WOOSTER PHYSICS

Greetings Wooster Physics Veterans & Friends!

The 2016-2017 academic year was an exciting and eventful one for the department. As Dr. Lehman went on sabbatical, I took over as czar. (Oops — I mistyped “chair” and it autocompleted to “czar”!) We enjoyed having Dr. Tess Oliver with us to teach and advise IS, and we look forward to Dr. Laura DeGroot joining us in August for three years. With the booming success of Math, CS, and Physics, Taylor Hall did not have enough offices — so we made a new one by partitioning the Reading Room into a full-sized corner office and a smaller reading room with a really cool glass wall! I look forward to ceding my czardom to Dr. Leary next academic year. Dr. Bolton completed her first year as President — and as a tenured member of our department.

Physics Club was well represented at PhysCon 2016 in a distant Los Angeles. We sent a record-sized team to the March 2017 APS meeting in New Orleans, the 20th consecutive year that Wooster students have presented at this largest annual American Physical Society Meeting, in addition to the large group we sent to the October 2016 APS meeting in Bowling Green. Wooster professors gave research talks in faraway places including Louisiana, Washington, Oregon, Germany, Austria, and Japan. During the summer of 2016 we hosted record-tying NSF REU summer program, with 5 faculty and 14 students, including students from Wellesley, Hiram, Kenyon, Ohio State, and Agnes Scott.

The 9th annual Science Day in April featured a record number of science clubs, organized as usual by the Physics Club. Astronomy and Robotics Clubs also were very active this year — and I have so many T-shirts, I don’t know what to wear! Our 28th annual Taylor Bowl was another wonderful event, but it may be our last, as Scot Lanes will be demolished next year — stay tuned!

Manon Grugel-Watson completed her 9th year as Laboratory Coordinator and Adjunct Instructor, and Jackie Middleton completed her 28th year as Administrative Coordinator. We are fortunate to have both of them with us. (Special thanks to Jackie for creating this newsletter!) Tim Siegenthaler completes his 3rd year at the College as Machinist, and he continues to work wonderfully with our faculty and students constructing experiments.

Alumni please email us or visit if you’re in the area -- we love to hear how you’re doing!

John Lindner,
Czar of Physics

Wooster Physics participated in the March for Science rally last spring in downtown Wooster.

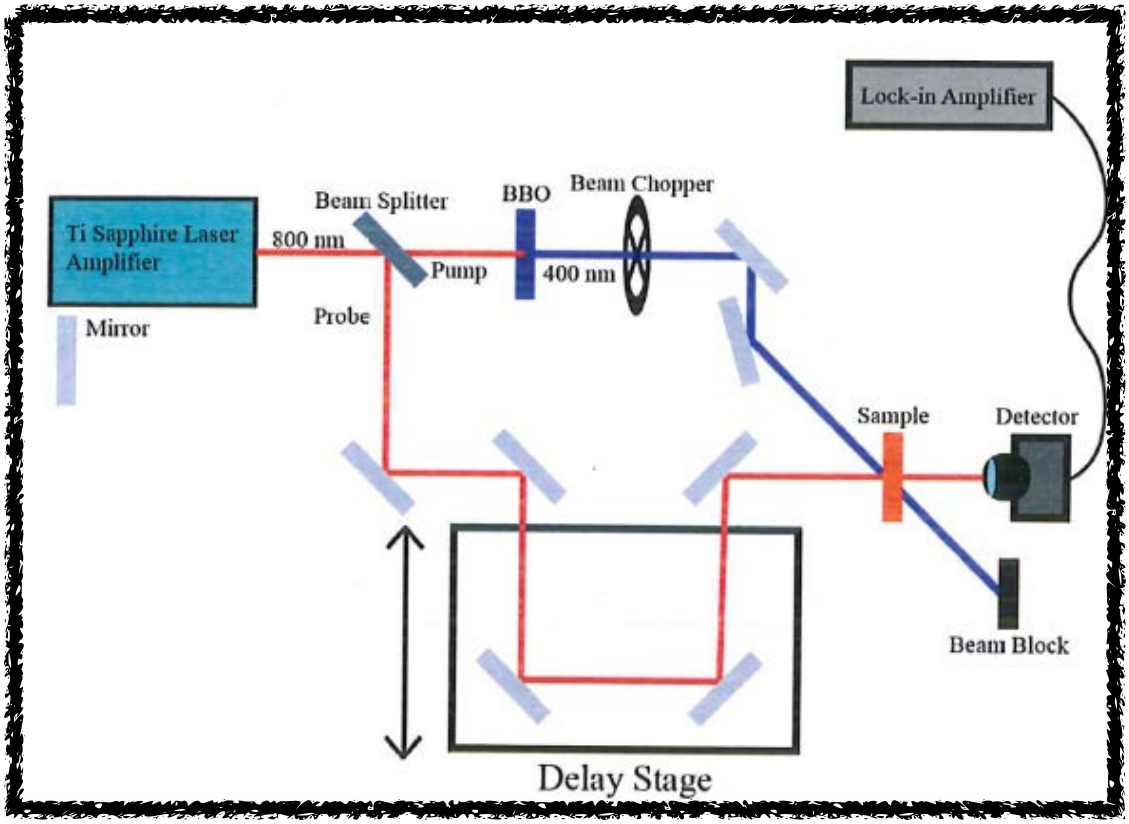
SENIOR INDEPENDENT STUDY

Transient Absorption of $CdSiP_2$ and $ZnGeP_2$

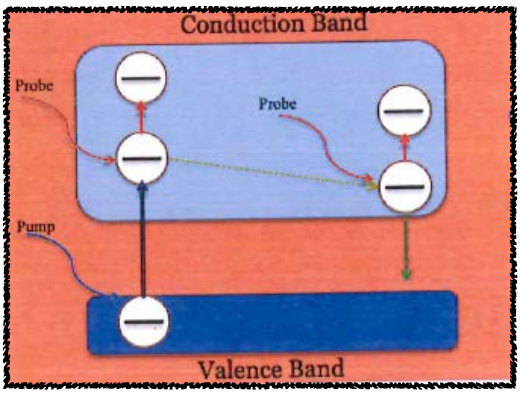
HEROKAZU ENDO, PHYSICS MAJOR

ADVISED BY TESS OLIVER

Transient absorption spectroscopy was used to observe and study the dynamic behavior of light and matter interaction for semiconducting nonlinear optical crystals, $CdSiP_2$ and $ZnGeP_2$. A mode locked Ti Sapphire laser amplifier generating pulses at a central wavelength of 800 nm with a pulse width of 100 fs at a 1 kHz repetition rate, and an average power of 3.5 W, were split into two beams, pump and probe. The pump beam was given larger power than that of the probe to excite the carriers within the sample. The probe, which has negligible effect on the excited state to the sample observes the change in carrier concentration. After carefully aligning the beams and adjusting the power, data were collected using a computer program which plots intensity vs. time. The collected data were normalized and plotted onto a graph with exponential decay according to the rate equation. It was found that both samples have three exponential terms for higher power, indicating more complex dynamics happening in these samples.



Schematic of transient absorption spectroscopy experiment



The pump beam is used to excite the carriers, while the probe beam is used to measure the change in number of excited carriers over time.

On the Creation of a Lab-Sized Hydrodynamic Event Horizon Analogue

MARC MANHEIM, PHYSICS MAJOR

ADVISED BY NIKLAS MANZ

It has been mathematically proven that gravity waves in water can behave analogously to electromagnetic waves traveling through space-time. The purpose of this project was to construct a scaled-down experiment that makes use of this analogue to hydrodynamically model the interaction between electromagnetic waves and event horizons. Such an analogue has already been created in a (30 x 1.8 x 1.8) m^3 tank with promising results. For this project, the size of the apparatus has been significantly reduced in order to improve the accessibility of the analogue. In this experiment, gravity waves were generated in a water tank and propagated in a direction opposed to a flow of varying velocity. The rate of volumetric flow in the channel varied from (6.58 ± 0.85) cm/s at maximum cross-sectional area to (12.00 ± 0.85) cm/s at minimum cross-sectional area and was insufficient for an event horizon simulation. A difference in wave behavior was evident when comparing waves generated in systems without flow and with flow respectively, the latter characterized by reduced wave speed and increased wave curvature.

Side view of wave tank after completion. An adjustable mount for the ball dropper was attached via clamps to the wave actuator.

Sphere dropping mechanics for the full wave tank. In order to remain consistent, an iris was used to mechanically release the sphere.

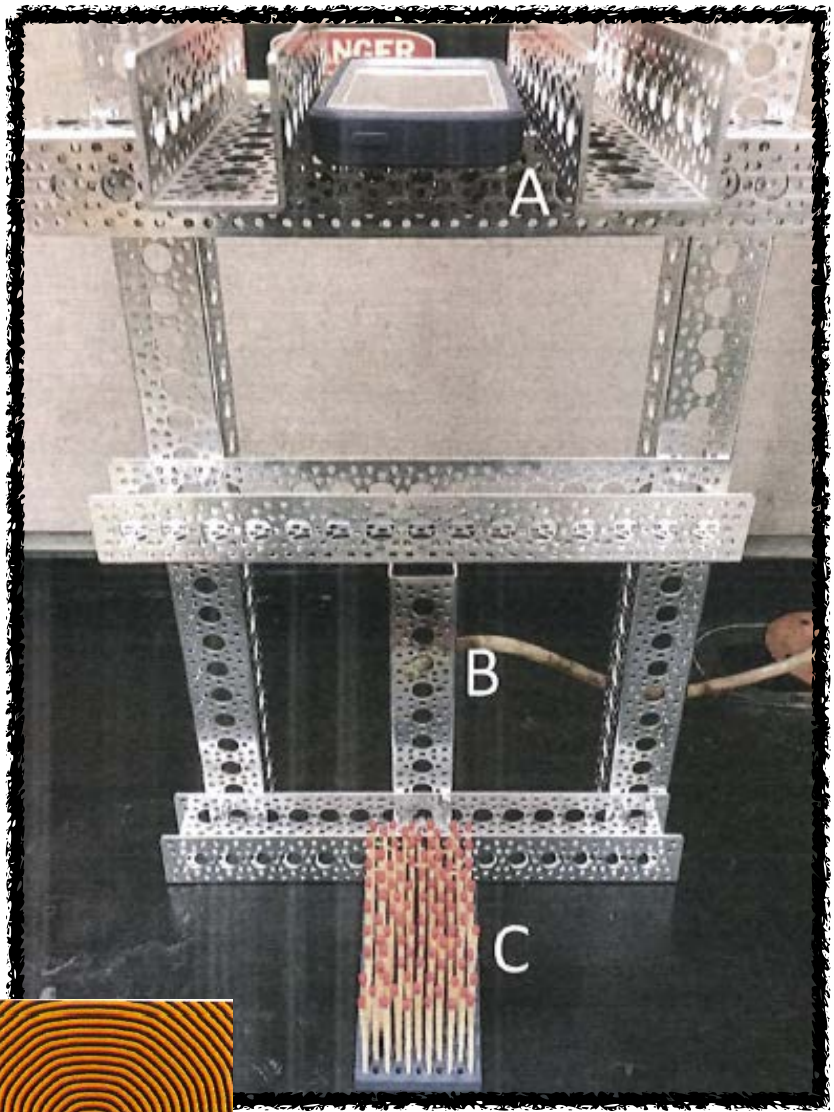
The Effects of Slope upon Propagation Speed and Pattern Formation in Forest Fires

ROBIN M. P. MORILLO, PHYSICS AND MATH DOUBLE MAJOR

ADVISED BY NIKLAS MANZ

We examined forest fires both experimentally and computationally to more fully understand the effects that slope has upon fire propagation. For the experimental investigation we designed and 3D printed plastic molds in order to hold an array of matches in place as a model forest. These molds were designed to feature slopes of different angles. By recording the burning of these model forests and analyzing the resulting videos, a relationship between the slope of the forest floor, Θ, and the speed at which the flames propagated across the model forest, R, was found. The best fit we found for this data, after making certain assumptions about the data collected, was that for positive values of Θ the relationship is $R = (38 \pm 4) \tan^2 \Theta + (15.04 \pm 0.07)$ and for negative values of Θ the relationship is $R = (-24.9 \pm 0.7) \tan^2 \Theta + (14.51 \pm 0.05)$. This supports the findings of Richard C. Rothermel, who found that $R \propto \tan^2 \Theta$. An introduction to the mechanics of fire is also presented to give a proper understanding of the results.

For the computational analysis a cellular automata model made by Punckt *et al.* that simulates forest fires was built upon. An adjustable slope factor was built into the code, as well as a method to measure the speed of the simulated flame front. Using this simulation, theoretical flame spirals and the effect slope had upon them were studied. The effect of inhomogeneity within the simulated trees upon the formation of the fire spirals was also examined. An overview of cellular automata is also provided to help give the proper background information before discussing the specific simulation we used.



The full filming apparatus containing A: iPhone 5s mounted for filming, B: Fire extinguishing system, C: matchstick forest to be burnt.

Three fire spirals on a flat surface. The images have a standard deviation of match critical temperatures of 0, 0.10, and 0.15.

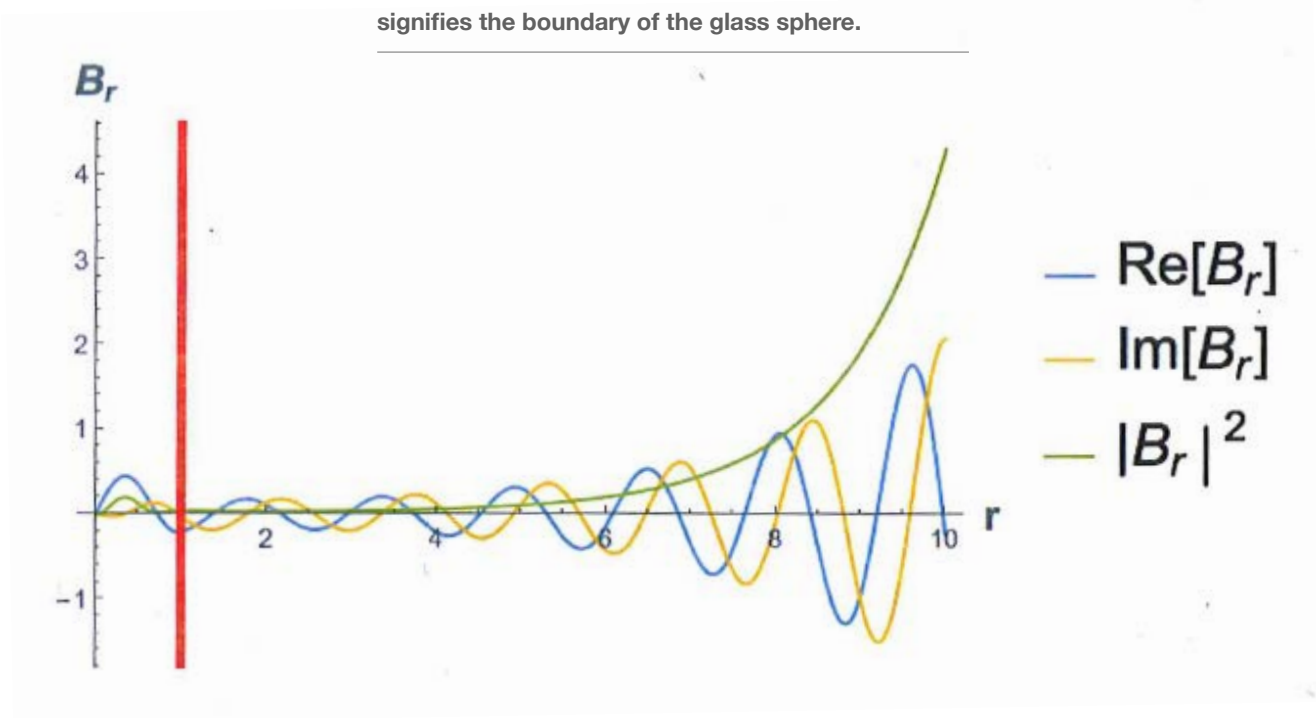
Blinded by the Light: An Investigation of the Wave Propagation of Vector Modes of Light in a Spherically Symmetric Refractive Index Profile

PRESTON POZDERAC, PHYSICS AND MATH DOUBLE MAJOR

ADVISED BY CODY LEARY (PHYSICS) AND DREW PASTEUR (MATH)

We investigated the two vector mode solutions to the spherically symmetric wave equation for a step function refractive index profile. The investigation began with a discussion on the classification and boundary conditions of partial differential equations. We proceeded with the derivation of the numerical finite difference method for different types of partial differential equations. In addition to this numerical technique, we presented the analytical separation of variables method for cartesian and spherical coordinates. We then analyzed our physical system, a glass microsphere surrounded by another medium, by dividing the spherically symmetric wave equation into an unperturbed Hamiltonian and a perturbative correction term. This separation allowed us to determine the two families of unperturbed solutions, the vector modes, analytically and to perform first order perturbation theory on the numerically computed wavenumbers. We studied the dependence of the waves' energy and propagation properties on the quantum numbers, vector modes, and different surrounding media. We finished our study of our wave equation by assuming our unperturbed solutions factorable in their spin and orbital degrees of freedom. Applying perturbation theory, we determined the vector basis that diagonalized the perturbation Hamiltonian.

Plot of the real, imaginary, and modulus squared of the radial component of the transverse magnetic field versus radius from $r = 0$ to $10a$. The red line signifies the boundary of the glass sphere.

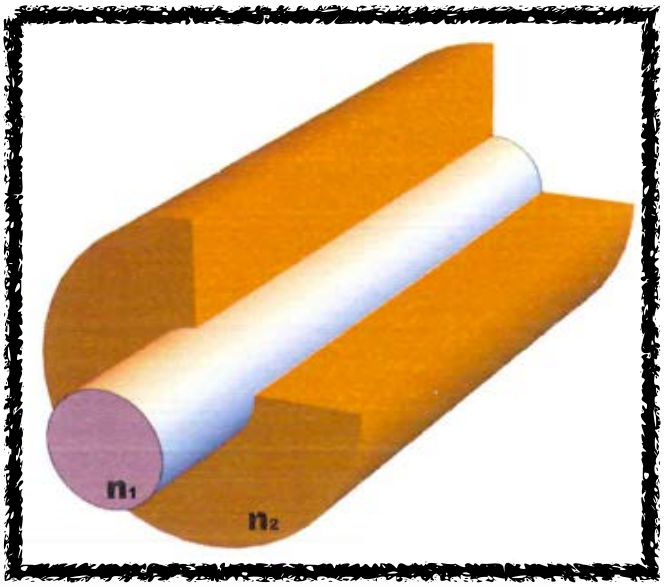


Optical Tractor Beam: Force on a Small Nanobead

MICHAEL WOLFF, PHYSICS MAJOR

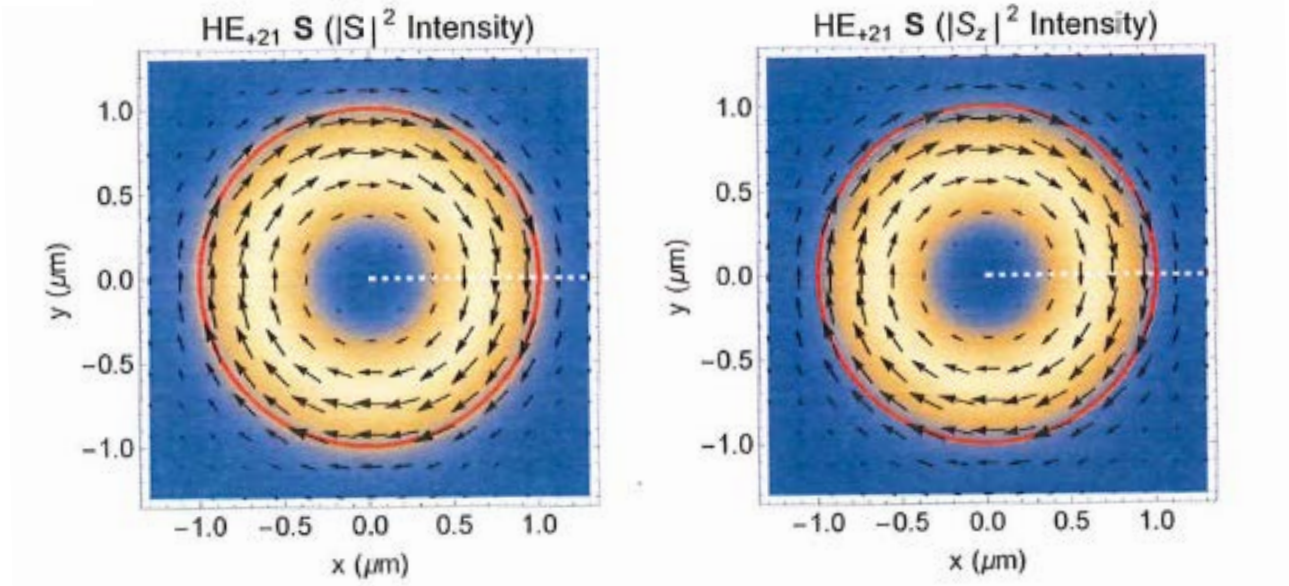
ADVISED BY CODY LEARY

Through the electromagnetic fields of light extending outside its boundaries, an optical nano fiber may manipulate microscopic objects. While previous work has involved the HE_{+11} field mode, we used boundary conditions, circularly polarized unit vectors, and Maxwell's equations to derive general formulas for six guided electromagnetic field modes in a "few mode" optical nanofiber. Plotting these modes, we found they matched their expected forms. Using these field equations, we calculated the general Poynting vector (energy flow) formula for each mode, finding that it had no radial component. Finally, approximating a dielectric nonacid as a dipolar particle, we used the electric fields and Poynting vectors to calculate the force on a bead near the fiber. We found the magnitude of the forces to be on the order of 10^{-30} N for a 1 mW laser. We have successfully expanded the concept of the "Optical Tractor Beam" to a new set of modes.



A cross-section of the basic structure of a step-index optical fiber, containing an inner core with an index of refraction n_1, and an outer cladding with an index of $n_2 < n_1$.

$$TM_{01}: \ M = 0, N = 1, \sigma = -1$$



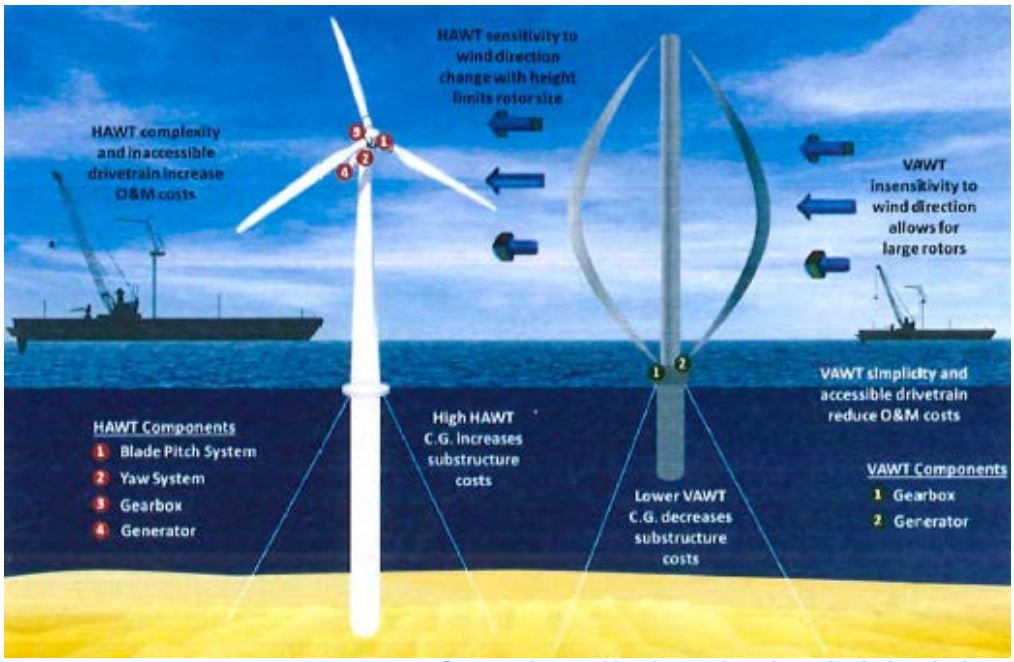
Vector and density plots of the HE_{+21} Poynting vector. Black vectors show the transverse field, and the left and right plot backgrounds show the overall and longitudinal intensity, respectively.

Development of a Turbulent Fluid Flow Simulation Using the *k-ω* Turbulence Model

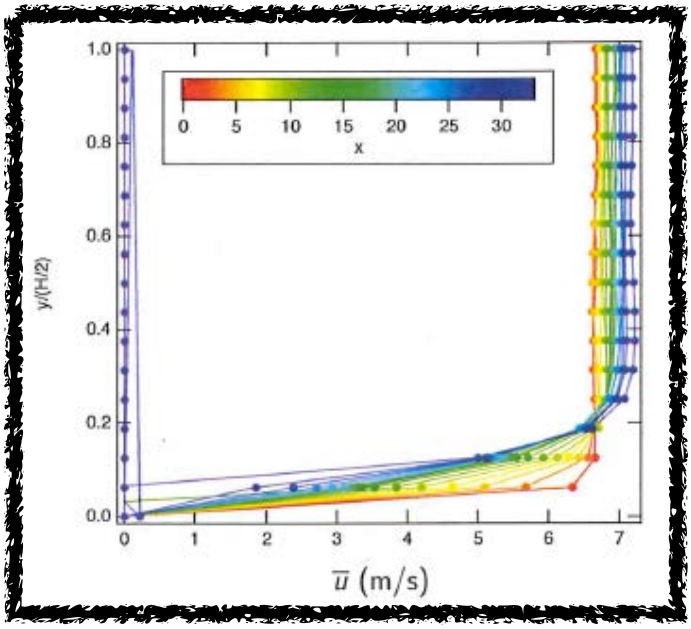
DYLAN HAMILTON, PHYSICS MAJOR

ADVISED BY JOHN LINDNER

To combat climate change, renewable energy will become increasingly important in the immediate future. Second only to energy efficiency measures in its potential to reduce carbon emissions, wind energy is already, and will continue to be, an important player in the field. The study of wind turbines presupposes the study of turbulence. To avoid the expensive, cumbersome, and slow process of experimental study, physically accurate simulations can be built. This thesis aimed to build such a simulation utilizing the most recent *k-ω* turbulence model developed by D. C. Wilcox (2006). Along the way, the thesis develops the turbulence theory necessary to understand and apply the turbulence model.



Comparison of horizontal and vertical six wind turbines, In offshore locations, VAWTs have several potential advantages. These include omnidirectIonality leading to fewer expensive components and a lower center of gravity (C.G.). This may lead to the possibility of larger rotors (due to insensitivity to wind direction), and lower substructure and operation and maintenance costs.



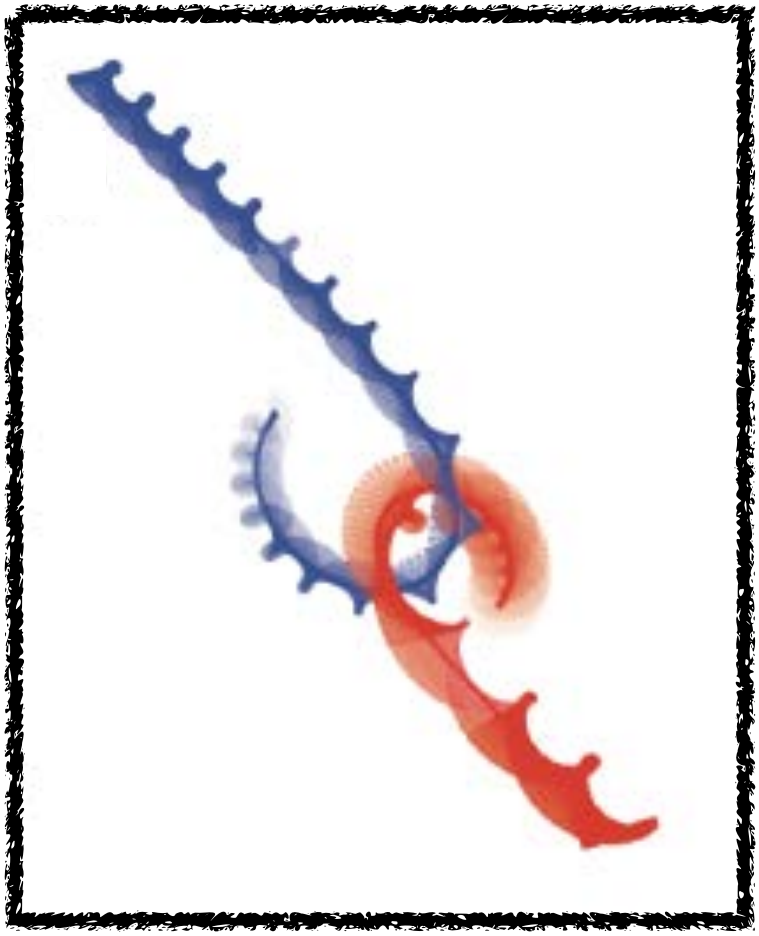
The cross-sectional velocity profile ū in the channel, color coded by the cells' horizontal position in the channel. The profiles become more parabolic as the distance from left fan increases. Even when the right fan is approached, the profiles continue to become more parabolic, which is unexpected.

C//

ROY HADFIELD, PHYSICS MAJOR

ADVISED BY JOHN LINDNER

The // Body Problem, read as slash-slash, is the study of the gravitational interaction of two massive line segments, or slashes. This problem has been previously explored for the scenario when the universe is restricted to two dimensions with the slashes laying in the plane. The potential energy of this system contains a term which becomes 0/0 when the slashes are parallel, a numerical instability which would need to be evaluated analytically using L'Hôpital's Rule. Handling this instability was previously accomplished by extending the numerical precision using software and switching to a second potential term whenever the slashes were parallel. However, through the implementation of CVODE, a differential equation solver, these steps are no longer needed. Instead the Jacobian is found by taking partial derivatives of the equations of motion and supplied to CVODE for implicit integration. A GUI application was created to animate the system and allow user interaction.



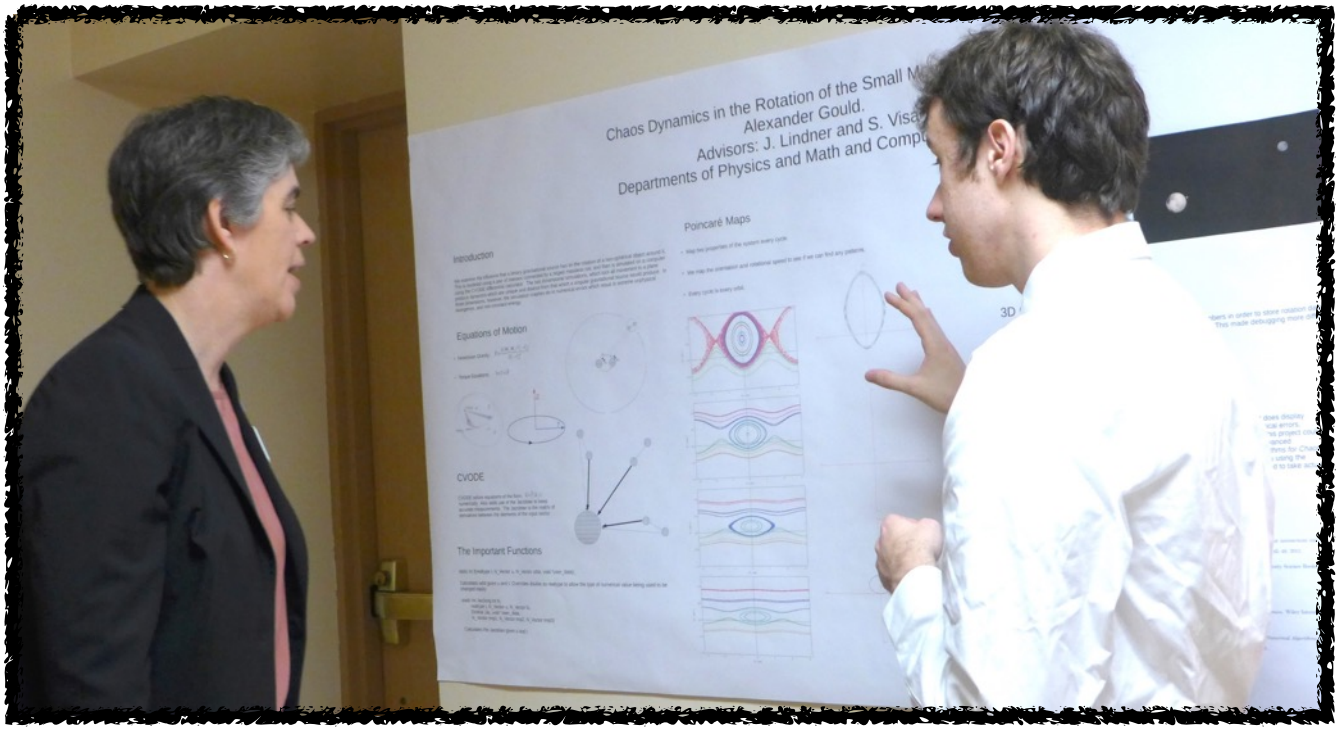
A plot of the // System experiencing a close encounter which results in escape.

Chaos Dynamics in the Rotation of the Small Moons of Pluto

ALEX GOULD, PHYSICS & COMPUTER SCIENCE DOUBLE MAJOR

ADVISED BY JOHN LINDNER, PHYSICS, AND SOFIA VISA, COMPUTER SCIENCE

We examine the influence that a binary gravitational source has on the rotation of a non-spherical object around it. This is modeled using a pair of masses connected by a rigid massless rod, and then is simulated on a computer using the CVODE differential integrator. The two dimensional simulations, which lock all movement to a plane, produce dynamics which are unique and distinct from that which a singular gravitational source would produce. In three dimensions, however, the simulation crashes do to numerical errors which result in extreme unphysical divergence, and non-constant energy.



Alex explains his I.S. to The College of Wooster President Sarah Bolton, who happens to be a physicist, at the Senior Research Symposium held in April.

Understanding Mental Causation in the Enlightenment of Top-down Causation within the Physical

ZIYI SANG, PHYSICS AND PHILOSOPHY DOUBLE MAJOR

ADVISED BY JOHN LINDNER, PHYSICS, AND GARRETT THOMSON, , PHILOSOPHY

Physics is traditionally described by bottom-up evolution, an evolution where the lower levels of complexity determine the higher levels of complexity so that a system is equal to the sum of its parts. However, this traditional physics view can no longer explain everything we witness today such as consciousness or fractional quantum hall effects. As recent arguments suggest that top-down causation is not only consistent with elementary physics but also necessary to be taken into consideration when analyzing a physical system. On the other hand, the concept of Top-down causation is closely related to the topic of mental causation in philosophy of mind, where the mental is the higher level (the Top) and the physical is the lower level (the down). Such a topic is concerned with the problem of free will and the nature of consciousness. Hence, our project will examine Top-down causation with a fuller consideration from both the physics and philosophy perspectives. Though the problem of mental (to physical) causation is more complex than the problem of Top-down causation within the physical, the analysis of the latter, in fact, points out the right way to deal with the former.

We will first introduce the basic concept of Top-down causation based on Ellis's, Anderson's and Laughlin's accounts in Chapter 1. In Chapter 2, we will consider List & Menzies' reply to the objection of Kim's exclusion principles. During the process we will introduce the ideas of reductionism, supervenience, multiple realizations and proportional causation. In Chapter 3, we will demonstrate Top-down causation by applying the introduced concepts to several physical systems. In Chapter 4, we introduce Davidson's Anomalous monism as an alternative view to the account of Top-down causation provided previously. In anomalous monism, description of an event is treated separately from the state of affairs itself. Our comments on Davidson's account also demand the necessity of the mental description, which is answered in Chapter 6. In Chapter 5, by distinguishing causal explanation and causation, we reveal that "levels" of complexity and "proportional causation", though reflecting certain causal processes and dependency within the system truthfully, are descriptive-dependent, and hence should be treated as an intentional explanation rather than an extensional causation. Meanwhile, Anomalous monism should be taken into consideration when analyzing Top-down causation. In Chapter 6, we reveal the structure of the system itself is what makes the description of mental phenomena necessarily and possibly true. This structure comes from the "constitutive relation" between the constituents (the down – the lower level) and the whole (the top – the higher level), and reflected through the description based on our perception. Top-down causation is therefore not a genuine causal relation but a constitutive relation. However, the denial of top-down causation does not weaken mental causation, for the constitutive relation guarantees the causal efficacy of the mental. In the end, we introduce the appropriate account of Top-down causation/constitutive relation by renewing the concepts of "levels" and "causation" considered in the previous Ellis and List & Menzies accounts.

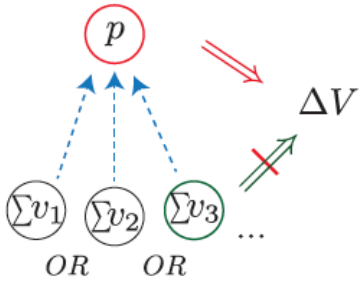


Diagram of the thermal dynamics inside an inflating balloon. Dotted arrows indicate the “supervenient" relation with the arrows pointing from what’s supervenient on to what's realized. Double lined arrows indicate the causal relation with the arrows pointing from the cause to the effect.

Class of 2017

HEROKAZU ENDO, SHANGHAI, CHINA

ALEXANDER GOULD, SAN CARLOS, CALIFORNIA

ROY HADFIELD, AMBRIDGE, PENNSYLVANIA

DYLAN HAMILTON, BOULDER, COLORADO

JOHANNA MALAER, SAN FRANCISCO, CALIFORNIA
(DEGREE CONFERRED DEC. 2016, DUAL DEGREE ENGINEERING, WASHINGTON UNIV. ST. LOUIS)

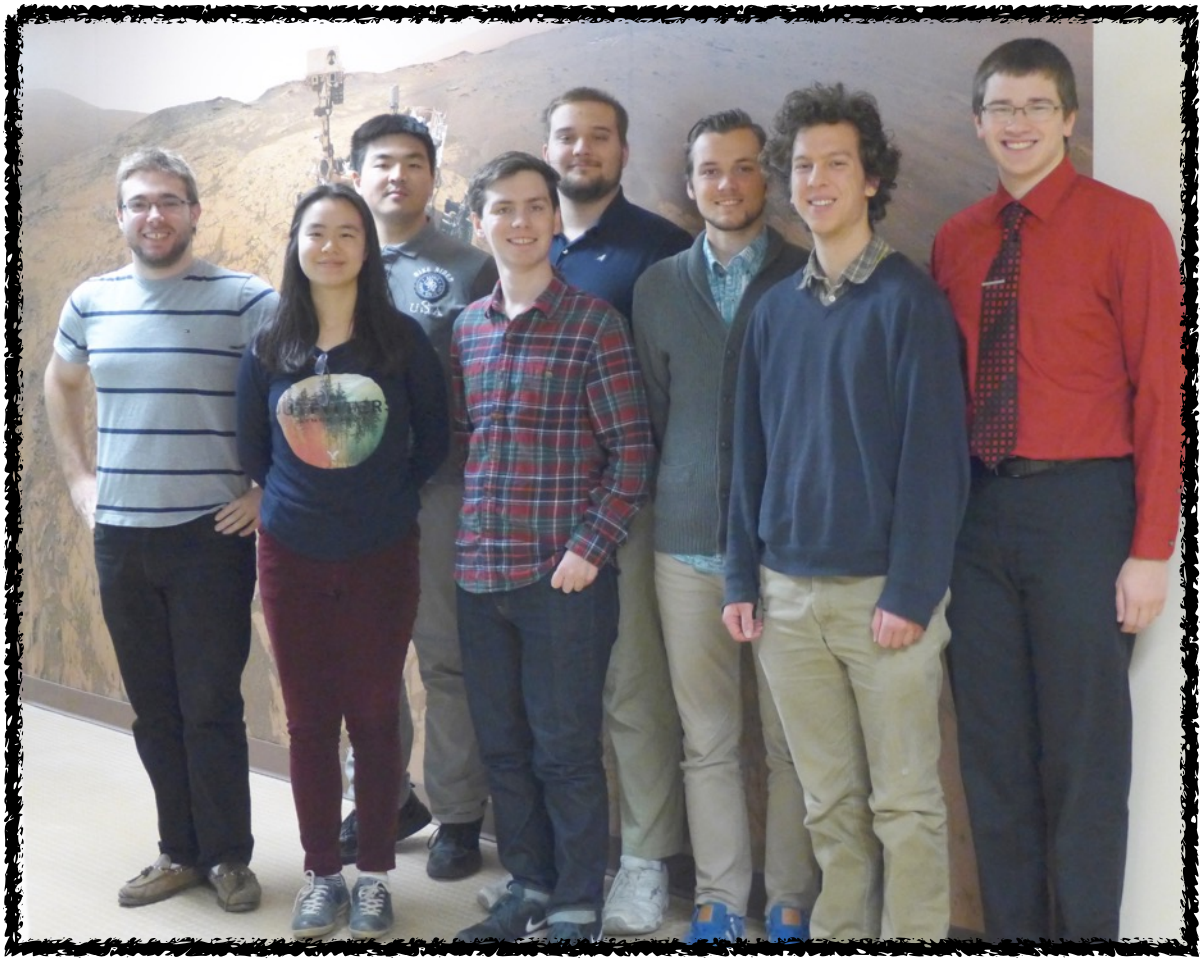
MARC MANHEIM, DANVILLE, KENTUCKY

ROBIN MORILLO, CRAWFORDSVILLE, INDIANA

PRESTON POZDERAC, WESTLAKE, OHIO

ZIYI SANG, QINGDAO, CHINA

MICHAEL WOLFF, TOLEDO, OHIO



Marc, Ziyi, Hero, Michael, Robin, Roy, Dylan, Preston

Honors and Awards (Physics Majors)

ROBIN MORILLO '17 AND PRESTON POZDERAC '17
The Arthur H. Compton Prize in Physics
(awarded to the senior physics major attaining the highest standing in that subject)

ROBIN MORILLO '17
The Mahesh K. Garg Prize in Physics
(awarded to upper-class physics major who has displayed interest in and potential for applying physics beyond the classroom)

DYLAN HAMILTON '17
The J. Howard and Josephine Morris Volunteer Service Award

Latin Honors
Summa cum laude
DYLAN HAMILTON '17
PRESTON POZDERAC '17
MICHAEL WOLFF '17

Magna cum laude
ROBIN MORILLO '17

Cum laude
ZIYI SANG '17

Phi Beta Kappa
DYLAN HAMILTON, ROBIN MORILLO, PRESTON POZDERAC, MICHAEL WOLFF '17s

VINCENT HUI '19
The Joseph Albertus Culler Prize in Physics
(awarded to first- or second-year student who has attained the highest rank in general physics)

HAIDAR ESSEILI '19
Dr. Donald Dewald Prize
(awarded to a sophomore student who has who has shown commitment to learning and outstanding growth in a STEM-related field)

AVI VAJPEYI '18
The Edward Taylor Prize
(awarded to a student who has attained the highest academic standing their first and sophomore years)

7th Annual University Physics Competition

BRONZE MEDAL TEAMS

AVI VAJPEYI ’18, NATE MOORE ’18, VINCENT HUI ‘19
Bronze Medal Team

MICHELLE BAE ’19, KENNY HUANG ’19, HAIDAR ESSEILI ‘19
Bronze Medal Team

The University Physics Competition is an international contest for undergraduate students, who work in teams of up to three students at their home colleges and universities and spend 48 hours analyzing an applied scenario using the principles of physics and writing a formal paper describing their work. Both Wooster’s teams chose Problem A:

Reactor Waste Disposal
The disposal of radioactive waste is a serious problem for the nuclear power industry. One solution that has been proposed is to launch the waste into space, with the idea of either destroying the waste by allowing it to fall into the sun, or simply having it take up an orbit in the asteroid belt where the radioactive waste products would eventually decay. Make a comparison of these two methods of waste disposal. Which method would be easier to implement? How long could the waste be safely stored in the asteroid belt?

Of the 197 papers submitted in the 2016 University Physics Competition, 3 teams (1.5%) were ranked as Gold Medal Winners, 34 teams (17%) were ranked as Silver Medal Winners, 56 teams (28%) were ranked as Bronze Medal Winners, and 102 teams (52%) were ranked as Accomplished Competitors.

Physics Faculty & Staff

Manon Grugel-Watson, Tess Oliver, Niklas Manz, John Lindner, Cody Leary

JOHN LINDNER

CHAIRPERSON

PROFESSOR OF PHYSICS AND THE MOORE PROFESSOR OF ASTRONOMY

(AT WOOSTER SINCE 1988)

Courses taught in 2016-17: First Year Seminar: Belief in God in an Age of Science, General Relativity, Calculus Physics Lab, Computational Physics, Math Methods in Physical Science, 4 Senior Independent Study advisees

Dr. Lindner completed two multi-year experiments, to design and construct a novel wind powered clock and to harvest wind energy to detect faint signals, with publications in *Physical Review* and *Chaos*, with eleven undergraduate coauthors. With North Carolina State University's Applied Chaos Lab, he coauthored "Nonlinear Dynamics as an Engine of Computation" in the *Philosophical Transactions of the Royal Society*, the same journal that published work by Isaac Newton. As Principle Investigator, he supervised our 10-week National Science Foundation summer research program, which included a record number of students. Dr. Lindner served as advisor to the Physics Club, the Astronomy Club, and the Robotics Club.

TESS OLIVER

VISITING ASSISTANT PROFESSOR OF PHYSICS

(PH.D. 2015 WEST VIRGINIA STATE UNIVERSITY)

Courses taught in 2016-17: Calculus Physics I and II + labs, Modern Physics, Physics Revolutions, 1 Senior Independent Study advisee

Tess joined the department as a one-year visiting assistant professor this past year. Her research areas include condensed matter physics and optics, transient absorption spectroscopy, and quantum dot heterostructures. Dr. Oliver is also a professional cyclist and raced in several Professional National Championships. In 2016 she spent a month in Europe, working on her skills while racing in Holland and Belgium.

Physics Faculty & Staff

CODY LEARY

ASSISTANT PROFESSOR OF PHYSICS

(PH.D. 2010 UNIVERSITY OF OREGON; AT WOOSTER SINCE 2011)

Courses taught in 2016-17: Calculus Physics I, Modern Physics lab, Electricity and Magnetism, Particle Physics, Junior Independent Study, 2 Senior Independent Study advisees

Cody Leary is continuing his research in the fields of quantum mechanics and optics in partnership with students from Wooster and elsewhere, through both the department's NSF-sponsored summer REU program and throughout the academic year. One of his senior independent study students, Maggie Lankford '16, was one of seven finalists for the American Physical Society's Award for outstanding achievement in physics by undergraduate students, on the basis of her senior thesis. Dr. Leary was second author on a paper published in *Physical Review Letters* with coauthors* at the University of Oregon and Boston University, entitled "Observation of Interaction of Spin and Intrinsic Orbital Angular Momentum of Light*. He also attended the Frontiers in Optics Conference in Rochester, New York in fall 2016 where this paper was presented, and traveled in spring 2017 with Wooster student co-author Michael Wolff '17 to the Conference on Optical Nanofibers and Applications in Okinawa, Japan, where they presented their joint work stemming from Michael's senior independent study work.

*Dashiell L.P. Vitullo, Cody C. Leary, Patrick Gregg, Roger A. Smith, Dileep V. Reddy, S. Ramachandran, and Michael G. Raymer. *Phys. Rev. Lett.* 118, 083601.

NIKLAS MANZ

ASSISTANT PROFESSOR OF PHYSICS

(PH.D. 2002 UNIVERSITY MAGDEBURG, GERMANY; AT WOOSTER SINCE 2015)

Courses taught in 2016-17: Algebra Physics I and II, Modern Physics Lab, Mechanics, Thermal Physics, 2 Senior Independent Study advisees

Dr. Manz continues to equip the Wave Lab for use by seniors doing I.S. and summer research students. He also has great interest in the history of the Velousov-Zhabotinsky reaction and presented an Illustrative timeline of Boris P. Belousov and Anatol M. Zhabotinsky at a Gordon Research Conference on Oscillations & Dynamic Instabilities in Chemical Systems. C.S. major Mijiti Mierkamili is working on an on-line, zoomable timeline of the history of the Belousov-Zhabotinsky reaction. In June, Dr. Manz traveled to Otto-von-Guericke University, Magdeburg, Germany, and gave a talk entitled "About chemical waves, migraine auras, and forest fires" to the Department of Nonlinear Phenomena. At Kenyon College, he gave a colloquium talk entitled "Reaction-diffusion waves: From migraine auras to forest fires". He attended all conferences at which his students presented their research and also attended the 2017 Spring Meeting of the American Association of Physics Teachers - Ohio Section, at Cuyahoga Community College.

Dr. Manz continues to teach ballroom dancing and coach the Ballroom Club. For the first time ever, Wooster students participated in the Collegiate Ballroom Competition.

Physics Faculty & Staff

SUSAN LEHMAN

CLARE BOOTHE LUCE ASSOCIATE PROFESSOR OF PHYSICS

(PH.D. 1999 NORTH CAROLINA CHAPEL HILL; AT WOOSTER SINCE 2003)
On sabbatical 2016-2017

Susan Lehman has focused on developing new measurement and analysis techniques for her on-going avalanche experiments during her research leave. With the support of a National Science Foundation grant, she is working with her collaborator Karin Dahmen from the University of Illinois to better understand the effects of cohesion on avalanche statistics for a bead pile or for a system under a constant slow shear. Because many aspects of pile behavior are universal, better understanding of this simple model system allows better understanding of real world systems like earthquakes and landslides. She visited several research groups in the Netherlands, including at the University of Amsterdam, to compare measurement methods and develop new collaborations. Susan presented the results of this work at invited seminars at the University of Oregon and at James Madison University.

MANON GRUGEL-WATSON

LABORATORY COORDINATOR AND ADJUNCT INSTRUCTOR OF PHYSICS

(M.S. 2001 CASE WESTERN RESERVE UNIVERSITY)

Manon taught all three sections of algebra physics labs in both fall and spring semesters.

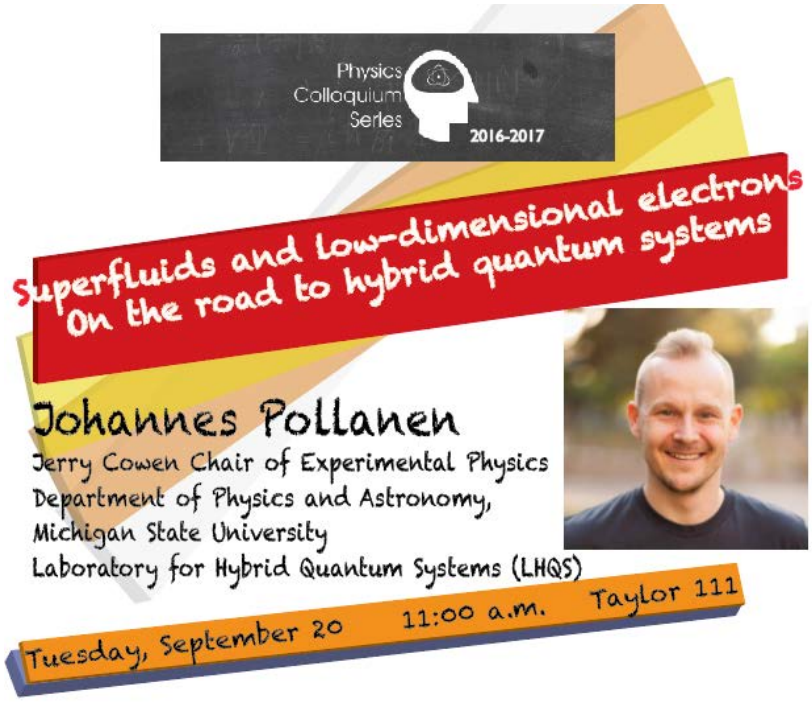
JACKIE MIDDLETON

ADMINISTRATIVE COORDINATOR, PHYSICS, MATH, COMPUTER SCIENCE)

Jackie has been a member of the Physics, Math, and CS Departments at Wooster for 28 years. She recently attended a "cousin reunion" in New Concord, OH, where her father grew up and attended school with boyhood friend, John Glenn. Jackie remembers John Glenn visiting their home when she was a child.

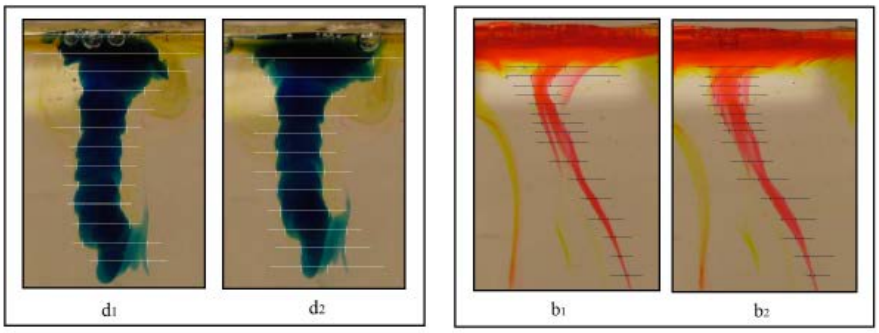
2016-2017 Colloquium Series

• Physics Juniors, Junior I.S. Self-Designed Experiments, 2 May and 4 May
• Veronica Dexheimer, Kent State University, *Phase Transitions in Dense Matter*,18 April
• Mark Tinsley, West Virginia University, *Collective behavior in coupled oscillatory chemical systems*, 6 April
• Bryan Prusha, CoW Class of 1998, iOS App Engineer at Apple, Inc., *Opportunity and Ability: What Happens After Graduation? My Experience in Physics and Computers*, 30 March
• Christopher Kelly, Wayne State University, N*anoscale Membrane Curvature Revealed by Polarized Localization Microscopy*, 2 March
• Laura DeGroot, Denison University, *Deconstructing Galaxies: Morphological Implications for Galaxy Formation and Evolution*, 6 February
• Nate Tompkins, Brandeis University, *How the Leopard Got Its Spots (Testing Turing's Theory of Morphogenesis in Chemical Cells)*, 30 January
• Bart Schenk, NobleTek, *Physics Based Careers in a Digital World*, 2 February
• Arnaldo Vargas, Indiana University, *Signals for Lorentz and CPT Violation in Atomic Spectroscopy Experiments*, 9 December
• Seth Hopper, Instituto Superior Tecnico, CENTRA, Lisbon, Portugal, G*ravitational wave astronomy: A new window to the universe*, 5 December
• *Physics Phun at PhysCon*, 15 November
• Brian Clark, The Ohio State University, *Ultra-high Energy Neutrino Astrophysics with Radio Detectors,* 4 October
• Johannes Pollanen, Michigan State University, *Superfluids and low-dimensional electrons: On the road to hybrid quantum systems*, 20 September
• *I don't know what you did last summer: Physics majors share summer research experiences*, 6 September and 13 September



Junior Independent Study
Self-Designed Experiments

EMMA BRINTON
Testing the Success in Creating Laminar Flow Using a Couette Cell Apparatus



Velocity = 0.11 rev/s Velocity = 0.33 rev/s

COLLIN HENDERSHOT
The Effect of Concavity on the Aerodynamics of High Speed Automobiles

GABRIEL DALE-GAU
Stochastic Resonance in a Hysteretic Circuit

KYLE MCNICKLE
An Examination of RLC Circuit Behavior When Employing a Mechanically Oscillating Inductor

JACK MERSHON
Viability of Heat Expansion Driven Water Propulsion System Through Computational Analysis

NATHANIEL MOORE
Variable Stars: Mekbuda and Photometry

NATHANIEL SMITH
Modeling Solar Sail Propulsion in Spacecraft using Xcode Software

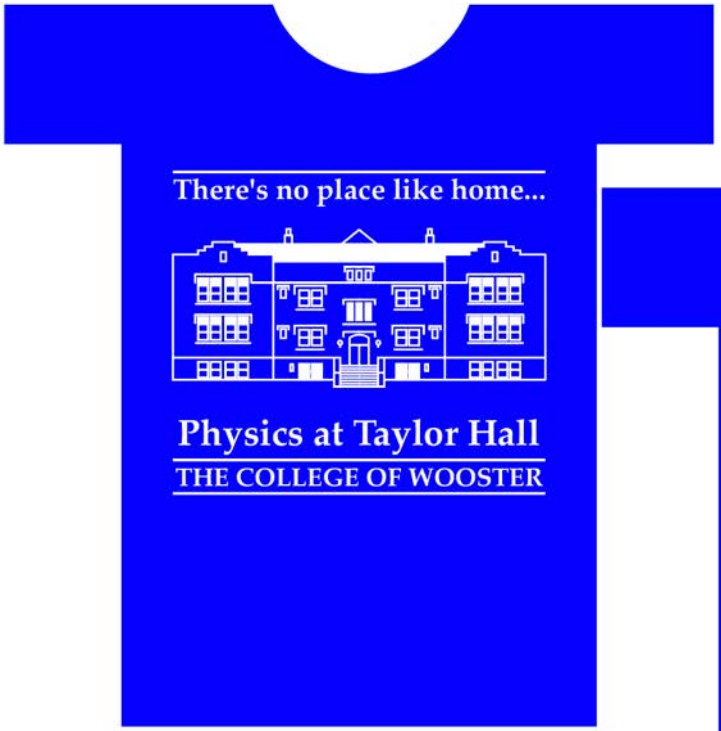
ZANE THORNBURG
Investigation into Accuracy of a Cavity-Enhanced Light Absorption Spectroscopy Method

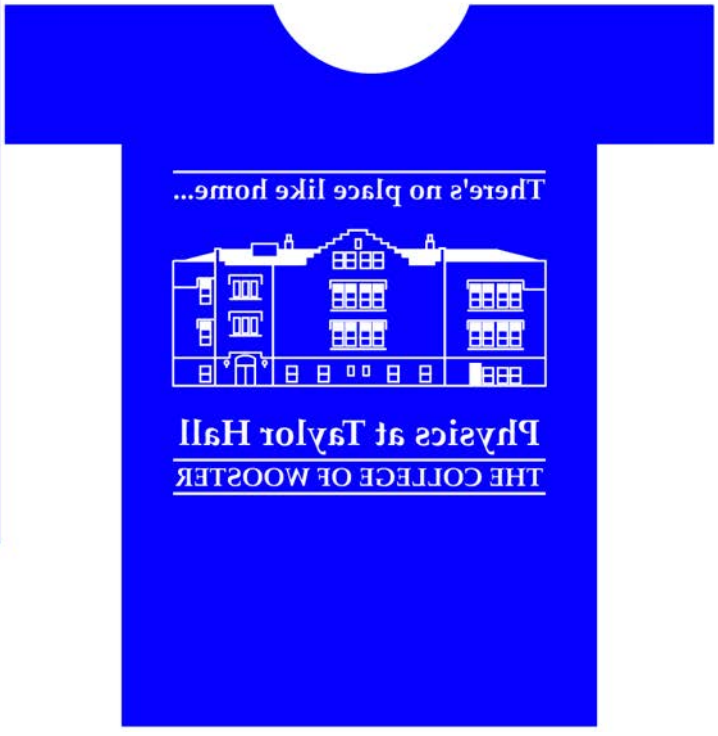
AVI VAJPEYI
The Storage of Quantum Memory with the Evolution of Polarization States

JUSTINE WALKER
Building a Passive Robot for Active Learning

Physics & Astronomy Club

September 2: Scot Spirit Day
September 6: Viewing stars & planets at the observatory
September 8: Luce Pizza and Dessert Night
September 15: Physics Club Meeting
September 22: Astronomy Club Meeting
September 29: Physics Club Meeting
October 20: Physics Club Meeting
October 27: Physics Club Meeting
November 10: Physics Club T-Shirt Meeting
November 15: PhysCon 2016 Report
November 17: REUs & Internships
November 17: Physics Club Meeting
February 2: Viewing crescent Venus at the observatory
February 6: Astronomy Club presents the movie Gravity
February 8: Physics Club Meeting
March 30: Bryan Prusha ('98 Physics and CS) Talk
April 8: Science Day 9
April 23: Taylor Bowl 28 (Results: Physics 100.1 Math/CS 113.6)





Physics & Astronomy Club

PHYSICS CLUB OFFICERS

Zane Thornburg, Caesar
Robin Morillo, Co-Caesar
Nate Moore, Quaestor
Emma Brinton, Aedile
Justine Walker, Consul
John Lindner, Czar

ASTRONOMY CLUB OFFICERS

Zane Thornburg
Nate Moore
Michelle Bae

Justine, Nate, Emma, Zane

Four Wooster physics majors attended the 2016 Quadrennial Physics Conference (PhysCon) last fall in Silicon Valley.

PHYSCON HIGHLIGHTS

- Tour of Google X (Google's Moonshot Factory)
- Plenary speaker Jocelyn Bell Burnell (Honorary Congress Chair), world-class astrophysicist known for discovering pulsars
- Plenary speaker Eric Cornell, Senior Scientist at JILA, NIST, and the Department of Physics, University of Colorado at Boulder, and 2001 Physics Nobel Laureate
- Doing the “Cupid Shuffle” with the president of American Institute of Physics at the PhysCon dance party

Physics & Astronomy Club

Astronomy Club at Community Science Day allows people to look at the Sun using a solar filter on one of their telescopes.

COMMUNITY OUTREACH

The Physics Club has done elementary school outreach for many years, but this year took it to the next level. The club has had less than 25 total outreaches in the past two years combined, whereas this year the club extended the program to do 44 in a single year. In addition, many of these 44 outreaches were to an entire grade rather than to a single classroom.

This was the ninth annual Community Science Day. Just as with outreach, we kicked Science Day up to a whole new level. This year there was a record number of STEM clubs participating in Science Day; a total of twelve clubs doing over twenty different demonstrations and activities. Unlike previous years, Physics Club made sure that every single STEM club on campus participated.

Physics & Astronomy Club

Physics, Astronomy and Robotics Clubs share a table at Scot Spirit Day 2016

Emma Brinton and Sam Nash demonstrate “States of Matter” at Community Science Day

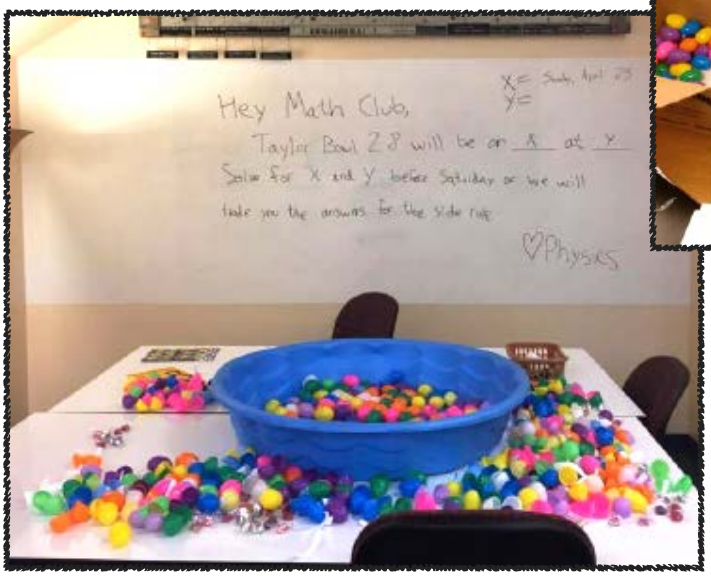
Physics & Astronomy Club

ASTROPHOTOGRAPHY CONTEST

Michelle Bae ’19 won the Astronomy Club’s astrophotography contest with this shot of star trails in the sky above Ebert Hall, taken with a Canon 700D multiple 30s exposures.

TAYLOR BOWL CHALLENGE

Right: In the basement of Taylor Hall, Physics Club members prepare the Taylor Bowl Challenge to deliver to the Math Club.



Left: The Taylor Bowl Challenge after several hours of Math students opening Easter eggs searching for the date and time of Taylor Bowl.

Conference Presentations

2016 FALL MEETING OF AMERICAN PHYSICAL SOCIETY OHIO-REGION SECTION, BOWLING GREEN UNIVERSITY

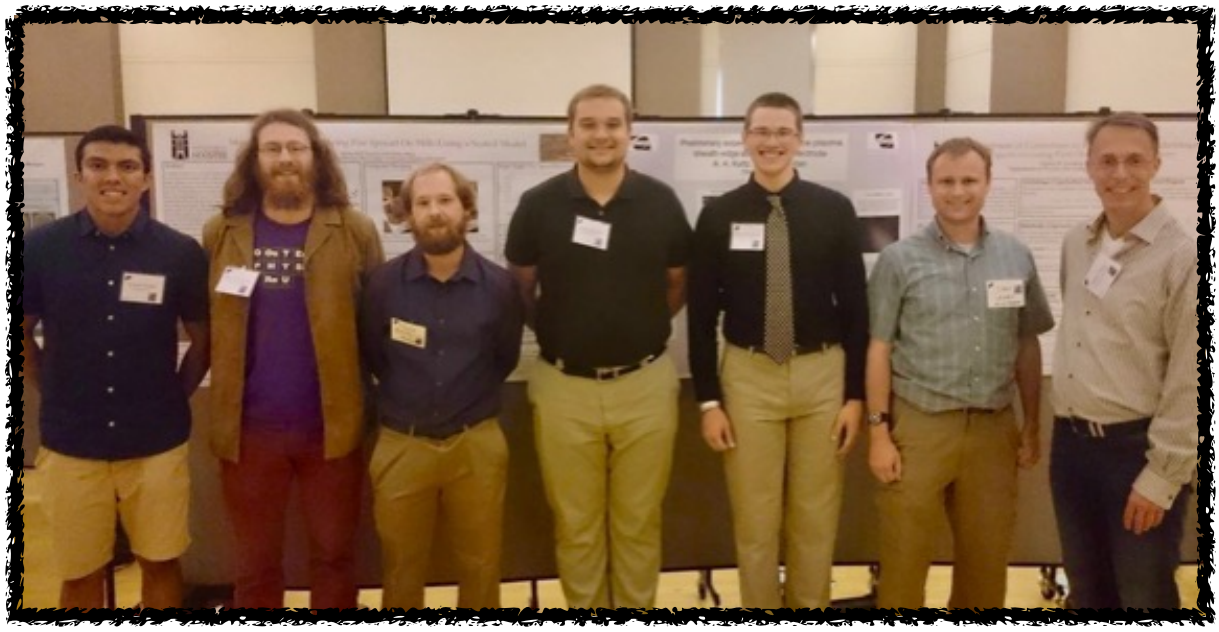
•J. Pachar* and N. Manz
"Effects of Advection on Reaction-Diffusion Waves" (NSF-REU Summer Research)

•R.M.P. Morillo* and N. Manz
"Matchstick Forests: Studying Fire Spread On Hills Using a Scaled Model" (Junior and Senior I.S. project)

•T. Branscum* and P.A. Bonvallet
"Synthesis of Swellable Organically Modified Silica at Various Temperatures and Concentrations" (NSF-REU Summer Research)

•Z. Thornburg* and P.A. Bonvallet
"Characterizing the Swelling of a Crosslinked Organosilicon Polymer" (NSF-REU Summer Research)

•P. Pozderac* and C.C. Leary, "Comparison of Corrections to the Helmholtz and Schrodinger Equations using First Order Perturbation Theory" (NSF-REU Summer Research/Senior I.S. project)
**student co-author*



Jersson Pachar (Wittenburg Univ), Zane Thornburg, Tyler Branscum (Ohio Univ), Robin Morillo, Preston Pozderac, Dr. Leary, Dr. Manz at the Ohio Section of the APS at Bowling Green.

Conference Presentations

2017 MARCH MEETING OF THE AMERICAN PHYSICAL SOCIETY, NEW ORLEANS

•Hwan Bae*# and John Lindner, “Hannay's hoop revisited beyond asymptotics”

•Nathaniel Moore*# and John Lindner, “Sliding on a spinning asteroid (geodesics on a rotating ellipsoid)”

•Marc Manheim*, John Lindner and Niklas Manz, “Experimentally Modeling Black and White Hole Event Horizons via Fluid Flow”

•Robin Morillo* and Niklas Manz, “The Ring of Fire: The Effects of Slope upon Pattern Formation in Simulated Forest Fire Systems”

•Jordan Dennis*#, Laura Grace* and Susan Lehman, “Period Doubling in Bubbling from a Submerged Nozzle”

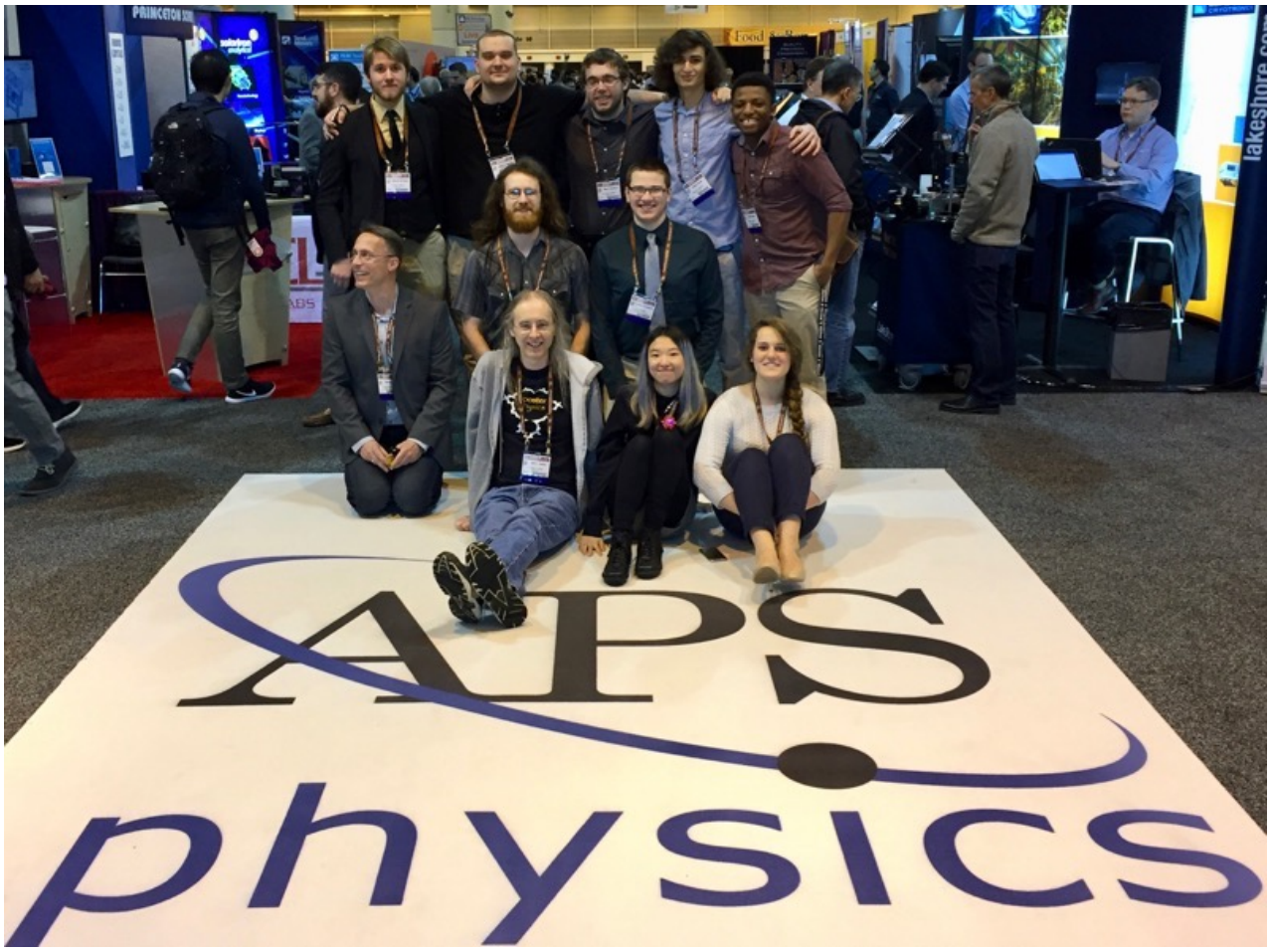
•Haidar Esseili*, Avi Vajpeyi* and Susan Lehman, “Tracking particles during avalanches on a conical bead pile”

•Tessa Rosenberger*# and John Lindner, “Soliton creation, propagation, and annihilation in aeromechanical arrays of one-way coupled bistable elements"

•Preston Pozderac*# and Cody Leary, “Investigation of the Wave Propagation of Vector Modes of Light in a Spherically Symmetric Refractive Index Profile”

•Zane Thornburg*# and Paul Bonvallet, “Characterizing the Swelling of a Crosslinked Organosilicon Polymer”

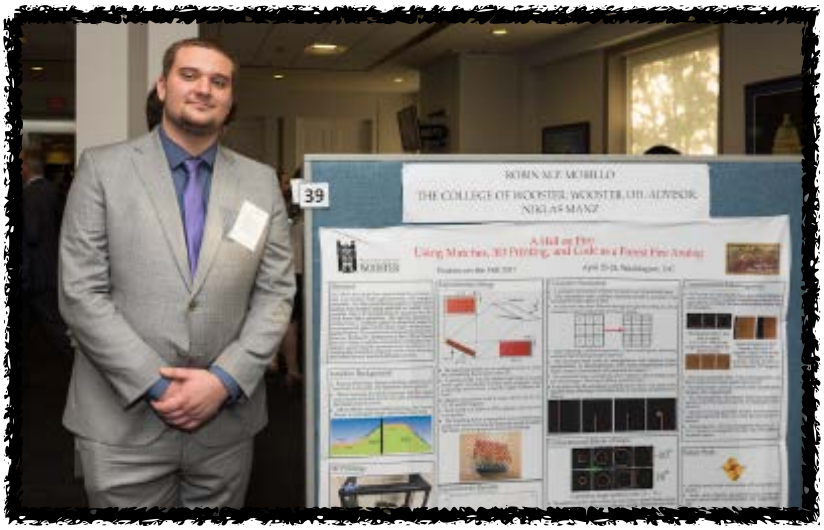
**student co-author; #NSF-REU student*



Posters on the Hill

21ST ANNUAL POSTERS ON THE HILL-WASHINGTON DC

Robin M.P. Morillo was selected to present his Senior Independent Study results, *A Hill on Fire: Using Matches, 3D Printing, and Code as a Forest Fire Analog,* at the 21st Annual Posters on the Hill on April 26, 2017 in the Rayburn House Office Building in Washington, D.C. This is an event put on by the Council for Undergraduate Research (CUR) every year to bring together the best and brightest students in the United States and give them a chance to present their research on a national level. Robin was the first ever College of Wooster Physics major to be selected by CUR and his research project was the third ever College of Wooster project to be selected by CUR. Robin's trip to Washington D.C. was supported by a Center for Undergraduate Research's Physics and Astronomy division (CURPA) student travel award and a generous gift from Wooster Physics graduate John Redfield '77.



Robin Morillo and his research advisor, Dr. Niklas Manz, in Washington DC.

2017 Prize for Industrial Applications of Physics

ASAD KHAN (WOOSTER CLASS OF '93) RECEIVES PRIZE FROM AMERICAN PHYSICAL SOCIETY

"For novel contributions to the physics of bistable, reflective cholesteric liquid crystals, and the commercial applications of pressure-sensitive liquid crystal displays, including switchable windows, eWriters and numerous new products."

Asad Khan, Ph.D., is the chief technical officer of Kent Displays (maker of Boogie Boards and eWriters), where he has worked for more than 20 years, having held numerous management and research and development functions. Dr. Khan is also a member of Kent's executive committee, overseeing the engineering, quality, manufacturing, and research and product development functions. With more than 20 U.S. and international patents, Dr. Khan is also a co-inventor on several pending U.S. and foreign patents on cholesteric materials and displays. The author of numerous technical publications in liquid crystals, including a contributing author in the book, "Flexible Flat Panel Displays". Dr. Khan has given numerous presentations and seminars on liquid crystal display technologies in national and international conferences. He is a member of the Society for Information Display and the Society for Optical Engineering. Dr. Khan has a B.A. in physics from the The College of Wooster (Ohio), an M.S. in physics from Kent State University (Ohio), and a Ph.D. in chemical physics from the Liquid Crystal Institute at Kent State University.

Physics/CS Alum Gives Career Talk

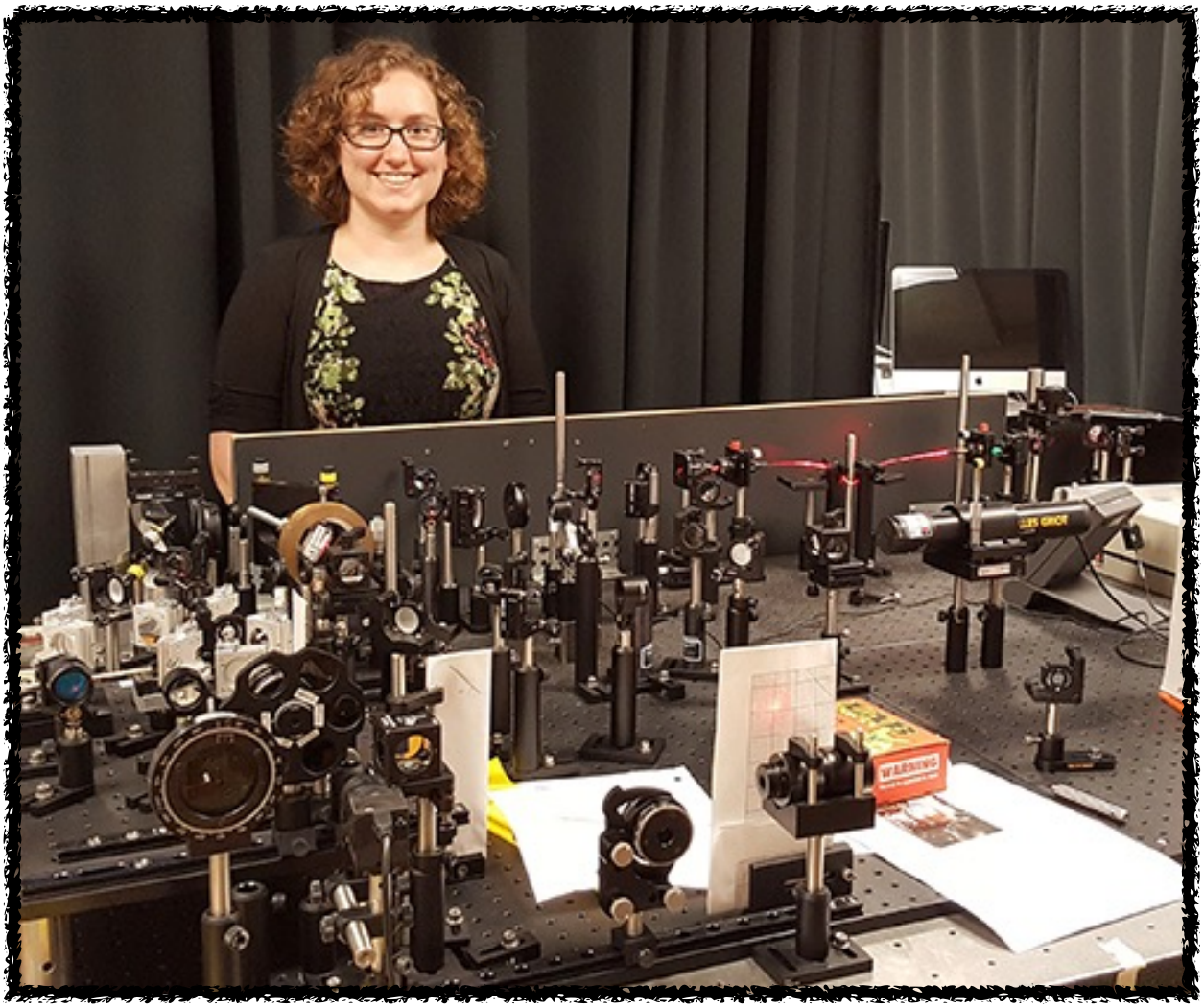
PHYSICS CLUB INVITES BRYAN PRUSHA '98 (PHYSICS AND COMPUTER SCIENCE) TO GIVE CAREER TALK

Bryan Prusha '98, iOS App Engineer at Apple, Inc. visited Wooster and gave a talk to physics students entitled "Opportunity and Ability: What Happens After Graduation? My Experience in Physics and Computers". Bryan shared his experience in seeking a career in physics that did not include graduate school, a topic of interest to many of our majors and described his job at Apple Computer in California, where he has worked for many years. We thank Bryan for taking time from his busy schedule to visit us!

Apker Finalist Maggie Lankford ‘16

Maggie Lankford, a physics major who graduated from The College of Wooster in 2016, was selected as one of seven finalists for the American Physical Society’s LeRoy Apker Award, known as the preeminent honor for undergraduate research in physics in the United States. Maggie earned the distinction for her senior Independent Study, entitled “The Production and Manipulation of Nonseparable Spin-Orbit Modes of Light Under Hong-Ou-Mandel Interference Conditions.” The project, advised by Cody Leary, has to do with quantum computers, involving the theoretical prediction and experimental creation of new structures of light with potential applications to the sharing of information for communication or to do computations. Lankford is certainly in good company with other finalists hailing from the likes of Dartmouth College, Kenyon College, and MIT among others. She and the other finalists presented their research in front of the Apker Award selection committee in Washington, D.C., in August.

Lankford, a native of Lebanon, Ohio, joins Stephen Poprocki ’07 and Jeffrey Moffitt ’03 as the third Wooster alumnus to be a finalist for this award.



Summer Research (NSF-REU)

Experimental Realization of the Hannay Hoop-and-Bead Anholonomy
by Norah Ali (Hiram '19)

Studying How Slope Affects the Speed of Forest Fire Propagation
by Abigail Ambrose (CoW '20)

Absorbing Organic Solids in CyclaSorb to Study IR Spectroscopy and Swell Capacity
by Daniel Blaikie (CoW '19)

Under Pressure: Developing a Method for Measuring the Area of Avalanches on a Conical Bead Pile
by Gabe Dale-Gau (CoW '18)

I'll Be Watching You: Bead Pile Video Analysis
by Haidar Esseili (CoW '19)

Effects of Advection on the Belousev-Zhabotinsky Reaction: Standing Excitation Waves in a Quasi 1D System
by Chase Fuller (CoW'19)

Towards a General Understanding of Pancharatnam Phase
by Ian George (Kenyon '18)

Modelling of Reaction-Diffusion Waves with Various Boundaries
by Vincent Hui (CoW '19)

Nanofibers and Midiclorians: The Force is...Evasive
by Benjamin Jenkins (CoW '19)

A Dumbbell Orbiting Two Primaries: A Study of Pluto's Moons
by Polly Michel (Ohio State '20)

Creating A Timeline for The BZ History Website
by Mijiti Mierkamili (CoW '19)

Quantifying Chaos on a Spinning Ellipsoid
by Hannah Peltz Smalley (Wellesley '18)

Gravitational Equilibria of Rods
by Anna Tomkins (Agnes Scott '18)

Investigation of Polymer Synthesis in Swellable Organically Modified Silica (SOMS) Nanoreactors
by Hyuga Uchida (Cow '19)