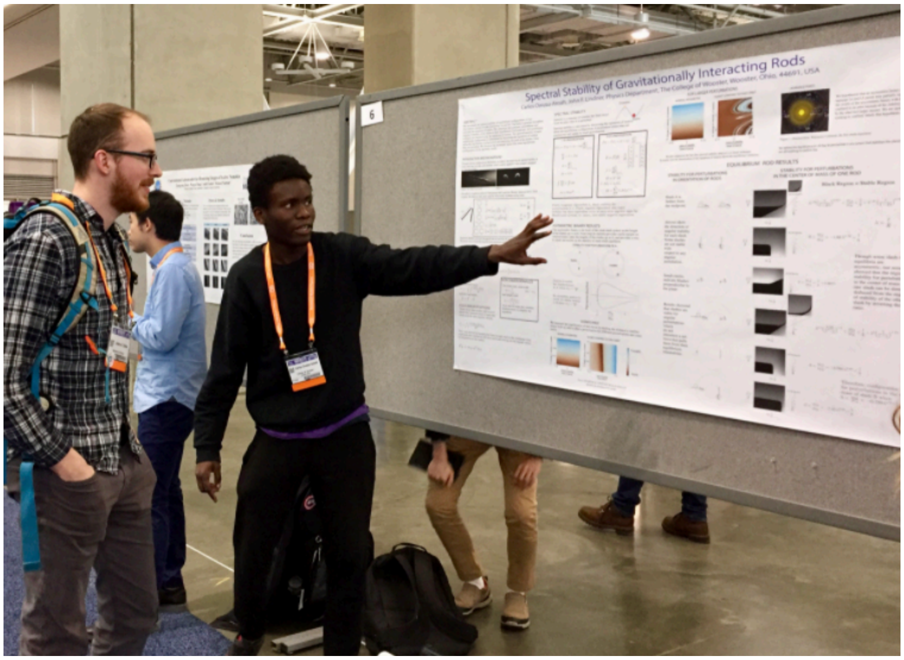
- Bennett Anderson*†, Susan Lehman, Automated Measurement of the Profile of an Avalanching Conical Bead Pile (oral presentation), American Physical Society, virtual (March 2021).

- Melita Wiles*, Susan Lehman, Adjusting Images of a Conical Bead Pile through Linear Transformations (oral presentation), American Physical Society, virtual (March 2021).

CONFERENCES

MARCH MEETING

IN BOSTON



Andrew Blaikie '13 talks to Carlos Owusu-Ansah '21 at the March Meeting in Boston to get the latest update on a **project** that Andrew began.

Andrew Blaikie '13

The // body problem (slash-slash) is the study of the gravitational interaction between 2 extended line masses. The topic of this thesis is the study of the planar // body problem, where the universe is restricted to a plane. The analysis is performed using completely classical methods. The potential and kinetic energies are derived in the center of mass frame using polar coordinates. The Euler-Lagrange equations are then used to write down the equations of motion. Geometric vectors are used to radically simplify the equations.

The equations of motion are shown to reduce to the planar /. body problem and the Newtonian 2 body problem in the appropriate limits. Three classes of periodic orbits are solved exactly and one class is believed to be stable. The Runge-Kutta-Fehlberg method is used to find numerical solutions for a given set of initial conditions using 64 digit precision. We describe a robust numerical mechanism to detect collisions before they occur. A GUI application automates the numerical processes.

Retrograde spin was observed to stabilize orbits while prograde spin destabilized orbits. Escape not possible in the Newtonian 2 body problem was observed in the planar // body problem. Using parameter space plots we found that the gravity gradient orbit generates a valley of stability around its theoretical curve.

COMPETITIONS

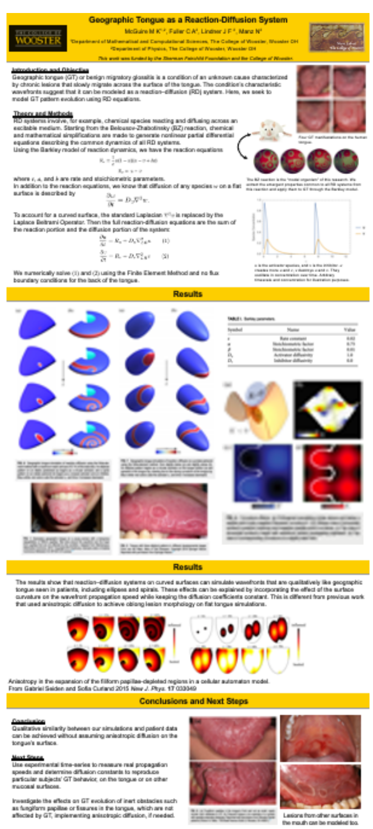
The 2020 University Physics Competition

The 2020 University Physics Competition Results Announcement – January 18, 2021

The University Physics Competition is an international contest for undergraduate students, who worked in teams of up to three students at their home colleges and universities all over the world, and spent 48 hours during the weekend of November 6, 7, & 8, 2020, analyzing an applied scenario using the principles of physics, and writing a formal paper describing their work.

Ohio-Region Section APS

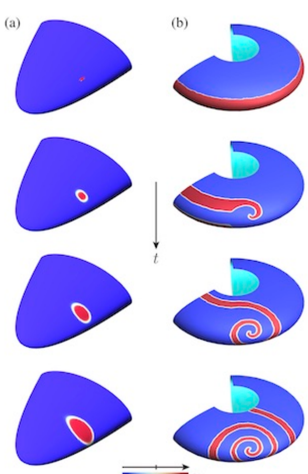
Margaret McGuire ’20 presented a poster twice during Spring 21 (https://wavelab.spaces.wooster.edu/presentations/poster/students) and won the graduate student poster award at our regional Ohio-Region Section APS meeting in April.

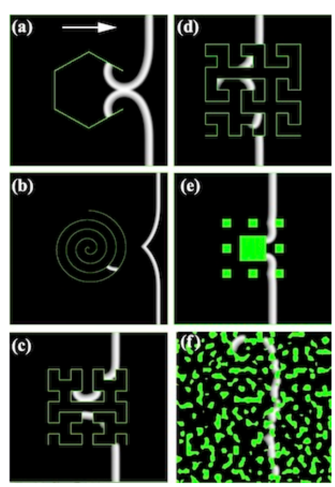


PUBLICATION

John Lindner, the Moore Professor of Astronomy at The College of Wooster, and Niklas Manz, Assistant Professor of Physics, recently published an article with two Wooster undergraduates, Fish Yu ’21 and Margaret McGuire ’20, and alumnus Chase Fuller ’19, that was a result of their research in the summer of 2019. The article, “Disruption and recovery of reaction–diffusion wavefronts interacting with concave, fractal, and soft obstacles,” was published in the statistical mechanics journal *Physica A* and investigates how reaction-diffusion wavefronts react to concave, spiral, fractal, random, and soft obstacles.

See the two published articles here:
https://wavelab.spaces.wooster.edu/publications/rd-systems/
One on the Geographic tongue with Margaret McGuire ‘20 as the first author and one on Disruption and recovery of reaction-diffusion wavefronts with Yang (Fish) Yu ’21 as the first author. Both were results from the Sherman-Fairchild grant during the summer 2019.



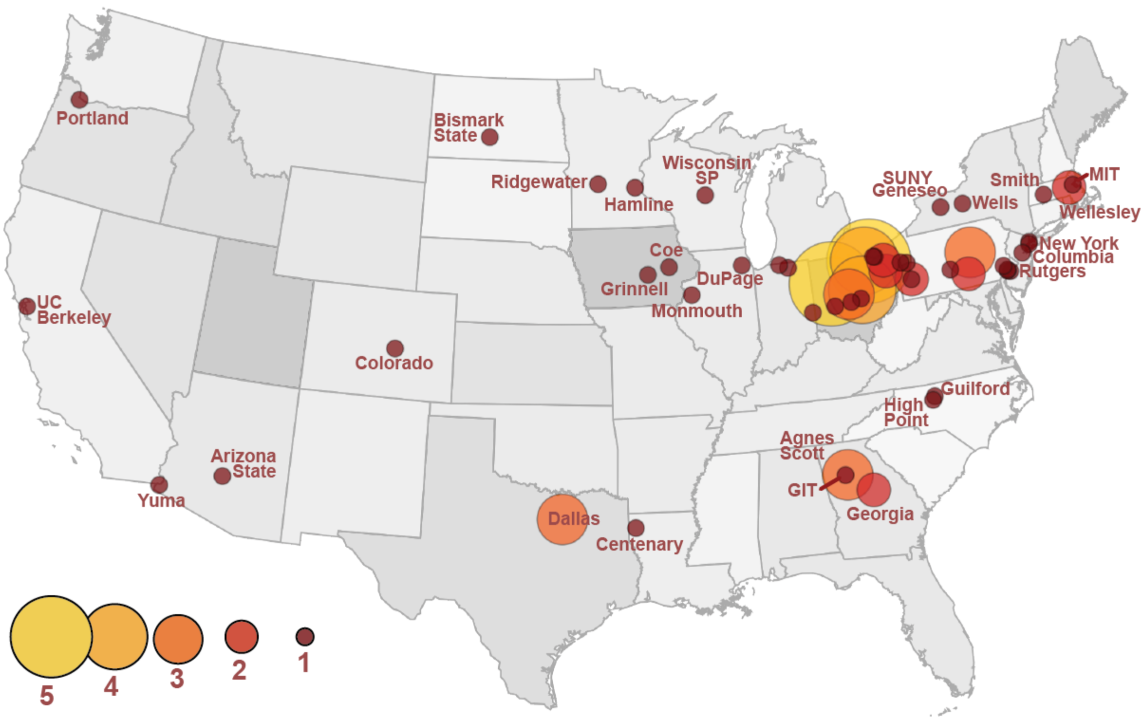


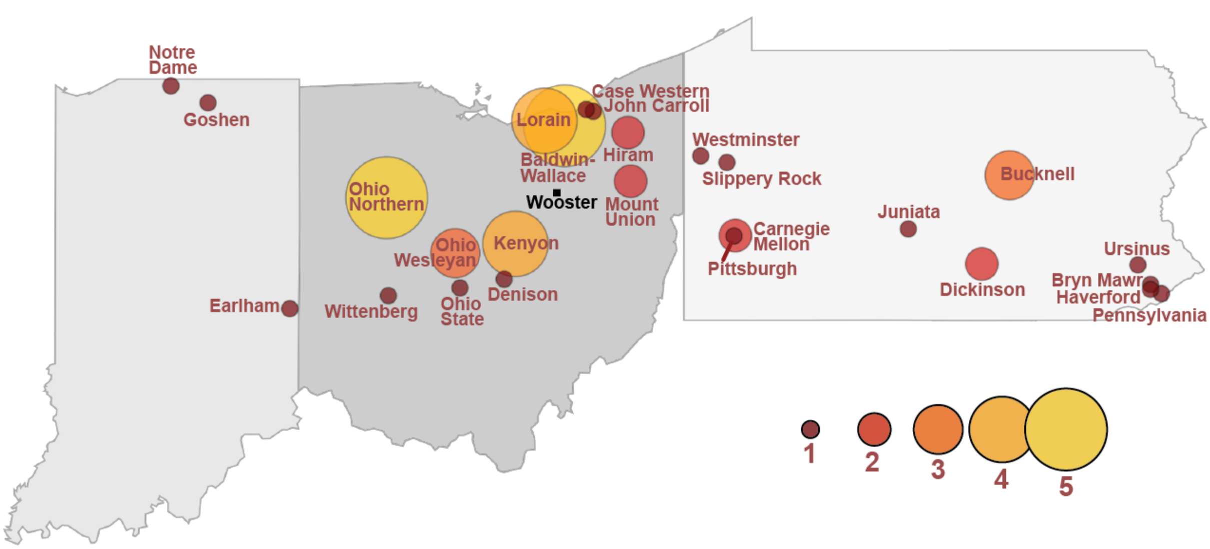
SUMMER RESEARCH

WOOSTER NSF-REU

Wooster Physics NSF REU

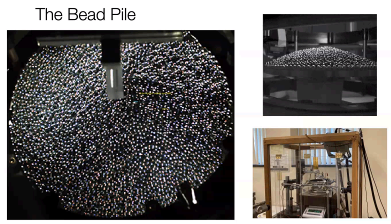
has integrated people from 55 colleges & universities with more to come!



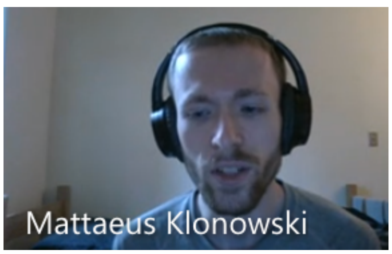


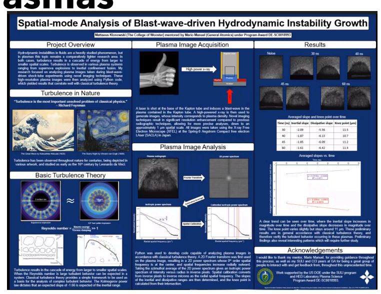
SUMMER RESEARCH

Melita Wiles ’22—Sophomore Research Program with Dr. Susan Lehman—“Particle Image Velocimetry and Pile Distortion”

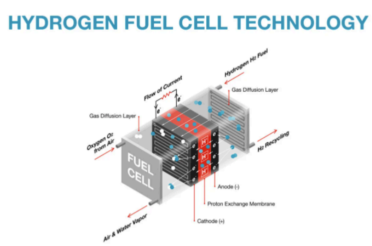


Matt Klonowski ’21—Internship at General Atomics through the Science Undergraduate Laboratory Internships Program—“Using Python to Analyze Turbulence in Plasmas”





Dani Halbing ’22—Internship at Schaeffler Group Headquarters in Germany—“Researching Surface Coatings for Hydrogen Fuel Cell Bipolar Plates”



Megan Fisher ’21—Remote Internship at the Aerospace Corporation in Virginia—“Space Architecture”