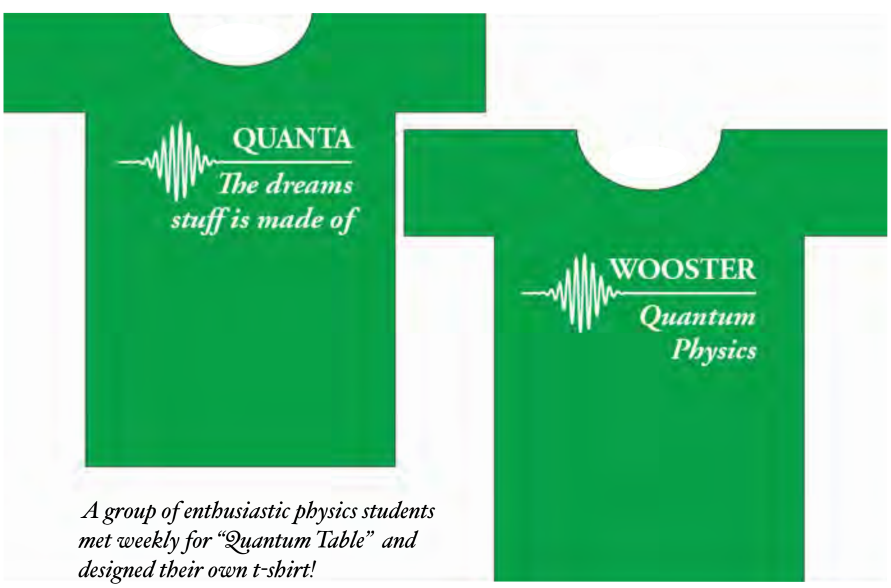
Wooster Physics

Recognition, Research, Retirements, Regalement

Prakrit Shrestha and Dr. Garg at commencement



A group of enthusiastic physics students met weekly for "Quantum Table" and designed their own t-shirt!

GREETINGS FROM THE CHAIR

2013-14 was another exciting year for the physics department – the students continue to be outstanding, and we have more of them than ever with a record-shattering 20 students in the class of 2016. As faculty, we pride ourselves on keeping the development of the students as our focus, whether through our teaching in the classroom or our mentoring of students in research. Our students continue to do amazing things and to be excited about what they can do in physics.

For the first time, a team of Wooster Physics students entered the University Physics Competition, a world-wide contest in which teams of three students spend 48 intense hours analyzing an open-ended real-world problem and writing a report to summarize their results. Our team of Dylan Hamilton '17, Yashasvi Lohia '16, and Michael Bush '16 used physics to analyze what life might look like on an earth-like planet with different temperature and gravitation conditions. They finished in the top 20 % of teams and were awarded a silver medal! Way to go Dylan, Yash and Michael!

I hope you enjoy the 2013-14 annual Wooster Physics newsletter!

Susan Lehman
Chair of Physics

CLASS OF 2014

Benjamin Harris

Physics major from Jacksonville FL

Plans: Graduate school at University of Tennessee Knoxville, radiological engineering

Ian Wilson

Physics major from Cincinnati OH

Plans: Position at EPIC in Madison WI

Vanessa Logan

Physics & Computer Science double major from Glenshaw PA

Plans: Teach for America, Detroit

Prakrit Shrestha

Physics & Mathematics double major from Lalitpur Nepal

Plans: Position at software company in Chicago

Prom pose !

Deepika Sundarraman

Physics & German Studies double major from New Delhi India

Plans: Graduate school in physics at University of Bonn, Germany

Danielle Shepherd

Physics & Mathematics double major from Northfield OH

Plans: Position at Kent Displays, Inc.

SENIOR INDEPENDENT STUDY

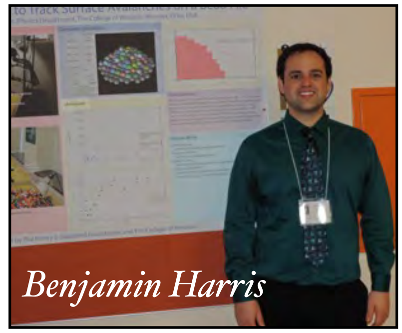
The Effects of Magnetic Cohesion and Drop Height on a Conical Bead Pile

The combined effects of cohesion and drop height on avalanche distributions were studied in a slowly-driven pile of steel beads. The pile was surrounded by a pair of Helmholtz coils that produced a uniform magnetic field to provide the cohesion between the steel beads. When the current in the Helmholtz coils was reduced, the beads did not remain magnetized, allowing us to vary the magnetic field strength as desired. Data was taken at four different field values with currents of 0 mA, 500 mA, 750 mA and 900 mA at a constant drop height of 4 cm, and data was taken at four different drop heights of 4 cm, 5 cm, 6 cm and 8 cm at a constant field value with a current 900 mA.

The data were analyzed to investigate the probability of avalanche sizes, the inter-event times between avalanches, and the angle of repose of the pile. Both the effects of cohesion and the effects of the drop height matched previous data taken at The College of Wooster. At a constant high cohesion value, the drop height was able to effect the size and shape of the characteristic hump of large avalanches in the avalanche size distribution plots. The higher the drop height was, the less prominent the hump in the data was. The higher drop heights also decreased the angle of repose on the pile and shortened the typical inter-event time. At a constant drop height, as cohesion was increased, the characteristic hump in the avalanche size distribution plots became larger and more defined. High cohesion values had longer inter-event times and a larger angles of repose. The drop height and cohesion were observed to have inverse effects on the pile, yet one was not dominant over the other at the maximum value for each parameter. *(Advised by Susan Lehman)*

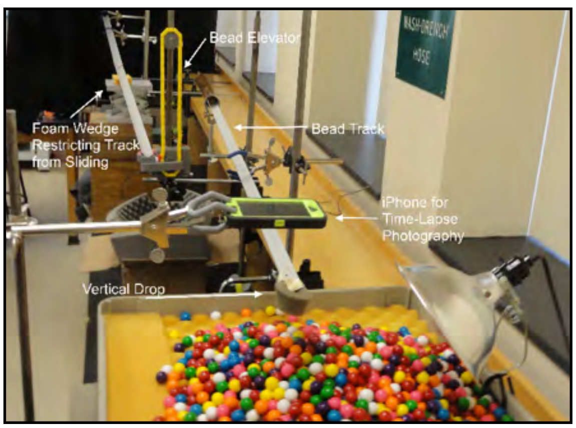
SENIOR INDEPENDENT STUDY

Establishing Methods to Track Surface Avalanches on a Bead Pile

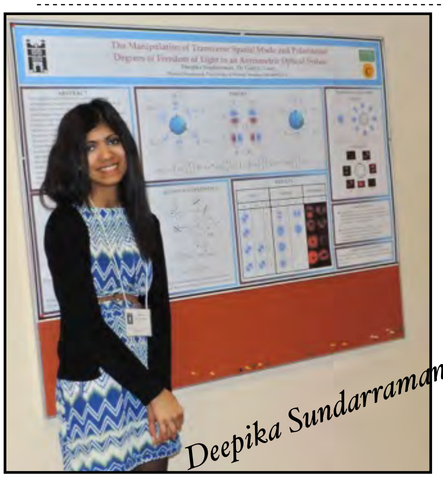


I studied surface avalanches on a granular pile model using two experimental apparatuses and a computer simulation. I vetted a three dimensional Newton's law bead pile simulation against results from previously conducted experiments. The simulation allowed for mass data collection of beads that fell off the pile during successive avalanches. Data collection was performed in the range of 1000 to 10 000 bead drops. I fit the data to a power law with an exponent tau = 1.5±0.1, compared to 1.5 observed in previous research for bead piles with small drop heights. Validating realistic behavior of the simulation established the potential to extend tracking to the movement of all beads and surface avalanche behavior.

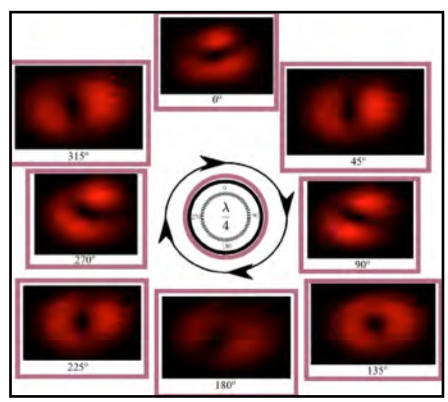
I constructed two experimental apparatuses to observe surface avalanches. I utilized gumballs in developing experimental methods because they were large, bright, colorful, and cheap. The gumballs used in the first and second apparatus were manufactured to be 0.92 ± 0.05 inches and 0.76 ± 0.05 inches respectively. The first model was a quarter conical pile composed of 1000 gumballs with a camera and microphone mounted to record the visual and aural qualities of avalanches. The second apparatus used automated bead delivery to drive a full conical pile. I established video tracking as the ground truth method to track avalanches by the total displacement of beads on the surface. The total displacement was the fundamental metric by which other methods were compared to. I expected to see larger displacements for larger avalanches. The disadvantage of video tracking was the tedium of the procedure. Manual tracking was slow and quickly encumbered the software used. My second method was subtracting pre- and post-avalanche images to measure the resulting difference in visual characteristics. I expected to see larger visual changes on the surface for larger avalanches. Image subtraction was advantageous because I developed a procedure to automate the process. The disadvantage was that data only correlated to the ground truth with typical correlation coefficients of 0.61 and 0.71 for the two subsets of image property channels tested. The last method was audio tracking. Data collection was conducted in a quiet place with a microphone to record avalanches. I expected to see that louder avalanches were larger in magnitude. Audio tracking was advantageous because it established a method of comparison to ground truth that could be automated with different equipment. The disadvantage was that when comparing audio data to ground truth, I obtained a typical correlation coefficient of 0.86. *(Advised by John Lindner)*



The Manipulation of Transverse Spatial Mode and Polarization Degrees of Freedom of Light in an Asymmetric Interferometric System

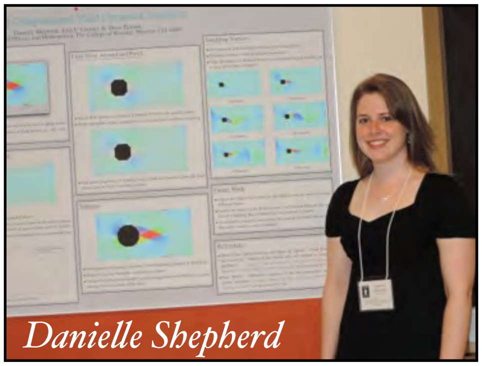


We establish both theoretical and experimental techniques to manipulate three degrees of freedom of light—the two transverse spatial mode and the polarization degrees of freedom–in an asymmetric Mach Zehnder interferometer (AMZI). The transverse spatial mode and polarization degrees of freedom function analogously when interfered in the (AMZI). A transformation of spatial modes possessing zero to non-zero orbital angular momentum along with polarization transformation was predicted theoretically and demonstrated experimentally in several cases involving classical laser light. Furthermore, the two input interferometer is capable of manipulating single photons in a similar manner and demonstrating a quantum phenomenon called Hong Ou Mandel Interference (HOMI) to create path entangled states of twin photons. This transformation can thus be extended to the quantum case, where a combined manipulation of spin and orbital angular momentum can be achieved for quantum information processing. *(Advised by Cody Leary)*



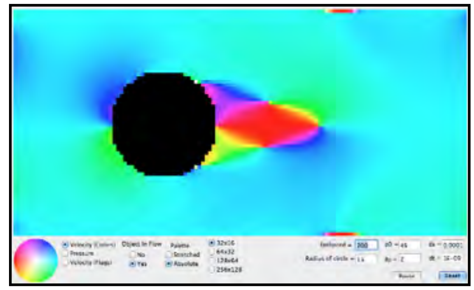
SENIOR INDEPENDENT STUDY

Go with the Flow: Developing Computational Fluid Dynamics Simulations According to the Navier-Stokes Equations



Danielle Shepherd

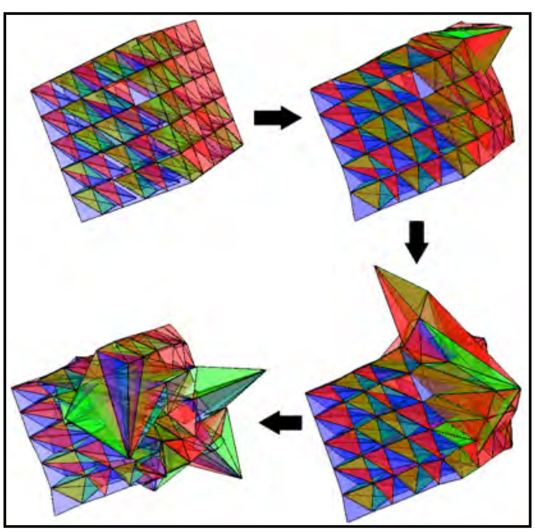
Although air flow and fluid flow occur around us everyday, how much is understood about these complicated phenomena? This project sought to explore fluid flow, according to the Navier-Stokes equations, through computational fluid dynamics and computer simulation. For this project, two simulations were created; the first used an artificial compressibility term to update the fluid where the second inverted a Laplacian matrix. The first simulation, while it produced an accurate steady state, artificially progressed to achieve it. As a result, the second simulation was created. This simulation could use either LU decomposition or a direct method to obtain the inverse matrix. The direct method employed *Mathematica* to invert the Laplacian to double precision and then stored the data in a binary file, which could later be imported into the simulation. This technique reduced round-off error and computation time, allowing for the accurate modeling of larger systems. All the simulations displayed a parabolic profile result during steady state, as

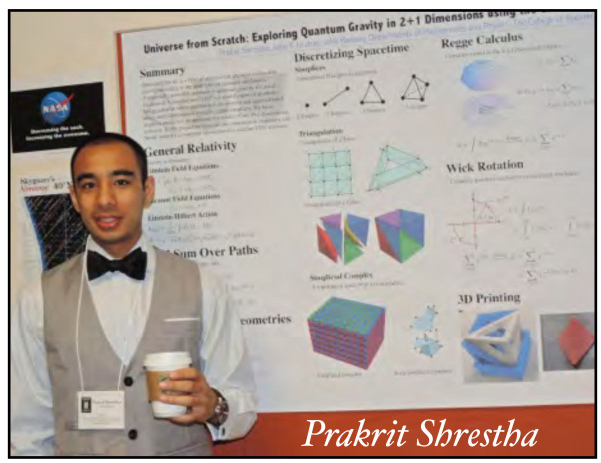


predicted by experiments and mathematical derivation. The development and shedding of vortices, within 10 hours of simulation time on a circa 2010 iMac computer, also helped affirm the accuracy of the simulation results. Implementing the exact inverse Laplacian provides a new technique for computational fluid dynamics simulation, as no other method uses the exact inverse matrix. With this advancement, the simulations may improve our knowledge of fluids and how objects interact with their flow. *(Advised by John Lindner, Physics, and Drew Pasteur, Math)*

Universe from Scratch: Exploring Quantum Gravity in 2+1 Dimensions Using the Causal Dynamical Triangulation Method

Quantum Gravity is a field of physics that attempts to describe gravity according to the principles of quantum mechanics. A potentially powerful approach to quantum gravity is Causal Dynamical Triangulations (CDT). CDT is a modification of quantum Regge calculus where spacetime is discretized and approximated using multi-dimensional triangles called simplices. This thesis implements a (2+1) dimensional toy model of our (3+1) dimensional universe. Its goal is to provide an introduction to quantum gravity and to expand the computational and analytical understanding of this model. It examines the topology of spacetime including concepts of general relativity and quantum mechanics. It generalizes Feynman's path integral to a sum over spacetime geometries characterized by the Einstein-Hilbert action. The topological structure of spacetime carries a Lorentzian signature and is distorted to obtain varying geometry by performing a set of Lorentzian Monte-Carlo moves. Finally, it describes the design, construction, operation and future work of a computer simulation of a 2 + 1 dimensional CDT universe. *(Advised by John Lindner, Physics, and John Ramsay, Math)*



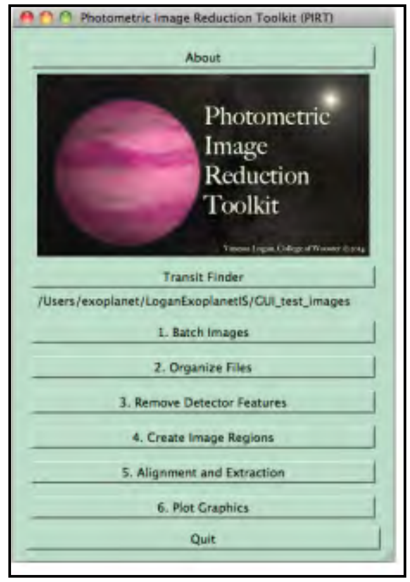


Prakrit Shrestha

SENIOR INDEPENDENT STUDY

Worlds as Real as Ours: Image Processing and Differential Photometry of Transiting Exoplanets

Exoplanets orbit other stars in the same way the Earth orbits the Sun. With over 1,600 exoplanets currently discovered, exoplanet research answers questions concerning solar system and planet formation and the possibility of life on other planets. This thesis focuses on the transit technique for exoplanet detection, in which a passing exoplanet temporarily blocks a small percentage of the light emitted by the star. To capture the transit, a series of images are taken throughout the duration of a transit. The data for this thesis were taken at Lowell Observatory's 31 inch telescope as part of the National Undergraduate Research Observatory (NURO). Over a course of seven nights, sixteen transits were tracked for thirteen different exoplanets. IRAF (Image Reduction and Analysis Facility) routines were used to develop a streamlined image processing software, Photometric Image Reduction Toolkit (PIRT). PIRT reduces the overall time for processing images, improves the registration and magnitude extraction for images, and is designed for astronomers to use with limited IRAF knowledge. The transits were found to be comparable and accurate when compared to previous data collected about the exoplanets. The duration and depth of the transits, the inferred inclination of the exoplanets' orbits and exoplanet radii are consistent with previously reported measurements. Several transits showed variations in transit duration and timing consistent with current trends. The data from this thesis is now part of the international exoplanet collaboration, Exoplanet Transit Database (ETD).*(Advised by Karen Lewis, Physics and Denise Byrnes, Computer Science)*



PHYSICS FACULTY

CODY LEARY, ASSISTANT PROFESSOR AT WOOSTER SINCE 2011

Dr. Leary published a paper with one of his 2012-2013 senior I.S. students as co-author:

C.C. Leary and Karl H. Smith, "Unified dynamics of electrons and photons via Zitterbewegung and spin-orbit interaction", *Phys. Rev. A*, 89, 023831, (2014)

This work demonstrates that two fundamental and ubiquitous particles of nature—electrons and photons—may be caused to exhibit identical physics. It was previously known that two exotic quantum effects, known as the spinorbit interaction and the Zitterbewegung (German, translating as "trembling motion") occur in electrons. This publication is the first to demonstrate that these quantum effect also exists for photons, in complete quantitative analogy with the previously known electron effects.

Teaching 2013-2014

First Year Seminar:
Cogs in the Machine

Modern Physics
Modern Physics Lab

Foundations of Physics II
Foundations of Physics II Labs
(2 sections)

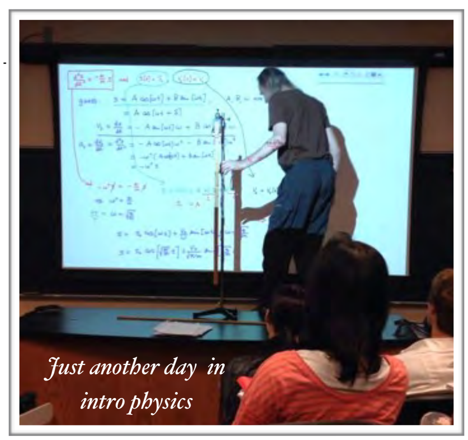
Math Methods for Physical Sciences

Senior Independent Study (1)

Student Deepika Sundarraman's Junior I.S. theoretical predictions helped contribute to Dr. Leary's successful single-investigator Cottrell grant application, "Generation and Manipulation of Entangled Two-photon States with Tailored Transverse Spatial Modes via Hong-Ou-Mandel Interference". Deepika's excellent senior I.S. work has set Dr. Leary's lab up well to begin work implementing the research proposed in the grant.

In the classroom, Dr. Leary introduced new content into the curriculum for his Particle Physics course, related to deriving the fundamental quantum wave equations governing nature using the mathematical study of symmetry (i.e., the theory of Lie groups) as a springboard.

JOHN LINDNER, PROFESSOR AT WOOSTER SINCE 1988



Just another day in intro physics

Dr. Lindner had two articles with multiple student co-authors* appear this past year:

"Order and chaos in the rotation and revolution of two massive line segments", A. Blaikie*, A. D. Saines*, M. Schmitthenner*, M. Lankford*, R. D. Pasteur, J. F. Lindner, *Physical Review E,* volume 89, pages 042917(1-9) (2014)

"Artificial Gravity Field", L. C. Markley*, J. F. Lindner, *Results in Physics,* volume 3, pages 24-29 (2013)

Teaching 2013-2014

Foundations of Physics I
Foundations of Physics I Lab

General Physics II
General Physics II Labs

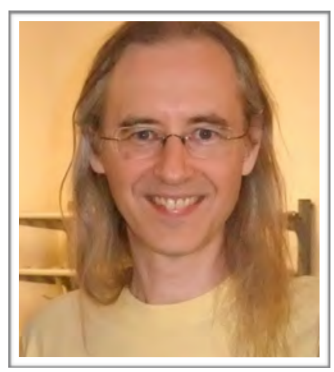
Quantum Mechanics

Thermal Physics (tutorial)

Senior Independent Study (3)

Dr. Lindner continued his role as Physics Club advisor, which included the planning and execution of the Sixth Annual Community Science Day.

In the spring semester, Dr. Lindner gave a talk entitled "Quantum Reality" at Philosophy Roundtable and another talk entitled "Chaos, Cosmos, Mythos, Theos" to a class of ancient mythology students.



Dr. Lindner will be on sabbatical during the 2014-15 academic year, which he will spend at the University of Hawaii Manoa.

PHYSICS FACULTY

KAREN LEWIS, ASSISTANT PROFESSOR AT WOOSTER SINCE 2010

Dr. Lewis had a year filled with observing! She traveled to Lowell Observatory in Flagstaff, AZ with Vanessa Logan ('14) in October and Nathan Johnson ('16) and Yashiva Lohia ('16) in January to observe exoplanet transits. These trips included the entertaining yet futile attempts to create Rube Goldberg-like live traps for the observatory mice and of course a visit to the Grand Canyon. We've obtained excellent data at Lowell Observatory, which led to an invitation for The College of Wooster to join an international collaboration to continue monitoring transiting exoplanets to search for transiting timing variations. The fall was also very busy, training students to use The College of Wooster observatory, which was greatly facilitated by a series of instructional pamphlets made by Nate and Yash. Dr. Lewis was awarded eight nights of observing time on the 4m SOAR telescope in Cerro Panchon, Chile which she used to observe X-ray sources in the XMM-Newton Slew Survey. On these two observing runs, Dr. Lewis added 40 newly discovered Active Galaxies to her growing sample. On the first trip in March, Dr. Lewis gave a colloquium entitled "35,000 Square Degrees and Counting: Optical follow-up of the XMM Slew Survey." She also received training to operate the telescope remotely, so her second run over the 4th of July weekend was executed from the comfort of her office! Although she missed the thrill of being at the telescope in person, she did not miss the 16 hours of travel to get there.

Teaching 2013-2014

- Astronomy of Stars & Galaxies
- Astrophysics
- Modern Physics lab
- Senior Independent Study (1)
- on sabbatical Semester II

Dr. Lewis spent the spring and summer on leave in the Department of Astronomy at University of Wisconsin in Madison, WI. While there, she started a new project using data mining techniques to search for a rare type of Active Galaxy (known as Double-Peaked Emitters) in the Sloan Digital Sky Survey. There are only 150 of these objects known, and only 6 are close enough to have studied in great detail. Out of the nearly 1 million galaxies observed with Sloan, Dr. Lewis has whittled this down to the 1000 most likely candidates. She is particularly excited to have found ~30 of these objects in our nearby Universe.

This larger sample size should help resolve many outstanding questions about these rare objects. Dr. Lewis was awarded a $35,000 Cottrell Science Award from the Research Corporation in support of this new project and is looking forward to working with students on this project.

SUSAN LEHMAN, ASSOCIATE PROFESSOR AT WOOSTER SINCE 2003

Dr. Lehman and Karin Dahmen, professor of physics at The University of Illinois at Urbana-Champaign, have been awarded a three-year, $355,973 collaborative grant from the National Science Foundation. The main objective is to understand and explain the effect of cohesion on the avalanche statistics in granular material, particularly predicting or minimizing catastrophic avalanches. Dr. Lehman and her student assistants are using a simple granular pile as a model system to test the effect of cohesion on avalanche behavior.

Dr. Lehman gave a talk at the March meeting of the American Physical Society in Denver entitled “Scaling Analysis And Tuning Parameters For Avalanches On A Slowly-Driven Conical Bead Pile”. She was accompanied at the meeting by four Wooster physics majors, Maggie Lankford ’16, Paroma Palchoudhuri ’16, Brian Maddock ’15 and Nicu Istrate ’15, who gave poster presentations on their research from last summer.

Teaching 2013-2014

- General Physics labs
- Foundations of Physics lab
- Modern Physics lab
- Condensed Matter Physics
- Junior Independent Study
- Senior Independent Study (1)

Dr. Lehman and her colleagues hosted several visitors from International Christian University in Japan, including physicist Dai Hirashima. ICU sent faculty and students to develop relationships and talk about ways to start an exchange program between our institutions. Wooster Physics major Dylan Hamilton ’17 was part of a group that visited Japan in May.

PHYSICS FACULTY

SHILA GARG, PROFESSOR AT WOOSTER SINCE 1986

Dr. Garg officially retired from teaching at the end of fall semester 2013, but continued in her role as Wooster's ambassador to India. She visited India to network with alumni in Kolkata, Mumbai and Delhi during the spring. She also visited a variety of schools in these cities and met with prospective students and families. She is leading a project on "Emerging Models of Liberal Arts Education in India", and along with a group of five other GLCA faculty, she will be developing a plan to explore some of the newly emerging liberal arts institutions in India. Dr. Garg is concluding a research project on Pattern Formation in Liquid Crystals. Along with student co-authors and Dr. John Lindner, she hopes to write a manuscript with the results of the project. Dr. Garg also served on three different NSF panels during the spring.

Teaching 2013-2014

Electronics for Scientists

Electronics lab

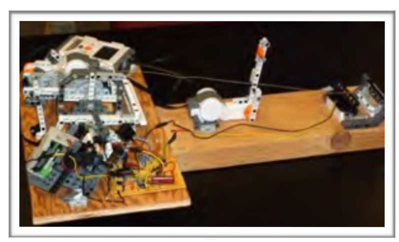
Mechanics

Dr. Garg circa 1988 with some middle schoolers

Dr. Garg, Dot the therapy dog-in-training, Jai Ranchod '15 and Amanda Steinhebel '15

ROBOTS!

A quartet of robots performed human-like assigned tasks on the last day of the fall semester in Dr. Garg's Electronics for Scientists class. The students created the robots using Lego Mindstorms NXT kits and designed a sensor programmed to react to something in the environment.



Elliot Wainwright

Evan Hagedorn

"Li'l B the Bridge Bot" - tested the structural integrity of bridges

Ben Harris

Shawn Bowman

Trent Ziemer

"Tuning Bot" - used its sensor to tune a string to a certain frequency

Matt King-Smith

Jairaj Ranchod

"Spot-Bot" - a metal detecting robot

Calvin Milligan

Nate Mathewson

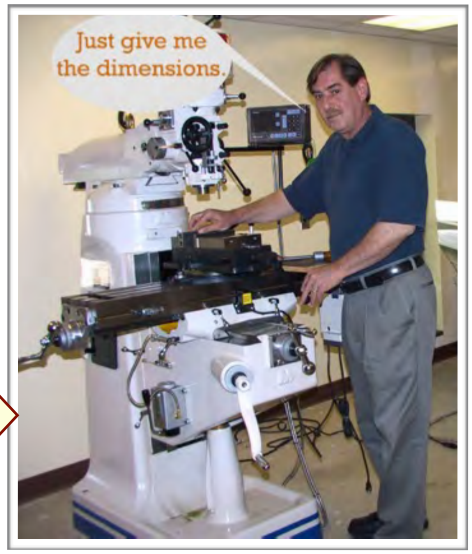
Nate Stone

"Mine Sweeper" - detects concealed magnets located on the tabletop surface

STAFF

RON TEBBE, INSTRUMENT TECHNICIAN & MACHINIST

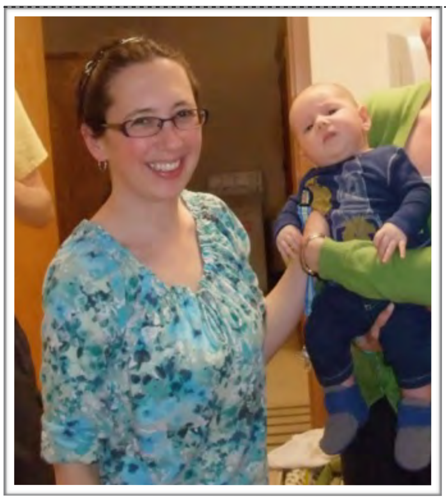
AT WOOSTER SINCE 2004



In addition to countless small projects that have helped keep Dr. Leary's quantum optics lab up and running, Ron helped design and construct protective casings for our single photon counting modules and for the nonlinear optical crystal comprising our photon pair source.

The end of the academic year marked the retirement of Ron Tebbe, an invaluable resource to both students and faculty for the past 10 years.

Congratulations, Ron!



MANON GRUGEL-WATSON LABORATORY COORDINATOR

AT WOOSTER SINCE 2008

Manon continued her dual role as laboratory coordinator and adjunct instructor for introductory physics labs. She welcomed her second son, Lowen Charles Watson, on February 17, 2014.

THROWBACK!
DR. GARG,
DR. JACOBS,
AND
DR. LINDNER
1988

JACKIE MIDDLETON ADM. COORDINATOR

AT WOOSTER SINCE 1989

It is hard to believe that 25 years have passed since Jackie had an employment interview with Dr. Don Jacobs (Physics) and Dr. Don Beane (Math). She remembers taking a typing test on an IBM Selectric typewriter and having to use an interchangeable type ball to produce the special characters. Her first computer was a Mac Plus which led to her unflappable devotion to all things Apple.

HONORS AND AWARDS AWARDED TO PHYSICS MAJORS

UNIVERSITY PHYSICS COMPETITION

The team of Dylan Hamilton '17, Yash Lohia '16, and Michael Bush '16 earned a silver medal in the 4th annual University Physics Competition. The team spent 48 hours during a weekend in November analyzing an applied scenario using the principles of physics and writing a formal paper describing their work.

http://www.uphysicsc.com/2013_UPC_Results.pdf

The Wooster paper on Problem B - Extraterrestrial Life was ranked in the top 20% of 119 teams.

LATIN HONORS

Summa cum laude
Danielle Catherine Shepherd

Cum laude
Prakrit Shrestha
Deepika Sundarraman

DEPARTMENTAL HONORS

Danielle Catherine Shepherd
Prakrit Shrestha
Deepika Sundarraman

PHI BETA KAPPA

Danielle Catherine Shepherd

THE ARTHUR H. COMPTON PRIZE IN PHYSICS

Deepika Sundarraman

THE JOSEPH ALBERTUS CULLER PRIZE IN PHYSICS

Maggie Erin Lankford '16
Michael Antione Lorenzo Bush '16

THE KARL COMPTON SCHOLARSHIP

Maggie Erin Lankford '16
Michael Antione Lorenzo Bush '16

THE MAHESH K. GARG PRIZE IN PHYSICS

Vanessa Rae Logan

CAMPUS COUNCIL LEADERSHIP AWARD

Vanessa Rae Logan

Deepika Sundarraman accepts her diploma from President Cornwell

WILLIAM H. WILSON PRIZE IN MATHEMATICS

Danielle Catherine Shepherd

MARY SANBORN ALLEN PRIZE AWARDED TO A STUDENT WHO HAS BENEFITED MOST FROM STUDY OUTSIDE THE U.S.

Deepika Sundarraman

SOCIETY OF PHYSICS STUDENTS: BLAKE LILLY PRIZE

The Blake Lilly Prize, named after the late Blake Lilly and given in his honor, recognizes SPS chapters and individuals who make a genuine effort to positively influence the attitudes of school children and the general public about physics. The Blake Lilly Prize is an opportunity to be publicly recognized for these types of physics outreach efforts.

Wooster Physics SPS has been named a recipient of the Blake Lilly Prize in **2014** in recognition of our elementary school outreach program. Our chapter of SPS also won the award in **2007, 2009** and **2013**.

JUNIOR INDEPENDENT STUDY

SELF-DESIGNED PROJECTS

JAIRAJ RANCHOD
INTERSTELLAR ELECTROMAGNETIC PROPULSION

SAUL PROPP
THE OPTICAL ELECTRON AND THE ZITTERBEWEGUNG

ELLIOT WAINWRIGHT
PARTICLE CHARACTERIZATION USING TURBIDITY

BRIAN MADDOCK
SIMULATION OF THE EXPANSION MECHANISM OF OSORB®

JOSEPH SMITH
CHAOS AND CHANCE: SIMULATING A TWO-DIMENSIONAL DICE ROLL

NICOLAE ISTRATE
A NEW APPROACH TO KALUZA-KLEIN THEORY

SHAWN BOWMAN
EFFECT OF SEAM HEIGHT ON MAGNUS FORCE

AMANDA STEINHEBEL
INVESTIGATION OF FINE-TUNING THROUGH THE VARIATION OF FUNDAMENTAL CONSTANTS

PHYSICS COLLOQUIUM SERIES

Wooster Physics Juniors, Junior Independent Study Projects, 29 April 2014

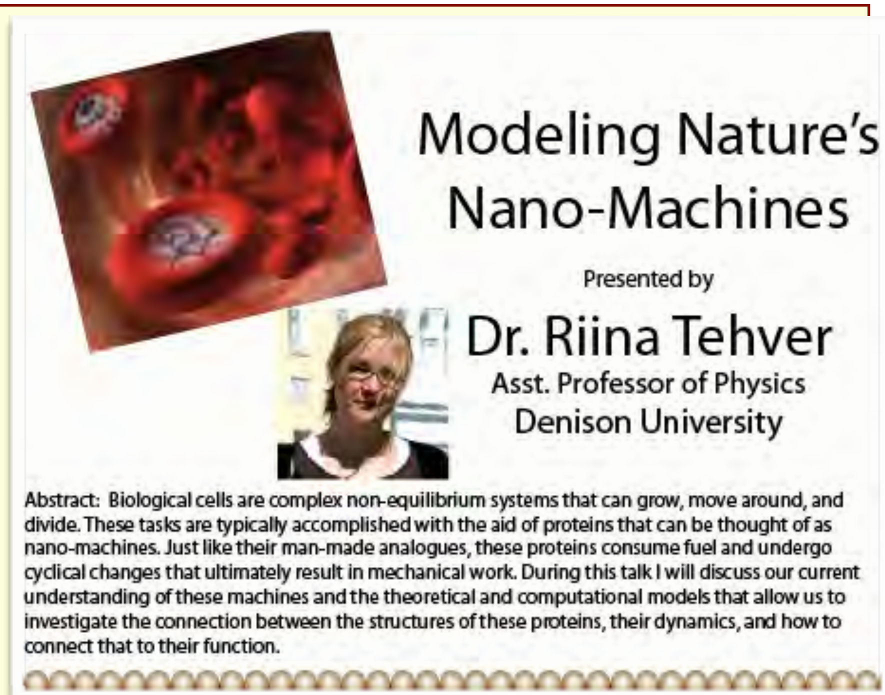
Dale Force, NASA Glenn Research Center, Cassini Radio Science: The Glenn Contribution, 27 March 2014

Savan Kharel, University of Tennessee, From Scattering of Gluons to Quantum Gravity, 26 February 2014

Adam Fritsch, Michigan State University, Pushing the Envelope of Science: Exploring Nature on the Nuclear Scale, 24 February 2014

Benjamin Shank, Stanford University, The Universe's Missing Mass (and What You Can Do About It), 19 February 2014

Nelia Mann, Reed College, Old Quantization from a Modern Perspective, 17 February 2014



Wooster Physics Seniors, Fall Senior Independent Study Progress Reports, 3 December 2013

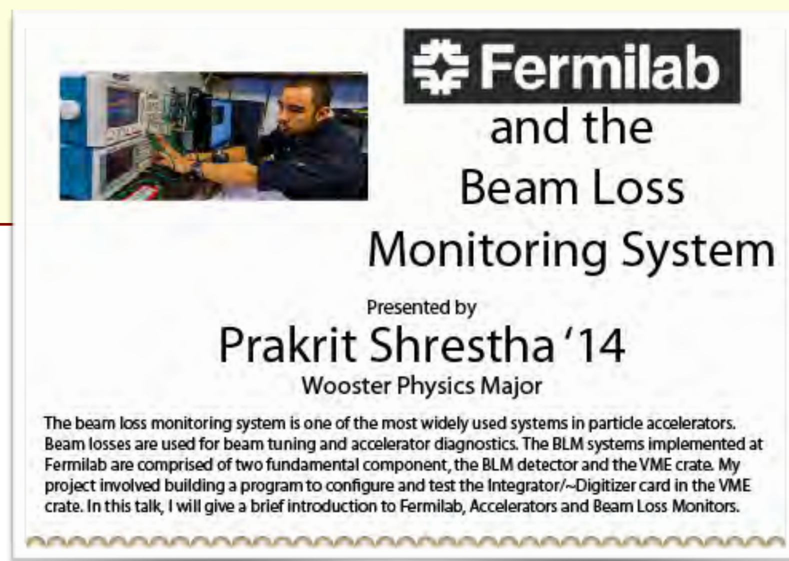
Prakrit Shrestha '14, Wooster Physics Major, Fermilab and the Beam Loss Monitoring System, 18 November 2013

Riina Tehver, Denison University, Modeling Nature's Nano-Machines, 5 November 2013

Patrick Durrell, Youngstown State University, Searching for Virgo's Intracluster Globular Clusters, 15 October 2013

Sarah Wingfield, Wolfram Research, Inc., An Overview of *Mathematica* for Education and Research, 24 September 2013

Vanessa Logan '14 and Danielle Shepherd '15, Summer Research Experiences, 17 September 2013



PHYSICS CLUB & ASTRONOMY CLUB

PHYSICS CLUB OFFICERS

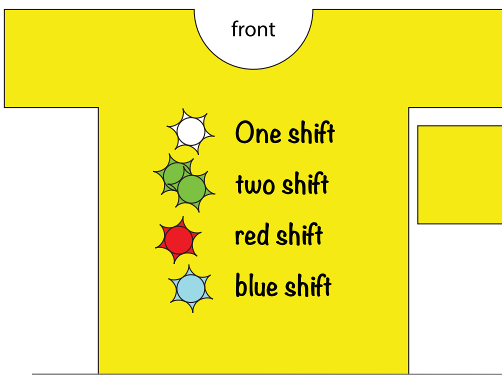
President: Vanessa Logan '14
Vice President: Danielle Shepherd '14
Treasurer: Elliot Wainwright '15
Secretary: Ian Wilson '14

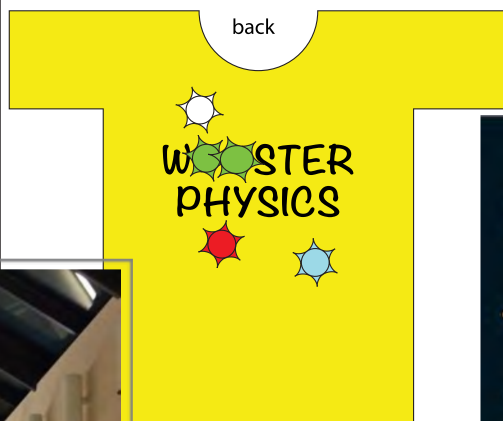
ASTRONOMY CLUB OFFICERS

President: Amanda Steinhebel '15
Vice President: Jairaj Ranchod '15
Treasurer: Yash Lohia '16

EVENTS

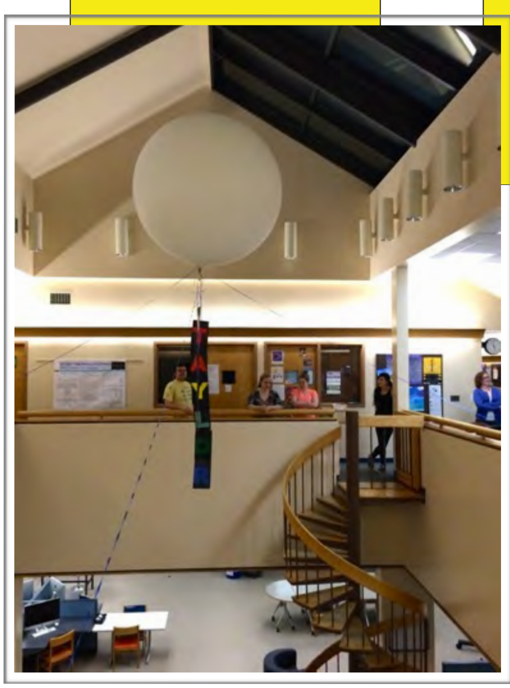
August 30: Scot Spirit Day
September 4: Luce Dinner
September 11: General Meeting
September 14: Community Viewing of Luna, Albireo, Andromeda Galaxy,
September 18: Outreach Training
September 25: Outreach Training
September 27: College Viewing of Albireo, M13, ring nebula, Andromeda Galaxy, Pleades
October 16: General Meeting
November 2: Great Lakes Science Center trip
January 15: General Meeting
March 1: Astronomy Club at the Cleveland Natural History Museum
March 27: Astronomy Club NASA Talk by Dale Force
April 2: General Meeting
April 13: Taylor Bowl 25
April 26: Science Day 6





OUTREACH

Physics Club made 12 visits to local elementary schools this past year, including a first-time visit to the Montessori School in Wooster.



This year's Taylor Bowl challenge by the Physics Club included the launch of a weather balloon in the Taylor Hall atrium.

Taylor Bowl XXV Results

Math/CS:	113.6
Physics:	86.6

Nat'l Meeting-American Physical Society

DENVER, COLORADO
MARCH 2014

Maggie Lankford* and John Lindner, "Order and chaos in the rotation and revolution of two massive line segments"

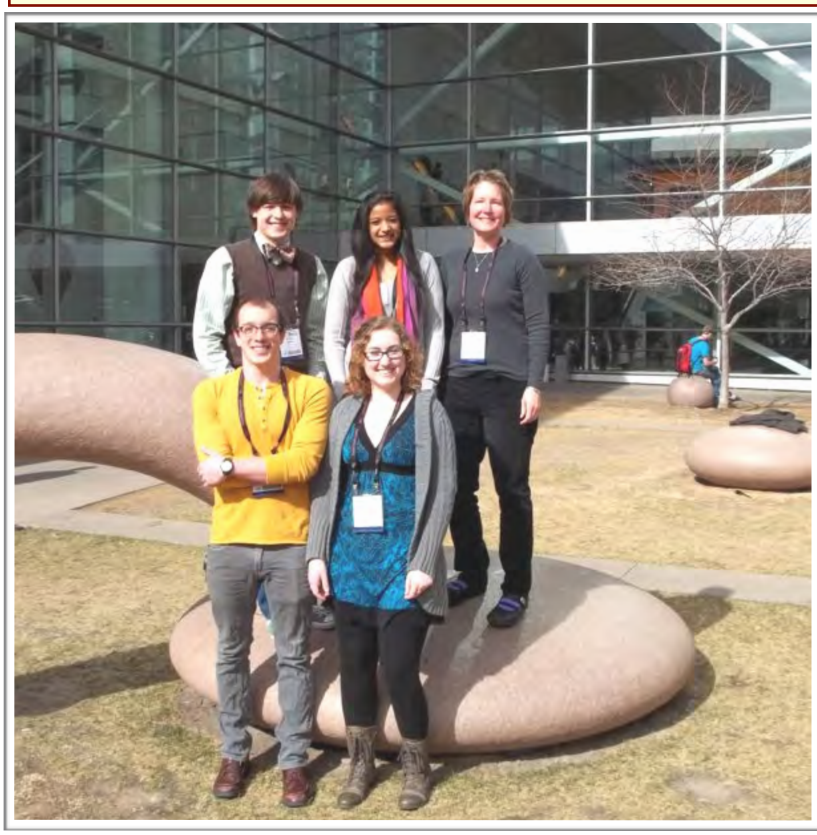
Susan Lehman, Lilianna Christman*, Paroma Palchoudhuri* and D.T. Jacobs, "Scaling Analysis And Tuning Parameters For Avalanches On A Slowly-Driven Conical Bead Pile"

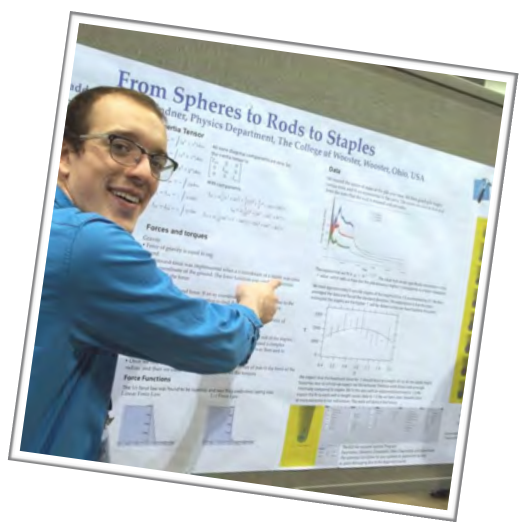
Paroma Palchoudhuri*, Susan Lehman and D.T. Jacobs, "Effects of Cohesion On the Dynamic Response of A Conical Bead Pile"

Brian Maddock* and John Lindner, "Computer simulation of the classical entanglement of U-shaped particles in three dimensions"

Nicolae Istrate* and John Lindner, "Stress-energy distribution for a cylindrical artificial gravity field via the Darmois-Israel junction conditions of general relativity"

*Student co-author





Front: Brian Maddock, Maggie Lankford
Rear:Nicu Istrate, Popi Palchoudhuri, Dr. Lehman

Colorado Convention Center, Denver

SUMMER RESEARCH

IN THE PHYSICS DEPARTMENT

Michael Bush ’16 “Balancing Gravity and Spin: The Impact of Geometry on Newtonian *n*-Spheres”

(advised by John Lindner)

Nathan Johnson ’16 “Analyzing Gaussian Distributions of Large Avalanche Events”

(advised by Susan Lehman)

Andrew King-Smith ’16 “Counting Photon Coincidences”

(advised by Cody Leary)

Maggie Lankford ’16 “Hong-Ou-Mandel Interference in a Mach-Zehnder Interferometer”

(advised by Cody Leary)

Yashavi Lohia ’16 “Mechanical Stochastic Resonance”

(advised by John Lindner)

Ziyi Sang ’17 “/// Dynamics of 3 Gravitating Rods”

(advised by John Lindner)

Catherine Tieman ’16 “New Analysis Techniques on Avalanche Statistics in a Conical Bead Pile”

(advised by Susan Lehman)

OFF-CAMPUS

Saul Propp ’15 calculated cross-sections for single boson and diboson decay modes for the W± and Z bosons using MCFM and DYNNLO at the University of Michigan at Ann Arbor, working with Dr. Jianming Quian. He also helped to compare these cross-sections with the data from ATLAS using the ROOT package. In addition to the research, the REU at Michigan included weekly field trips to local museums, extensive free live music courtesy of the on-campus summer festival, and culminated in an overnight trip to Fermilab.

Amanda Steinhebel ’15 participated in the National Undergraduate Fellowship through Princeton Plasma Physics Labs, a national laboratory researching plasma physics and its application in fusion energy. Her work was done at General Atomics, a close collaborator in San Diego, California. Amanda worked with Drs. Todd Evans and Wen Wu to improve and optimize a computational model of a tokamak - a device that uses magnetic fields to contain plasma and produce a fusion-favorable environment.

SUMMER RESEARCH

OFF-CAMPUS

Dylan Hamilton '17 worked at the University of Colorado Boulder at JILA, a joint laboratory between CU and NIST with the Lewandowski group, which studies very cold (on the microkelvin scale) molecules and interactions. Dylan worked on tuning two lasers to specific absorption frequencies in order to cool down calcium ions. These cold calcium ions will then in turn be used to sympathetically cool molecular ions which will then be brought together with neutral molecules to observe reactions between them. These interactions between very cold molecules in a high-vacuum environment mimic the environment of space and will hopefully give us information about interstellar reactions. In addition, the extreme coldness of the molecules limits the possible internal states of the molecules as well as the energy available to the reaction, allowing us to study reactions dictated by the individual quantum states of each molecule rather than those governed by massive averages of the properties of many bodies (such as temperature).

Jairaj Ranchod '15 did some research into the fabrication of transparent conductive odices (TCOs) as part of the MORE center at Case Western Reserve University in Cleveland Specifically he spent most of his time making thin films of Indium Tin Oxide under different conditions and hoping they would be conductive.

Matt King-Smith '16 worked at the NASA Goddard Space Flight Center in Greenbelt Maryland. He interned in the Parts, Packaging and Assembly Branch which is responsible for assembling, testing, and redistributing electrical, electromechanical, and electronic parts to various projects throughout NASA. While working in the failure analysis lab, he was given the task of working with special kinds of resistor called foil resistors. These are expensive precision resistors which are meant to keep their resistance value over a large temperature range. NASA has experienced numerous failures with them. Matt's goal was to create a reproducible nondestructive screening technique using pulses of direct current at various duty cycles to weed out potentially prone-to-failure parts, then to create another test of pulses which will break the the bad resistors into an open circuit and remove them and allow the other good resistors to continue in their process to become parts of flight equipment. Matt had the opportunity to use various equipment ranging from a basic oscilloscope up to a scanning electron microscope and a machine which uses x-ray spectroscopy. Goddard is an amazing campus with lots of different research and projects happening every day.

Joseph Smith '15 participated in the College's Applied Mathematics & Research Experience (AMRE) for the third straight year. The client was Kent Displays Inc., and the purpose of the project was to isolate production factors that cause faulty displays. Machine learning analysis techniques including decision trees found combinations of productions factors that can be used to improve yield. Multinomial logistic regression confirmed these general trends and explored the effect of late shift production times on yield. Regions of high and low yield were compared to replicate desirable production conditions and to avoid undesirable conditions. Data analysis scripts were written in Scilab and R to provide Kent Displays with access to these analysis techniques in the future.

Brian Maddock '15 also participated in AMRE, working on a project for Goodyear Tire & Rubber Co. The purpose of this project was to develop a predictive model of tire production failure. Goodyear can use this model to alert machine operators of impending failure, who can then maintenance the machine accordingly. Brian and the team examined a variety of tire measurements in a sample data set of tire production. Using *R*, *MATLAB*, and *Excel*, they explored several statistical and predictive analysis techniques.

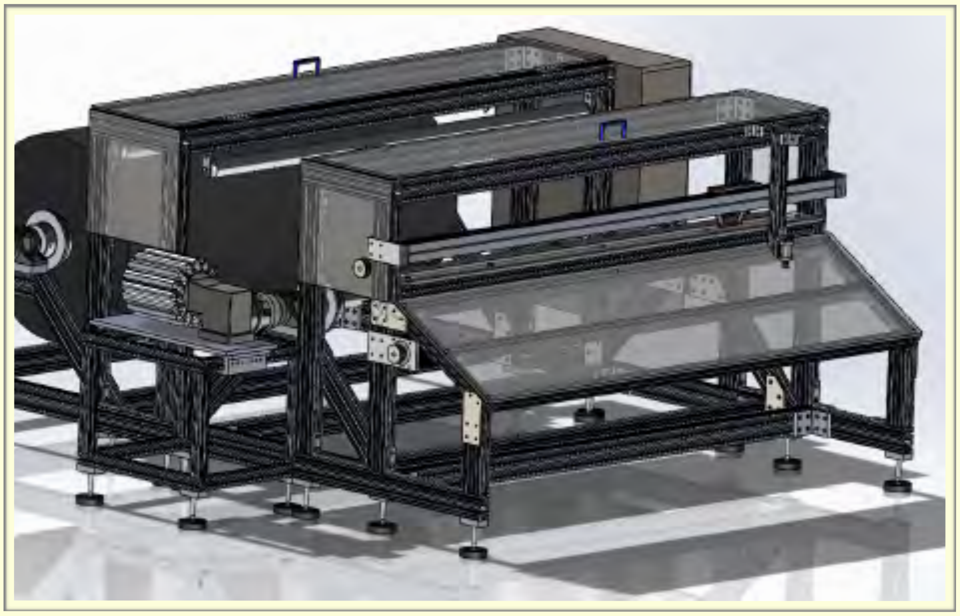
Popi Palchoudhuri '16 spent her summer in the Particle Physics Department of Fermi National Accelerator Laboratory, IL. Under the supervision of Eric Ramberg and Carlos Escobar, she worked in the field of quantum optics, developing a technique for the absolute calibration of single photon detectors using a quantum phenomenon called spontaneous parametric down conversion. This is a fairly new experimental research project at Fermilab, and Popi's main tasks were to collect high quality data, make improvements to the current experimental setup and write a program that can analyze the collected data. In addition to calibration, the group also performed a three dimensional scan of the ring that is formed due to spontaneous parametric down conversion, using a new and sophisticated method that has not been employed before.

SUMMER RESEARCH

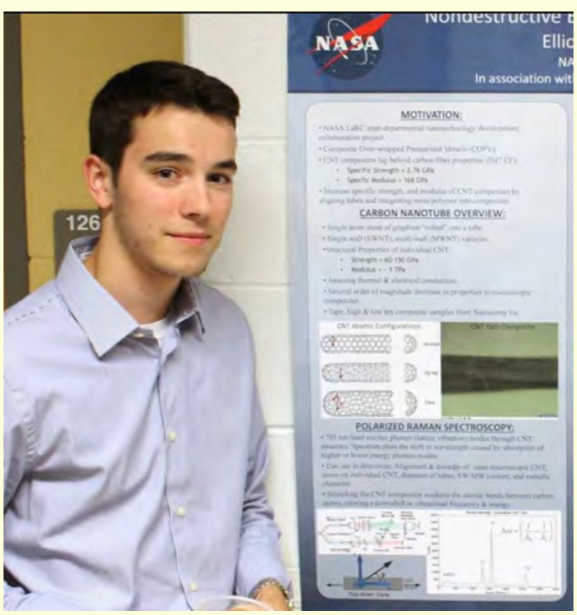
OFF-CAMPUS

Nicu Istrate '15 This summer Nicu decided to make a change. He put theoretical physics on the shelf and explored the fascinating field of engineering through an internship at Brentwood Industries, a plastic manufacturing company located in Reading PA. Brentwood was established in 1965 as a small thermoforming facility and it has grown into a international company since then. It creates products that are used in industries like water purification, cooling towers, batteries, construction and others.

Nicu's project for the summer was to design and create a machine that is able to take a roll stock of polyvinyl chloride plastic (PVC) and transform it into sheets of known dimensions. Soon after the start of my internship, Nicu found himself learning a new application for the material he has learned at Wooster. This internship gave Nicu an overview of mechanical and electrical engineering. He also got the chance to learn a new 3D designing software and how to use some machining tools.



Before starting working for Brentwood Industries, Nicu says he was a bit terrified since he had little knowledge about the engineering world. But soon he realized that with some effort and along with the knowledge gathered in the classes I took at The College of Wooster, he found himself feeling comfortable in the new field.

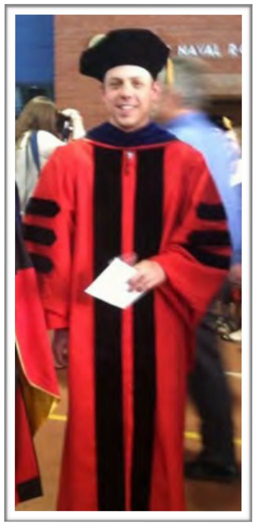


Elliot Wainwright '15 spent ten weeks at The College of William & Mary in their physics REU program, researching at NASA Langley Research Center under with Dr. Buzz Wincheski. He worked in the Non-destructive Evaluation Branch, doing characterization of carbon nanotube nanocomposites. Carbon nanotube (CNT) nanocomposites can be used as a structural reinforcement for aerospace components. Of particular interest is the application toward composite over-wrapped pressure vessels (COPV) to reduce weight and raw materials needed to maintain the strength of the chambers going into space. Je tested the tensile strength and modulus of CNT tape and yarn nanocomposites in order to determine ways to increase their mechanical properties to that of current carbon fiber composites.

ALUMNI NEWS

DANNY SHAI '07

Danny recently earned his Ph.D. in physics at Cornell University, where he was an NSF Graduate Fellow and an NSF IGERT Fellow.

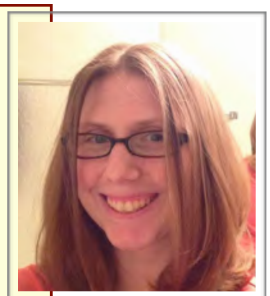


WOODY SHEW '98

Woody is an assistant professor in the physics department at the University of Arkansas. His research focus is biophysics of the brain including neural network dynamics, neural phase transitions, and cerebral blood flow dynamics.

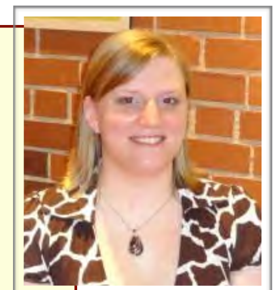
LISA MAY WALKER '07

Lisa May completed her Ph.D. in astrophysics at the University of Virginia and has moved west to begin a post-doc with the University of Arizona's NIRCam team for James Webb Space Telescope.



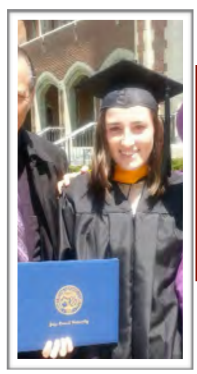
KELLY PATTON '08

Kelly has completed her Ph.D. at North Carolina State University. Her thesis is titled *Investigating Nuclear and Astrophysical Systems Using Neutrinos.*



NATHAN UTT '07

Nathan lives in Iowa and works for Ecosystems Service Exchange (ESE). He travels extensively across the U.S.to work with contractors, farmers, landowners, universities, and government agencies on the design and implementation of effective edge-of-field conservation practices.



LOUISA CATALANO '11

Louisa just completed her master's degree in mathematics at John Carroll University in Cleveland.

RICH BAILEY '91

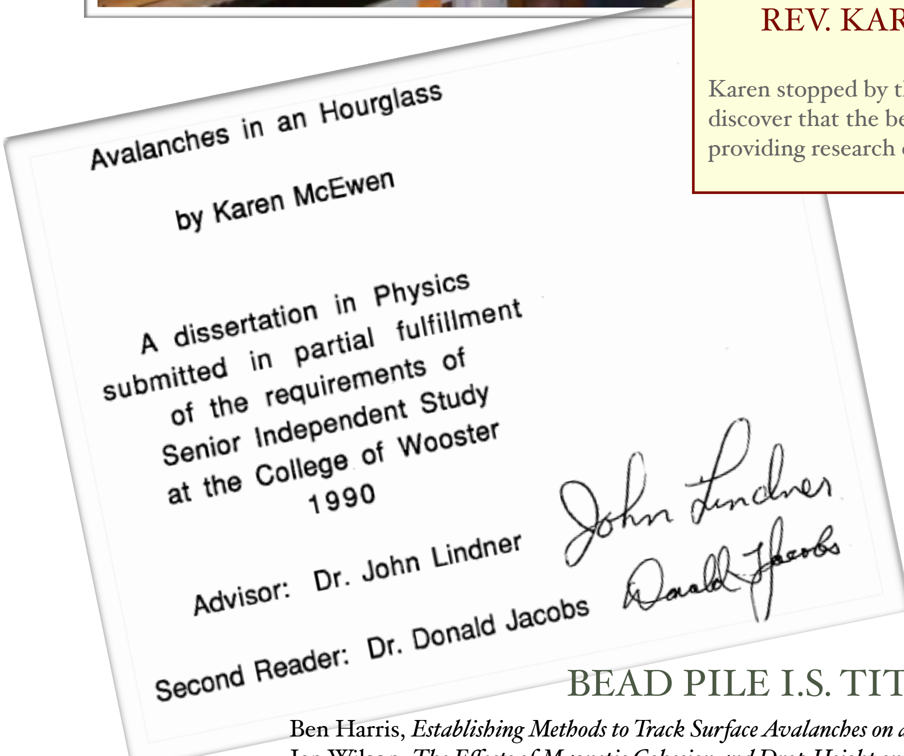
Rich lives in Musashino, Tokyo, Japan with his wife Joan and teaches ESL at Asia University.

SALEH SATTI '05

Saleh is an E^{2}SHI Fellow at Johns Hopkins University Department of Earth and Planetary Sciences. His focus is irrigation and hydropower strategies in Sudan and climate change's challenges.

A QUARTER CENTURY OF BEAD PILES

Dr. Lindner, Karen Farthing, and current bead pile student researcher Catherine Tieman '16



Avalanches in an Hourglass

by Karen McEwen

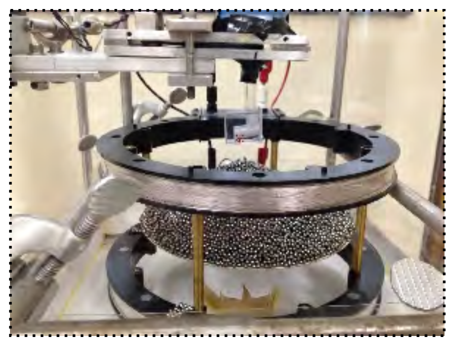
A dissertation in Physics
submitted in partial fulfillment
of the requirements of
Senior Independent Study
at the College of Wooster
1990

Advisor: Dr. John Lindner

Second Reader: Dr. Donald Jacobs

REV. KAREN MCEWEN FARTHING '90

Karen stopped by the department recently and was thrilled to discover that the bead pile experiment she began in 1989 is still providing research opportunities for Wooster physics majors.



current apparatus

BEAD PILE I.S. TITLES OVER THE YEARS...

Ben Harris, *Establishing Methods to Track Surface Avalanches on a Bead Pile* (2014)
Ian Wilson, *The Effects of Magnetic Cohesion and Drop Height on a Conical Bead Pile (2014)*
Lily Christman, *The Effects of a Magnetic Field on a Conical Bead Pile (2013)*
Ingrid Thvedt, *Exploration of the Effects of Cohesive Forces in a Bead Pile (2011)*
Mary Mills, *Self-Organized Criticality and the Effect of Pseudo-Randomly Dropping Beads Over a Bead Pile (2009)*
Howard Henry, *Self-Organized Criticality: An Investigation of Pseudo-Random Bead Drop Dynamics (2008)*
Andrew Kindschuh, *Self-Organized Criticality: An Investigation of Energy Dissipation and Bead Pile Dynamics (2006)*
Rebecca Urban, *Dynamics of a Steel Bead pile Exhibiting Self-Organized Criticality, (2003)*
Matthew Krivos, *Effect of a Dropped Bead's Kinetic Energy on the Self-Organized Critical Behavior of a Bead Pile (2002)*
Timothy Sir Louis, *Self-Organized Criticality in a Bead Pile (2000)*
Christopher Levy, *Self-Organized Criticality in a Conical Sandpile (1993)*
Douglas Halverson, *A New Method for the Experimental Investigation of Self-Organized Criticality (1991)*
Karen McEwen, *Avalanches in an Hourglass (1990)*

SPECIAL RECOGNITION

Joseph Richard Harrison Smith '15 has been named a 2014 Goldwater Scholar. A double major in Mathematics and Physics, Joey's future plans are to obtain a Ph.D. in either Mathematics or Physics and conduct research in mathematical- or simulation-based physics while possibly teaching at the university level.

Amanda Lynn Steinhebel '15 has been named a 2014 Goldwater Honorable Mention. A double major in Mathematics and Physics, Amanda plans to pursue a Ph.D. in particle physics and conduct research at a national laboratory.

IT'S A GIANT KALEIDOSCOPE!

Dr. Lindner has some fun demonstrating the giant kaleidoscope that Dr. Lehman constructed. It will make our outreach optics demo much more exciting for elementary school children and will also be a fun exhibit at our annual Community Science Day.