2008-09

THIRTEENTH ANNUAL REPORT

WOOSTER PHYSICS

FORCE & MOTION APRIL 2009

OUTDOOR OUTREACH

SHREVE ELEMENTARY SCHOOL

The Physics Club Outreach was once again extremely popular. This past year, our Outreach team made 23 visits to local elementary schools. The brand new waves and optics demonstration was offered for the first time and covered how sound is produced, how it reaches the ears, and the Doppler effect. The light waves portion looked at reflection, refraction, and total internal reflection and related these phenomena to applications such as lenses, mirrors, telescopes, and microscopes.

GREETINGS FROM THE CHAIR

WOOSTER PHYSICS ALUMNI & FRIENDS:

I hope you enjoy this 13th annual report from The College of Wooster Physics Department.

This year, Wooster students and faculty co-authored a paper on one-way coupling that was reported as news stories in both Physical Review Focus and NATURE News. They also presented research at the March American Physical Society meeting in Pittsburgh, where they met numerous alumni and enjoyed the local cuisine.

Physics Club had a wonderful year with a record number of outreach presentations to local elementary schools, winning another Marsh White Award, and organizing the inaugural Wooster Science Day. In addition, last year's Physics Club was selected as a national Outstanding SPS chapter!

The department just completed its 16th consecutive NSF-REU summer program, which involved 11 students from four different institutions. Next year, we look forward to two one-year visitors, Brendan Miller and Deva O'Neil, as Susan Lehman assumes chair of the department, and I enjoy a one-year sabbatical at the University of Portland.

I thank Jackie, our administrative coordinator, for creating the best annual report ever. Alumni, please visit or write whenever you can!

JOHN LINDNER
CZAR OF PHYSICS

WWW3.WOOSTER.EDU/PHYSICS

Contents

Physics majors Evan Heidtmann and Frank King (at right) were selected to meet with then-Senator now-Vice President Joe Biden during his campaign visit to Wooster last fall.

The Class of 2009

Martha, Henry, Matt, Frank, Mike, Mark, Evan, Mary, and Averell

Martha Irene Roseberry
Kennewick WA
Plans: Work in Madison WI
Marry Ben Strecker '08 Fall 2009

Henry Robert Timmers
Midland MI
Plans: University of Arizona (Physics)

Matt Thomas Gorski
Double major with Philosophy
Germantown TN
Plans: Notre Dame
(Philosophy of Science)

Frank Walker King
Double major with Mathematics
Needham MA
Plans: Ohio State University (Physics)

Michael Vincent Zappitello
Conneaut OH
Plans: Finish degree requirements
Fall 2009

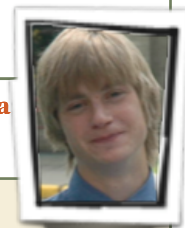
Mark David Zimmerman
Vandalia OH
Plans: The Ohio State University
(Physics Education)

Evan Zane Heidtmann
Double major with Mathematics
Portland OR
Plans: Pedal across the country

Mary Elizabeth Mills
Cincinnati OH
Plans: Miami University of Ohio
(Physics)

Averell Sydney Gatton
McLean VA
Plans: Solar cell researcher
Catholic Univ, Wash DC

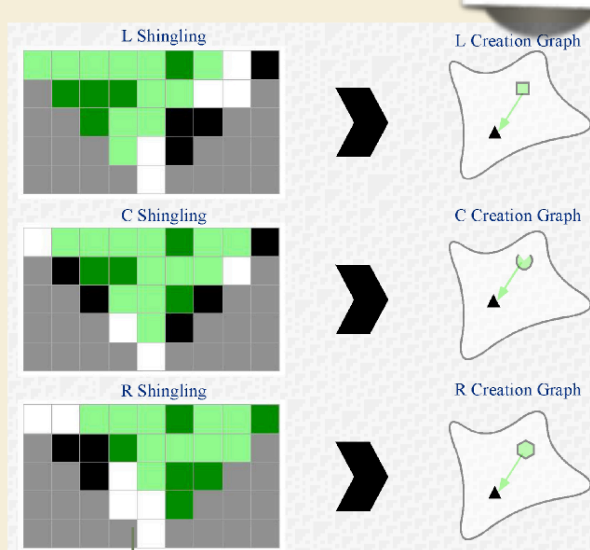
Senior Independent Study



The Brain vs. Rule 137: Using Spacetime Patterns to Classify the Complexity of Cellular Automata

by Averell Gatton **Advised by John Lindner**

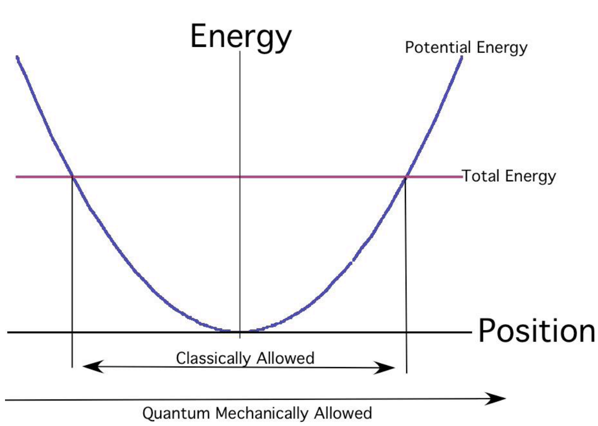
Cellular Automata (CA) are fundamental models of dynamical systems which can model all types of natural phenomena, perhaps even the fundamental laws of physics. CA are recursive algorithmic processes that operate in a discrete cellular array. We study the 88 elementary CA (ECA) defined by a two-state nearest-neighbor update rule. The 88 ECA display a wide variety of ordered and disordered, simple and complex evolutions. We define a metric that measures the complexity of each ECA. To construct this metric, we enumerate all possible shinglings of finite triangular spacetime patterns in past history cones of the 88 ECA. We then construct a graphical representation of the CA dynamics, with vertices representing the spacetime patterns and edges representing possible shinglings. We then adapt an algorithm from graph theory to search these graphs for closed walks that represent quiescent background patterns in the ECA evolution. We use the histogram of the frequencies of pattern occurrences in a sample evolution to seed the algorithm. This study defines the complexity, C , as the fraction of edges beginning on the vertices of the closed walks but not part of the closed walks themselves. C estimates the ability of the quiescent background to support non-trivial long lived structures in the evolution of the ECA. C is an estimation measure because the forecasting of CA evolution dynamics is undecidable for infinite evolution spaces. We speculate that our graph representation of pattern shingling is more fundamental than rule tables, and we apply this principle to a heuristic analysis of the repetitive structures of the cerebral cortex of the human brain.



The Consistent Histories Interpretation as a Solution to the Quantum Measurement Problem

by Matthew Gorski **Advised by John Lindner and Garret Thompson (Philosophy)**

This thesis considers the quantum measurement problem, the problem of representing definite measurement outcomes in the formalism of quantum mechanics. I evaluate the consistent histories interpretation as a solution to the problem, comparing its merits and deficiencies to those of the standard interpretation of quantum mechanics. The single-framework rule, a key principle of the consistent histories interpretation, is intertwined with the issue of whether the consistent histories interpretation solves the measurement problem. By arguing for a specific clarification of the rule, I show that the consistent histories interpretation does indeed solve the problem. The consistent histories interpretation is more rigorous and general than the standard interpretation. However, it provides a flawed metaphysical picture by treating measuring apparatuses as a fundamentally different type of entity than ordinary objects.



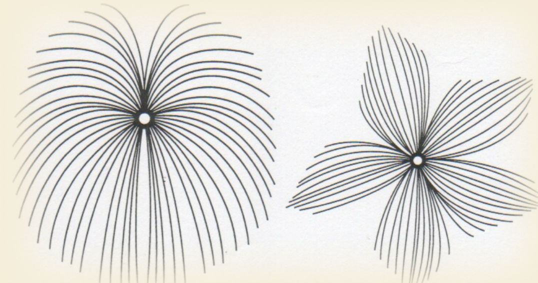
Quantum mechanical tunneling. Classically, a particle's potential energy cannot exceed its total energy. For this potential energy, therefore, it cannot be found outside a certain region. Quantum mechanically, the particle can "tunnel" outside the classically allowed region.

Senior Independent Study

A Differential Equations Model of Insulin Spherulite Growth and a Surprising Connection to Algebraic Topology

by Evan Heidtmann   Advised by Kristin Domike (Physics) and John Ramsay (Mathematics)

A certain type of aggregate of biological protein called a spherulite can occur naturally in humans under some disease conditions. This paper describes research on amyloid spherulites of bovine insulin protein as a model system for studying spherulite growth. Following a survey of the current state of knowledge in this subfield, a simple force-based computer model of spherulite growth is developed and analyzed for its agreement with experimental data. The Hairy Ball Theorem from algebraic topology is introduced, developed, proven, and applied to improve the understanding of the currently unexplained amorphous core that occurs in insulin spherulites. Promising avenues of future research are given for both the computer model and the implications of the mathematical theorem.



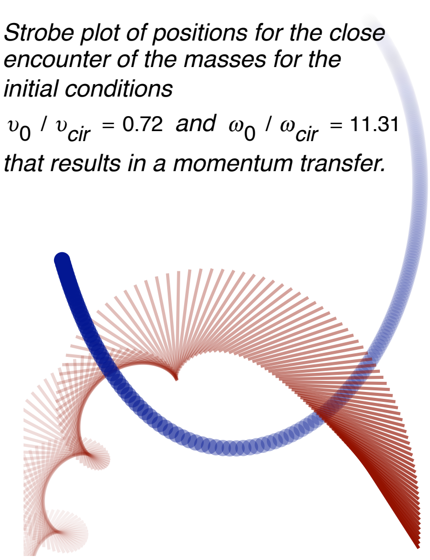
The hairy ball theorem implies that the hairs on a ball cannot be combed without producing any bald spots or tufts. Thus there must be at least one tuft as in left diagram. But if each fibril can fall on its own, it is much more likely that a configuration like that on the right will form. The regions of alignment might lead to birefringence, but it is not clear what might fill the space between the tufts.

/. by Frank King

Advised by John Lindner (Physics) and Derek Newland (Mathematics)

The planar /. body problem (pronounced "slash dot") is the gravitational interaction of a line mass (/) and a point mass (.). The force and torque on the line integrate exactly, facilitating analysis. The elongated asteroid Ida and its tiny moonlet Dactyl form a natural example. To study the /. body problem we used an advanced form of numeric integration called Symplectic Integration to take advantage of the symmetry of the positions and velocities in our equations. This also helped manage the numerical instability that we found in our equations. We prove that such an instability is not an essential feature of the equations of the system but a numerical artifact. We combine this sophisticated programming approach with cluster computing to collect large amounts of data on this system that exhibits a rich array of behavior. The /. body problem realizes the complexity of the 3-body problem with only 2 bodies. In parameter space, sequences of periodic orbits dot a background of chaotic orbits. We find known behaviors such as stabilization by gyroscopic motion and gravitationally stable orbits. Typically, the point and the line revolve (= orbit) in precessing ellipses, as expected for a perturbation of the classical 2-body problem. However, the line may also rotate (= spin) chaotically or periodically. Spin-orbit momentum transfer orbits can spin-up the line or unbind the point from the line, with applications in the statistics of asteroid rotation rates. Though our computation grid has collected a large amount of data which contains the various periodic and chaotic behaviors, it has searched but a small portion of the available parameter space. Our research has given us a glimpse into the complex behavior of this system, and, from this, we can see that the system is ripe for further investigation.

Strobe plot of positions for the close encounter of the masses for the initial conditions $\upsilon_0 / \upsilon_{cir} = 0.72$ and $\omega_0 / \omega_{cir} = 11.31$ that results in a momentum transfer.



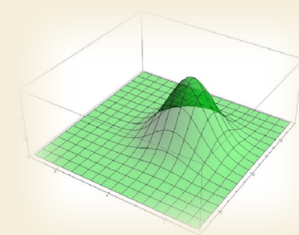
Senior Independent Study

Self-Organized Criticality and the Effects of Pseudo-Randomly Dropping Beads onto a Bead Pile

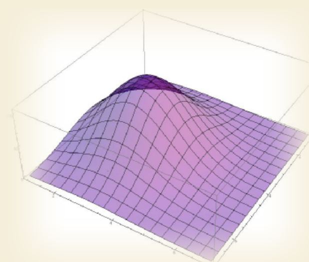
by Mary Elizabeth Mills **Advised by Donald Jacobs**

The effects of pseudo-randomly dropping beads onto a bead pile was investigated by modifying the 6 inch diameter randomizer used previously. The diameter of the randomizer was reduced twice, decreasing the area being dropped onto by a factor of 4 each time. This produced two randomizers with diameters of 3 inches and 1.5 inches. The 3 inch randomizer was used to take data at a drop height of 2 cm and 6 cm while the 1.5 inch randomizer was used to take data at 2 cm only. The probability of avalanches of a certain size was not described by a pure power law as the mean field theory predicts and thus two different functions were investigated to describe the data. The probability distributions of the data taken using the 3 inch randomizer were found to be best described

by a modified power law, developed from an energy dissipation theory, producing an exponent of $\tau = 1.45$. The 1.5 inch randomizer was not fit well by either the energy dissipation function or a stretched exponential as used previously. However, by plotting data from all three randomizer sizes as well as data taken when dropping on the apex, it appears the data will converge. As the diameter of the randomizer approaches zero, the data from dropping randomly over the pile will be equivalent to dropping on the apex.



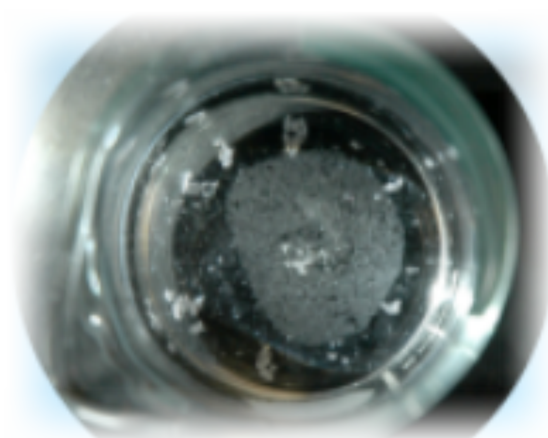
The distribution for the 1.5 inch randomizer is a Gaussian that is offset from the center slight.



The distribution for the 3 inch randomizer is also a Gaussian that is offset. Comparing it to the smaller randomizer, we see that the area being dropped over is larger for the larger randomizer.

Finicky Freezing: Investigations into the Causes of the Mpemba Effect

by Martha Roseberry **Advised by Susan Lehman**



Upon heating and freezing, the hard water solutes precipitated out of the water. Precipitates both sank (large clusters) and floated (blurry circle).

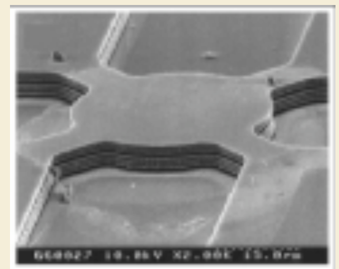
A study of the Mpemba effect, the phenomenon of initially hot water freezing faster than initially cold water was performed. Several types of water were frozen in beakers in a domestic freezer and the temperature of the samples was monitored using thermistors placed in the samples. Four thermistors were used to record the temperature of the samples throughout the cooling and freezing process, three at different places within the sample and one monitoring the temperature of the environment. When using nano-pure water, distilled water, and Wooster city tap water, no Mpemba effect was observed. However, data taken with a Millersburg water, a known hard water, demonstrated the Mpemba effect! Water with an initial temperature between 60 degrees C and 80 degrees C had a shorter freezing plateau than water with a higher initial temperature. These results support the theory that the Mpemba effect is caused by impurities within the water which hamper the freeze process. Heating the water removes some of these impurities from the water, causing the hot water to freeze faster.

Senior Independent Study

The Construction of a Continuous Wave Cavity Ringdown Spectrometer

by Henry Timmers   Advised by Susan Lehman

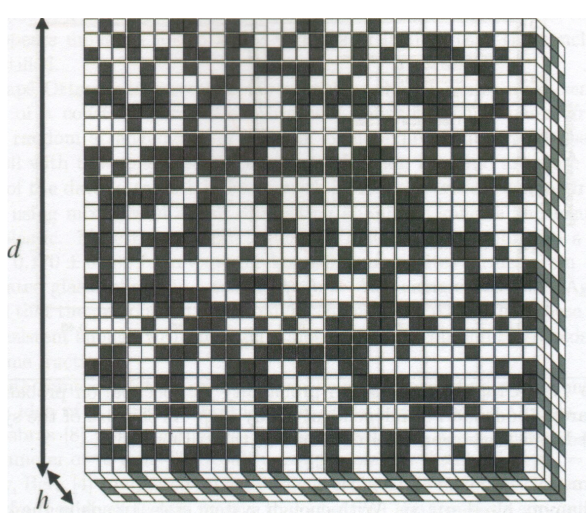
A continuous wave Cavity Ringdown Spectrometer has been constructed and implemented using two distinct designs. The first design injected infrared laser light into a half-symmetric spherical cavity using super mirrors to create the reflecting surfaces for the cavity. The curved super mirror of the cavity was dithered at a sinusoidal frequency much slower than the ringdown time, allowing the production of ringdown events as the cavity passed over resonant modes. From the decay constants of the ringdown events, a value of R = 0.9994 ± 0.0002 was measured for the reflectance of the cavity super mirrors. This first method produced low signals and inconsistent measurements for the ringdown decay constants, so a second set-up was constructed to incorporate optical feedback into the design. The second design injected light into the cavity using a pellicle beam splitter and dithered an extra-cavity mirror at a sinusoidal frequency much slower than the ringdown time, effectively changing the phase of the injected light. When the injected light moved in-phase with the ringdown cavity, the optical feedback of the system would increase by many orders of magnitude and interfere with the operation of the laser diode. This caused the laser diode light to lock to the ringdown cavity modes and build up to a maximum amplitude within the cavity. When this occurred, the laser was shut off using a system of electronics and the injected light was allowed to decay out of the cavity, producing ringdown events. The decay constants measured from this set-up produced a value of R_D = 0.9964 ± 0.0009 for the reflectance of the distributed Bragg Reflector. Once the optical feedback method of Cavity Ringdown Spectroscopy is fully optimized, the set-up can be used to accurately measure the reflectivity of semiconductor mirrors as well as the absorption of a sample of graphene.



Percolative and Conductive Properties of Spherical Mixtures

by Mark Zimmerman   Advised by Donald Jacobs

The electrical conduction of a cylinder filled with silver-coated glass spheres (d = 1.064 ±0.006 mm) and uncoated glass spheres (d = 1.00 ± 0.01 mm) was investigated using percolation concepts. At high fractions of silver-coated spheres, the system conducts electricity, but, at low fractions, the system is insulating. Between these two extremes, the behavior switches between insulating and conducting phases at a critical point called the percolation threshold; this study has located this critical point at a volume fraction of 0.21 ±0.02. Our value is consistent with those for similar systems reported in the literature. The impact of system size on the percolation threshold and also the conductance was investigated, and the height of the system was observed to have an effect. As the height of the system decreased, either the percolation threshold occurred at a lower volume fraction or the conductance increased more quickly. The normalized conductance was not observed to vary as the width of the cylinder was changed, but the overall conductance was observed to increase as the width increased. Finally, the conductance above the percolation threshold was observed to be consistent with a second order power law as expected from the literature, and the coefficient was found to be proportional to area/height.



Example lattice with dimensions d x d x h. Percolation occurs over the length h and across the area d^2.

Physics Majors Win Honors and Awards

Arthur H. Compton Prize in Physics
Matt Thomas Gorski
Martha Irene Roseberry
Henry Robert Timmers

Latin Honors
Summa cum laude
Matt Thomas Gorski
Henry Robert Timmers

Magna cum laude
Evan Zander Heidtmann
Martha Irene Roseberry

Cum laude
Mark David Zimmerman

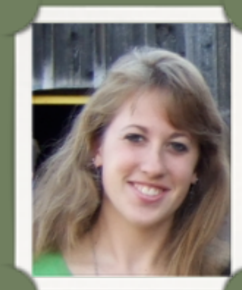
Departmental Honors
Matt Thomas Gorski (Physics & Philosophy)
Evan Zane Heidtmann (Mathematics)
Henry Robert Timmers
Martha Irene Roseberry
Mark David Zimmerman

Phi Beta Kappa
Matt Thomas Gorski
Evan Zane Heidtmann
Henry Robert Timmers
Martha Irene Roseberry

The John F. Miller Prize in Philosophy
Matt Thomas Gorski

The Ronald E. Hustwit Prize in Philosophy
Matt Thomas Gorski

The Helen Secrest Scholarship was established by the Women's Advisory Board and awarded annually to a young woman on the basis of scholarship and potential leadership.
Heather Jean Moore



The Albert Gordon McGaw Memorial Scholarship is administered by the Women's Advisory Board and awarded for general excellence.
Heather Jean Moore

The Harold G. and Helen F. Arnold Scholarship Fund is awarded annually to a young woman recommended by the Women's Advisory Board.
Heather Jean Moore

The Joseph Albertus Culler Prize in Physics is awarded to the first- or second-year student who has attained the highest rank in general college physics.
Roger Davies Klein

The Mahesh K. Garg Prize in Physics is awarded annually to an upperclass physics major who has displayed interest in applying physics beyond the classroom.
Frank Walker King
Henry Robert Timmers

Endowed Faculty Scholarship
Martha Irene Roseberry

The J. Howard Morris and Josephine L. Morris Volunteer Service Award for excellence in volunteer service through the Wooster Volunteer Network.
Evan Zane Heidtmann

The Theron L. Peterson & Dorothy R. Peterson Award for Outstanding Academic Achievement is awarded annually to a student majoring in biology, chemistry, physics, or mathematics and has earned the recognition as an outstanding scholar.
Evan Zane Heidtmann

Physics Faculty & Staff

Viewing "Up" in 3D

John Lindner

Professor and Chairperson

The Moore Professor of Astronomy

With student coauthors Kelly Patton '08, Pat Odenthal, James Gallagher, and University of Portland colleague Barbara Breen, Dr. Lindner reported the successful construction of the first one-way coupled mechanical array in the paper, "Experimental observation of soliton propagation and annihilation in a hydromechanical array of one-way coupled oscillators", which appeared in the December 2008 issue of *Physical Review E* and was the subject of news stories at *Physical Review Focus* and *Nature News*. With student coauthor John Gamble '08, he elucidated how the classical world of everyday experience emerges from the quantum world of microscopic phenomena in the paper, "Demystifying decoherence and the master equation of quantum Brownian motion", which appeared in the March 2009 issue of the *American Journal of Physics*. Dr. Lindner accompanied five physics majors to the March 2009 meeting of the American Physical Society in Pittsburgh where he coauthored a poster with senior Frank King and NSF-REU summer student Jacob Lynn on "Chaos and Order in the /. Body Problem". He gave invited talks at Ohio Wesleyan University and Ohio Northern University on the one-way coupled array. With the Physics Club, Dr. Lindner helped produce our inaugural Community Science Day and accepted two national Society of Physics Students awards.

http://focus.aps.org/story/v22/st21

http://www.nature.com/news/2009/090109/full/news.2009.3.html

Teaching

Fall 2008
- *Astronomy of Solar System*
- *Electricity & Magnetism*
- *Foundations Lab*

Spring 2009
- *Astronomy of Stars & Galaxies*
- *Electricity & Magnetism tutorial*
- *Foundations Lab*

- *Advised 3 Senior I.S. theses*
- *Physics Club Advisor*
- *NSF-REU Director*

Kristin Domike

Assistant Professor of Physics

Teaching

Fall 2008
- *Foundations of Physics*
- *Foundations Lab*
- *Mechanics*

Spring 2009
- *Foundations of Physics*
- *Thermal Physics*
- *Foundations Lab*

- *Advised 2 Senior I.S. theses*

Dr. Domike joined the Department as a full-time faculty member this year. She served as advisor to the College's Pre-Engineering program. Along with Eric Hardin (REU 2007 student from Slippery Rock University) and Douglas Armstead (former Wooster faculty member), she published a paper in the *European Physics Journal E* entitled "Investigating the inner structure of irregular β -lactoglobulin spherulites (Volume 29, p 173-182, 2009). Dr. Domike and her family have recently relocated to Prince Edward Island, Canada, where her husband Reuben has taken a position at the University of Prince Edward Island. We wish them all the best.

Shila Garg

William F. Harn Professor of Physics

Dr. Garg is now serving as the Interim Provost. The Provost is the Chief Academic Officer of the College.

Jackie Middleton

Administrative Coordinator

Jackie celebrated her twentieth year of employment at the College this past June. She especially likes the daily interaction with students and enjoys organizing the Physics Club award winning outreach program with local elementary schools.

Physics Faculty & Staff

Susan Lehman Clare Boothe Luce Assistant Professor of Physics

Dr. Lehman had a very active year. She served on the Vice President for Finance and Business Search Committee as well as the VPFB Transition Committee. She attended the 2009 March Meeting of the American Physical Society where her 2008 REU student Ingrid Thvedt '11 presented their research into the Mpemba effect. She attended a workshop "CUR Dialogues and the Art of Grantsmanship" sponsored by the Council on Undergraduate Research where she served as a panelist for a discussion of how to integrate faculty research with undergraduates into the faculty workload. Dr. Lehman continues to do research with cavity ring-down spectroscopy with a new design for the optical resonating cavity and also continues to investigate quantum dots with scanning probe microscopy. She recently purchased a new module to add to the SPM to allow a different type of conductivity measurement. She presented "Measurement of Ultra High Reflectivities of Distributed Bragg Reflectors Using a Resonating Optical Cavity" at the Air Force Research Labs at Wright-Patterson Air Force Base in Dayton, OH. Outreach activities remain an important item on Dr. Lehman's calendar. She served as the leader of a workshop on "The Humpty Dumpty Experiment" for Expanding Your Horizons, a math and science program for 6th grade girls. She also coordinated the physics program for the Buckeye Women in Science, Engineering and Research (BWISER) summer institute for 7th grade girls. Dr. Lehman has been promoted to Associate Professor and will begin her "reign" as department chair this fall.

Teaching

Fall 2008
- *Modern Physics*
- *Modern Physics Lab*
- *Electronics for Scientists*
- *Electronics Lab*

Spring 2009
- *Modern Optics*
- *Junior Independent Study*

- *Advised 2 Senior I.S. theses*
- *Financial Advisory Committee*
- *Admissions Liaison*

Donald Jacobs Victor J. Andrew Professor of Physics

Teaching

Fall 2008
- *First Year Seminar*
- *General Physics*
- *General Physics Labs*

Spring 2009
- *General Physics*
- *General Physics Lab*
- *Math Methods*

- *Advised 2 Senior I.S. theses*
- *Teaching Staff & Tenure Com.*
- *HHMI Steering Committee*

This past fall, Dr. Jacobs taught a First Year Seminar course on complexity, chaos, and networks. He began a multiyear Research Corporation grant "Cylindrical micelles from block copolymers: Self-assembly as an indirect model for biological systems". He is Co-PI on a SANS beamtime grant from NIST "Small Angle Neutron Scattering Study of Micellar Transitions in Pluronics 17R4". Dr. Jacobs accompanied five physics majors to the March 2009 meeting of the American Physical Society in Pittsburgh where he coauthored a poster with senior Mark Zimmerman and another with REU 2008 student Michael Winters '10. He also attended the 17th Symposium on Thermophysical Properties in Boulder CO . He was one of three new research teams that involved incoming First Year (SEER) students in summer research. Funded by Howard Hughes Medical Institute and guided by Dr. Jacobs and Heather Moore '10, two SEER (Summer Early Engaged Research) students participated in percolation experiments.

Manon Grugel-Watson Lab Technician and Instructor

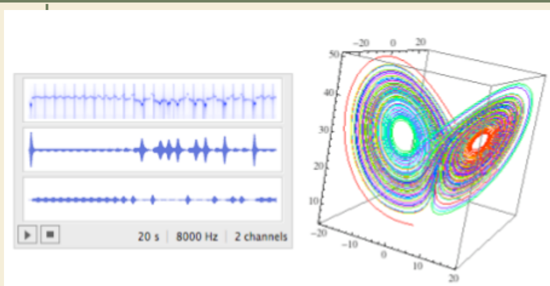
Manon completed her second full year as the Department's laboratory technician, and she also took on the additional title of lab instructor when she taught sections of General Physics and Foundations labs in the spring semester.

Junior Independent Study

Musical Mapping of Chaotic Attractors

by R. Michael Winters

The representation of physical phenomenon is overwhelmingly visual. Although this has many uses and serves as a sufficient if not near perfect means of representation, it only acknowledges one of our senses. Musical representation offers a refreshing alternative. Time varying aural effects are equally well if not better suited for the representation of some physical systems. Chaotic attractors provide an interesting point of comparison. In this experiment, *Mathematica's* "Play" function was used to generate music of time-varying frequency, amplitude, and origin using the governing equations of the Lorenz, Rossler, and Chua attractors. Despite conservative use of aural effects, not only were different attractors easily identifiable aurally, changes in the attractors' parameters could also be identified. The musical samples generated provide a experience of these attractors unlike any visual representation.

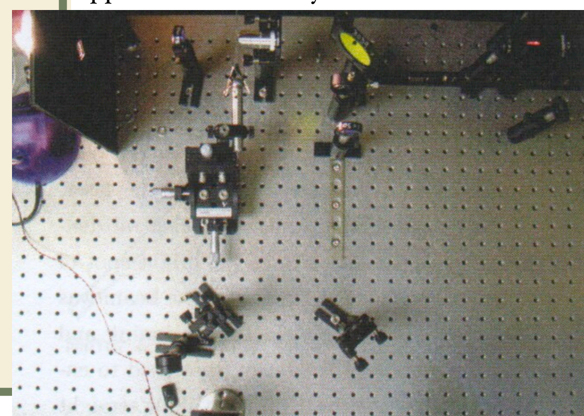


The output display of the Lorenz attractor using the Play function and corresponding 3-d plot with parameters: σ = 10, b = 8/3 and r = 30.

Optical Tweezers for the Undergraduate Laboratory

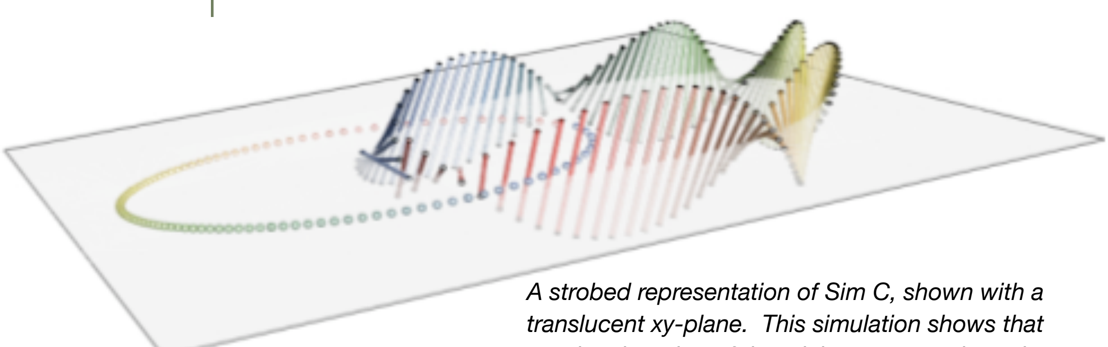
by Heather Moore

Optical trapping of 1.5 μm polystyrene beads suspended in a phosphate buffered saline solution has been attained with a simple set-up. Trapping strength was determined to be 2.5 ± 1.5 pN, with the trapping occurring not much deeper than the coverslip. This project looked at the process of creating, aligning, and calibrating an optical tweezing setup in an undergraduate program and gave examples of ideas for application of the optical tweezers in an upper-introductory or upper-level laboratory.



/. 3D by Corwin Atwood-Stone

A simulation of the mutual orbital motion of a point and a stick of equal masses in three dimensions, described as the 3D /.-body problem, is presented herein. This simulation uses forces and torques arrived at by exact integration over the length of the stick to produce equations of motion which describe both the orbits of the point and the stick as well as the independent revolution of the stick. Angular momentum and total energy are calculated for the simulation and their conservation is used as a check to insure that the system produces physically plausible results. Several simple cases of the system were tested to make sure they act as expected. More complex simulations were tested to examine facets of of the 3D /.-body problem such as the transfer of angular momentum between the orbital and rotational motion. Simulations were also created to examine how the different initial spin velocities, ω_ϕ and ω_θ , interact to affect the evolution of the system.

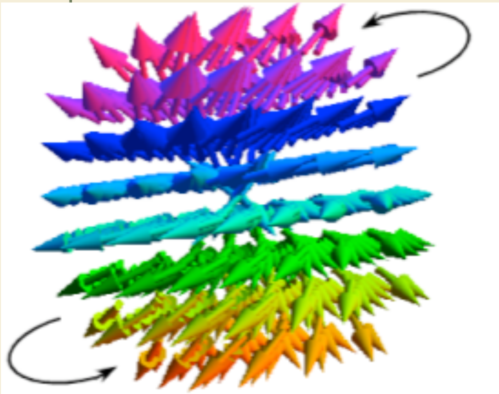


A strobed representation of Sim C, shown with a translucent xy-plane. This simulation shows that rotational motion of the stick can cause the point to move above and below the plane.

Junior Independent Study

Indirectly Exploring the Inner Structure of Spherulites **by Ingrid Thvedt**

A variety of diseases are caused by the misfolding of proteins into amyloid fibrils and their secondary structures. One such structure is the spherulite. Spherulites have been found in many diseased organisms and are thought to be a cause of such diseases. Spherulites exhibit birefringence and create useful images when viewed between crossed polarizers. These images change according to the inner structure of the spherulite. To better understand these inner structures, several types of possible spherulites were modeled in 3 dimensions using *Mathematica*. The images these various models would create when viewed between crossed polarizers were constructed in order to be compared to experiment. Various challenges with the way polarization was simulated led to images that were not necessarily useful for this comparison. More work needs to be done to more realistically model the way light interacts with spherulites in 3 dimensions.

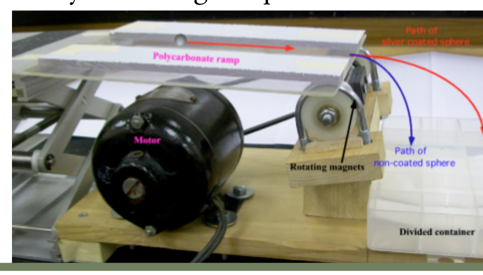


Spherulite with Opposite Curls on Top and Bottom

Separation of Glass Spheres from Silver Coated Glass Spheres

by James R. Daniels

In past experiments on electric percolation, mixtures of small glass spheres and silver coated glass spheres have been created. To be able to reuse these spheres in further experiments an efficient method for separating the spheres is needed. This experiment explores the option of utilizing eddy current separation to separate the spheres. The possibility of scaling down an eddy current separator like those used in the processing of scrap metal seems promising but results are inconclusive at this point. A rotating magnetic drum creates a rapidly changing magnetic field that induces eddy currents in the thin silver coating. These eddy currents create a magnetic moment apposing the applied magnetic field that results in the particles being accelerated off the end of the separator where they can be collected separately from the glass spheres.



Connecting Insulin Fibrils to Spherulite Growth

by Alison Huff

Previous research conducted on fibrils and spherulites has investigated mechanical and growth properties separately, where similarities between the two protein aggregates arose. Data from these earlier works were extrapolated in order to start creating a bridge between the gap between fibrils and spherulites. Equations from fibril mechanics research regarding breaking rigidity property were used with experimental data from insulin spherulite fibril growth. When the breaking rigidity was graphed against the mean lengths fro these individual fibrils, the best fit curve was a line with the equation:

$$C_B = \left[(3 \pm 3)\times 10^{-25}\,\mathrm{Nm}^2\right] - \left[(0+2)\times 10^{-20}\,\mathrm{Nm}\right]L.$$

This slope is extremely close to zero, indicating that almost no change occurs in the breaking rigidity, regardless of the length of the fibril. This was the expected result for this fibril mechanical property, but had a 50% error from the expected value of

$$(1.7 \pm 1.2)\times 10^{-25}\,\mathrm{Nm}^2.$$

Another Nobel Prize-Wooster Connection!

It turns out that Arthur Compton's Nobel Prize is not the only one with a Wooster connection. Yoichiro Nambu of the University of Chicago's Enrico Fermi Institute, who recently won the Nobel Prize in Physics for the discovery of the mechanism of spontaneous broken symmetry in subatomic physics, was the Ph.D. advisor for the father of current Wooster physics senior Alison Huff. Robert Huff, a double major in physics and mathematics, graduated from The College of Wooster in 1955 and went on to earn his Ph.D. from the University of Chicago in 1961. He worked with Dr. Nambu on his thesis entitled *Decay Rate of Bound Muons*.

As a graduate student, Huff attended a lecture by Robert Schrieffer at the University of Chicago on the theory of superconductivity. Yoichiro Nambu was also in attendance and noticed that the symmetry of electrodynamics did not hold for Schrieffer's superconductivity model. This observation ultimately led to Dr. Nambu's conclusion that superconducting ground states result from the spontaneous breaking of underlying gauge symmetry. Dr. Huff recalls that "I, on the other hand, was lost after the first 15 minutes" of Dr. Schrieffer's lecture.

Physics Club

2008-2009 Officers

President Heather Moore ’10

Vice President Henry Timmers ’09

Treasurer Frank King ’09

Secretary Mary Mills ’09

2008-2009 Events

9 Aug 2008: Scot Spirit Day
11 Sept 2008: Luce Dinner
24 Sept 2008: General Meeting
30 Sept 2008: Summer Research Symposium
6-8 Nov 2008: ΣΠΣ Quadrennial Congress at Fermilab
22 Nov 2008: COSI Columbus
22 Nov 2008: Senior I.S. Presentations
28 Jan 2009: General Meeting
28 Jan 2009: Physics Club wins a 2009 Marsh White Award!
4 Feb 2009: Physics Club selected as a 2008 Outstanding SPS Chapter!
25 Feb 2009: General Meeting
1 April 2009: Science Day Prep Meeting
4 April 2009: Science Day was a big success!
19 April 2009: Taylor Bowl 20
2 May 2009: Ethiopian dinner in Cleveland

SPS Quadrennial Congress at Fermilab

In November, ten Physics Club members attended the SPS Quadrennial Congress held at Fermilab, one of whom (Mary Mills ’09) presented a poster about the Science Outreach Catalyst Kit. The conference had a turnout of over 500 students from across the country. Students listened to talks on topics ranging from outreach to politics and then broke up into groups to discuss the issues addressed by speakers. Later, conclusions from each discussion group were summarized to be voted upon in order to create a set of new recommendations for SPS at the national level. During the first evening, several universities and organizations provided booths which allowed students to learn about future possibilities associated with physics. Students were able to tour the accelerator and various other facilities at Fermilab. The dinners, held in a local hotel where all of the students stayed, were comprised of talks by guest speakers. During the last dinner, Leon Lederman, a Physics Nobel Laureate and Director Emeritus of Fermilab, spoke and provided comedy to the audience with his “modern technology” - a projector and transparencies. All in all, we were extremely satisfied with the outcome of the Congress.

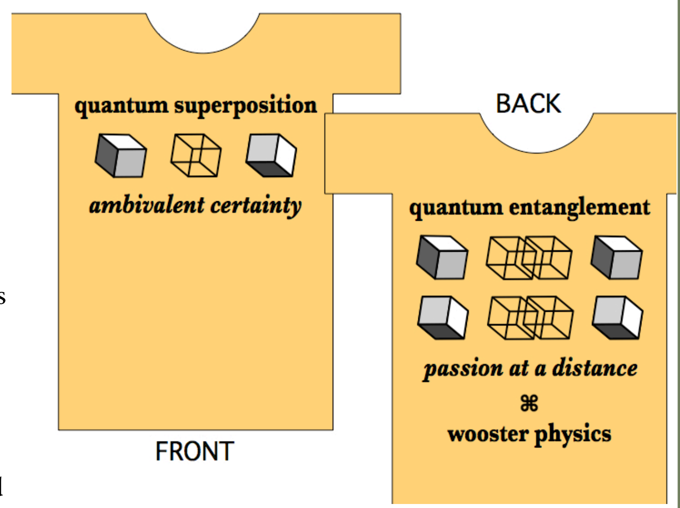
Taylor Bowl XX

Physics 108.8
Math/CS 100.7

After a four-year drought, the Physics Club finally won back the giant slide rule trophy in the twentieth annual Physics versus Math/CS Taylor Bowl. Prior to the event, the Physics Club issued the traditional “challenge” by filling Math Club advisor Dr. Newland’s office with hundreds of balloons, one of which contained a scroll declaring the official summons. Winning Taylor Bowl proved to be less difficult than getting all those balloons into the Taylor Hall elevator!

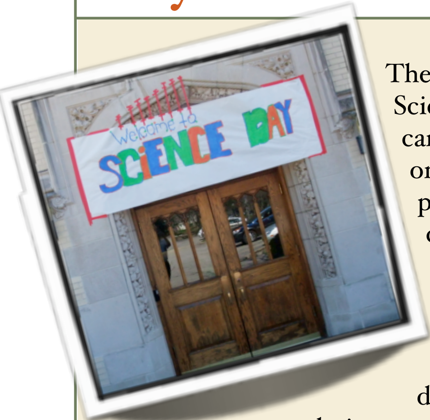
Physics T-shirt

This year’s T-shirt design is the quantum entanglement of photons represented by the illusion of the box. If you look at the center box you see it oscillating between the two solid boxes that surround it. The solid boxes represent the possible measurements that could be taken. Likewise, the back represents two entangled photons that are in both states. The solid boxes again represent the possible measurements that could be taken. The entangled photons will always be measured to be in the same state!



Community Science Day

by Heather Moore '10 & Henry Timmers '09



The idea for Science Day came about one physics club meeting while officers were discussing a desire to expand our current outreach program that targeted elementary school children to a program that incorporated the local and campus community. We were excited about the full extent of our outreach demonstrations, ranging from basic physics topics such as Newton's Laws to more advanced physics topics such as the inner workings of an electric motor, and wanted to reach out to a larger audience. In addition, we felt that science education in the classroom should be supplemented by activities outside of the classroom and supported by the entire family. From these goals, the Wooster Physics Club decided to host an open house for the entire Wooster community, welcoming families and college students alike to experience the phenomenon of physics! As planning progressed we felt that it would be an added bonus if we could showcase ALL the science being performed on campus, in addition to physics. We extended an invitation to all the other science clubs to participate in our open house. Upon receiving an overwhelmingly positive response from the other clubs, Wooster's first annual Science Day was born.

Science Day took over the entire physics wing of Taylor Hall at The College of Wooster and included a grand total of eleven stations, representing six different fields of science. Excitement was in the air the morning of April 4 as troops began to assemble their different outreach setups. Touch tanks were being filled in the Biology room, rocks were put under ultraviolet light in the Geology room, methane lines were being checked in the BMB room, brains were being set on display at the Neuroscience station, and tanks of liquid nitrogen were being distributed to the Physics and Chemistry rooms. As the caterers put out enough food for 200 people, we looked at each other apprehensively, still unsure about what kind of response Science Day would elicit. At about 12:50 PM the hoards of masses started filing into Taylor Hall and Science Day was underway without a backwards glance.

The first stop on Science Day was Waves and Optics. Here, visitors

could participate in a 25-minute interactive presentation, learning about the wave nature of light and sound. Continuing down the hallway, visitors reached the Polarization station where they could apply many of the optics concepts to understand how polarized sunglasses work and why corn syrup displays a spectrum of color when viewed through crossed

polarizers. Across the way mad scientists were giving an electrifying demonstration on electricity and magnetism, building up knowledge to explain the physics behind their exciting finale of the electromagnetic ring launcher. Taking a break from physics, visitors found themselves in the

Biochemistry and Molecular Biology room where they were able to hold flaming methane bubbles, find out how florescence is used to solve crime scenes, and extract DNA from a banana. Walking out the back door of the BMB demonstration, visitors found themselves immersed in an exploration of biological life. The Biology demonstration allowed visitors to touch live sea animals and view cellular life through a microscope. The Geology Club wowed visitors with a large-scale erupting papier-mâché volcano, and

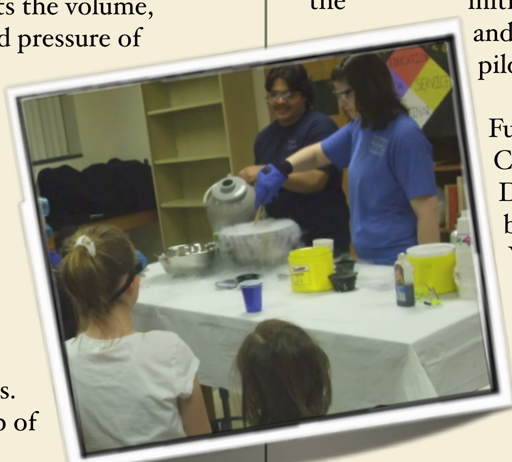
then continued to impress them with an extensive collection of rocks and fossils. Next door, jumping back into physics, was a demonstration of fundamental forces and how they

Physics Club

affect motion. Here visitors learned about Newton's Laws, gravity, and the conservation of the angular momentum in a gyroscopic bike wheel.

After grabbing a healthy snack (and a few desserts) from our catering station visitors walked downstairs to find the second round of demonstrations. As they rounded the corner they found themselves face to face with real sheep, rat and mice brains! The Neuroscience club used these models to explain the workings

of a human brain and the phenomena behind optical illusions. After learning about the basis for vision, visitors entered a room devoted to atomic spectra where they used diffraction gratings to study the spectra of florescent filaments of various elements. Visitors were then challenged to match the spectrum emitted from a glowing pickle to one of the displayed elements. Next door at the air pressure demonstration, visitors learned how the motion of air molecules affects the volume, temperature and pressure of gasses. With the help of a bell jar and some liquid nitrogen, the concepts were conveyed with shattered roses, exploding film canisters, and popped balloons. At the final stop of Science Day,



visitors were able to sample ice cream made from liquid nitrogen by the Chemistry club, and make their own flubber bouncy ball.

As the clock struck four we looked at the empty tables of snacks and beverages and declared Science Day a huge success. All the estimated 200 children, families, and college students expressed an overwhelmingly enthusiastic response to the entire event. We were especially thrilled to see that children as young as three years old were able to gain something from the experience. If we can spark an interest in science at that young age, then we feel like we have

succeeded in our mission for Science Day. We plan to continue to expose the Wooster community to the joy of inquiry by making Science Day an annual tradition where we will take the initiative to expand and improve upon this pilot event.

Funding for Community Science Day was provided by a 2009 Marsh White Award from the AIP's Society of Physics Students and by The College of Wooster's Campus Council.

The College of Wooster Physics Club 2008 Outstanding Chapter Award

Society of Physics Students
A Universe of Wonder

SPS Outstanding Chapters, selected by Zone Councilors and Associate Zone Councilors, are determined by carefully reviewing the information, photos and supporting material presented in the annual Chapter Reports.

COSI Trip

The Physics Club headed off campus to Columbus, Ohio to see and experience the Center of Science and Industry (COSI). There are many very popular exhibits among Wooster physicists, but the two favorites are far and away the high-wire unicycle and the gadgets exhibit. The members of the club had a great time learning about many new applications in other science fields. Many of us were especially impressed with current gene therapy and DNA research. After an afternoon touring exhibits, the Club took respite in the Imax theatre for a showing of *The Alps - Movie*. We all watched in amazement as one man fulfilled his life long dream of climbing the north face of the Eiger. A day of science can make anyone hungry, so before heading home, the Physics Club stopped at the Spaghetti Warehouse for dinner.

Summer Research

The Physics Department's National Science Foundation Research Experience for Undergraduates continued in full force this past summer as it completed its 16th year. Four Wooster students and four students from other colleges spent 10 weeks actively engaged in research with their faculty mentors. Also, Alison Huff '10 spent the summer studying micelles funded by Don Jacobs' grant from the Research Corporation. Heather Moore '10 served as a Summer Early Engaged Research (SEER) mentor, which is an opportunity for an experienced research student to mentor two incoming first year students in the research laboratory. In addition to participating in the Department's standard ten-week research period, Heather mentored incoming first year students for four of those ten weeks. The Department was very fortunate to have two very ambitious and creative SEER students: Tyler Rhoades from Guys Mills PA and Lorenzo Dumancas from Wellington FL. Professor Sarah Schmidtke of Wooster's Chemistry Department also joined our program this summer as a research advisor.

Projects

Examining 17R4 in Water: Refractive Indices and DLS
Alison Huff, CoW '10

Validating Old Wives' Tales: The Mpemba Effect
Erin Ford, Kenyon College '11

/. (slash-dot)
Amanda Logue, CoW '11

Computational and Experimental One-way Coupling
Katsuo Maxted, CoW '12

Self-organized Criticality: Energy Dissipation vs Ballistic Model and Coefficients of Friction
Larry Markley, CoW '12

Electrical Percolation Through One-Millimeter Insulating and Conducting Spheres
Heather Moore, CoW '10

Warp Drive, Time Machines and the Einstein Tensor
Conrad Moore, Bucknell University '10

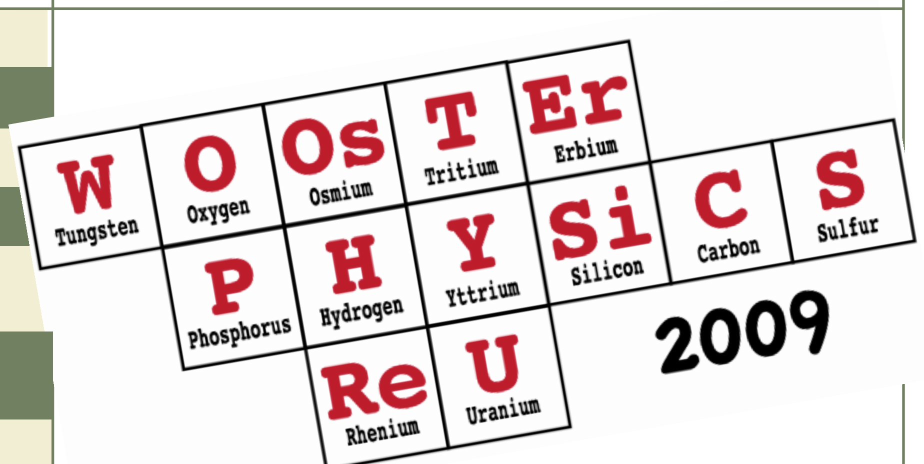
Escape from the 3 and 4-body Problems
Margaret Raabe, CoW '10

Cp of Poly(Propylene Oxide)-Poly(Ethylene Oxide)-Poly(Propylene Oxide) Triblock Copolymer in H2O
David Simpson, CoW '12

Structural and Environmental Effects on Intramolecular Charge Transfer in 4-Aminobenzoic Acid and Derivatives
Mitchell Thayer, Ohio Northern '12

The Construction of a Continuous-Wave Cavity Ringdown Spectrometer
Henry Timmers, CoW '09

Summer Research T-Shirt



John Lindner created this design for the first ever Department of Physics Summer Research T-shirt. Note that even the word "chemistry" cannot be spelled out with the periodic table symbols. Oh, the irony!

Corey Atwood-Stone '10 spent the summer at Purdue's Rare Isotope Measurement Laboratory (PRIME) studying the composition of primitive meteorites.

American Physical Society Meeting

Presentations

Mark D. Zimmerman*† and D.T. Jacobs, Percolation in Granular Material: Conduction through Silver/Glass/Air Mixtures

Mike Winters*† and D.T. Jacobs, Self-Organized Criticality: Bead Pile Dynamics Across Bead Types

Ingrid Thvedt*†, Martha Roseberry* and Susan Lehman, Investigation into the Mpemba Effect: Variation in the Freezing Time of Water Dependent on Initial Temperature and Purity

Patrick Odenthal†, John F. Lindner, Kelly M. Patton*, James C. Gallagher† and Barbara J. Breen, Experimental observation of soliton propagation and annihilation in a hydromechanical array of one-way coupled oscillators

Jacob Lynn†, Frank W. King* and John F. Lindner, Chaos & Order in the /.- Body Problem

*undergraduate co-author
†NSF-REU student

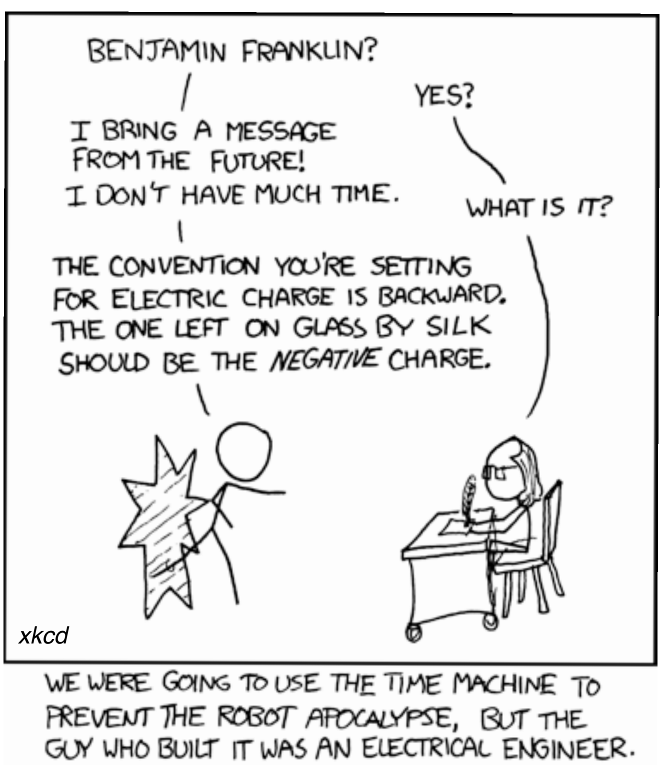
Mark Zimmerman '09 poses with his poster on percolation as Mike Winters '10 describes his SOC research to Doug Armstead, former Wooster physics faculty member.

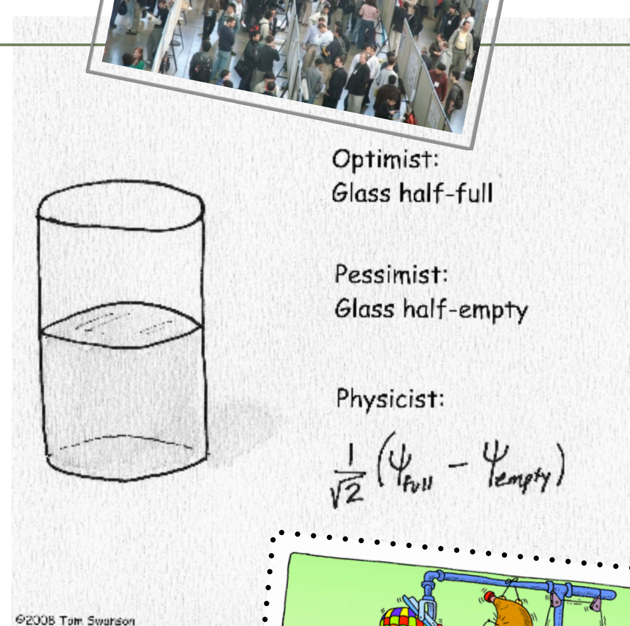
Pittsburgh, PA March 2009

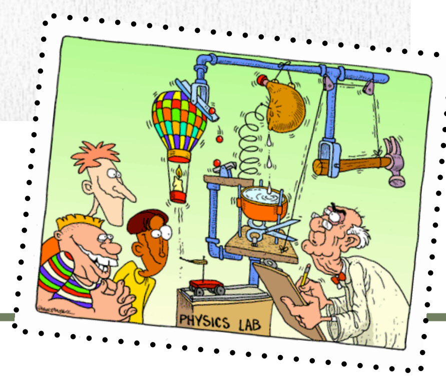
Susan Lehman, John Lindner, and Don Jacobs accompanied five students to the National Meeting of the American Physical Society in Pittsburgh. Wooster alums Kathy McCreary '06 (now at UC Riverside), Austin Carter '05 and Nick Harmon '04 (both now at Ohio State) were also in attendance and joined the Wooster contingent for several events.

Ingrid Thvedt '11 is hard to find in this massive group of physicists.

Phun Physics







Alumni Spotlight

Bryan Johnson '89

Bryan had been working at the Alaska Permanent Fund trading floor but recently switched to teaching at the University of Alaska Juneau. He says "the university here has an incredible view of Mendenhall glacier with a lake between the school and the glacier where students practice their kayaking in the summer/cross country skiing in winter." Bryan maintains his interest in music (see: http://www.juneauempire.com/stories/111008/loc_354328401.shtmlTeaches and also has a music tutoring business.

Diglio Simoni '89

Diglio is a High Performance Computing scientist in the Bioinformatics Program at RTI International. He recently received a Ph.D. in Computer and Information Science and Engineering from Syracuse University.

Clinton Braganza '03

Clinton has earned a PhD in Chemical Physics from Kent State University's Liquid Crystal Institute. His dissertation was titled "High dielectric constant mixtures containing liquid crystals". Clinton is a senior scientist at Kent Displays Inc. in Kent OH.

Nithya Venkataraman '04

Nithya just completed her Masters degree in Chemical Physics at Kent State University. Asad Khan '93 served as one of her thesis advisors. Nithya continues to work at Kent Displays Inc.

Zakir Thaver '01

For the past several years, Zakir has been involved with the production of science programs for science-deprived regions such as Pakistan. His main work has been a documentary film on the scientist and humanist Abdus Salam, who received the Nobel Prize in 1979 for unifying two of the four fundamental forces of nature. You can learn more about Salam and Zakir's docufilm at: www.kailoola.com/abdussalamdocufilm.

Dave Merriman '04

Dave and wife Jackie welcomed daughter Keiran Siobhan on Oct 26, 2008.

David Kaiser '80

David, who received an MBA in 1987 from Rochester Institute of Technology, is co-founding partner and vice president of Schedule Associates International, a firm that helps organizations get projects done on time and budget by providing training, consulting and curriculum development on project management and the use of Microsoft Project. He lives in Rochester NY.

Priyavadan Mamidipudi '95

After Wooster, Pri went to University of South Florida (Tampa) where he earned a Masters and PhD in Applied Physics (specializing in laser radar systems). Pri lives in the northern Virginia area and works in the Washington DC Metro Area as Chief Scientist for Optical Air Data Systems, where he designs Lidar sensors for military, aviation, and wind energy applications.

Khalid Sherdil '91

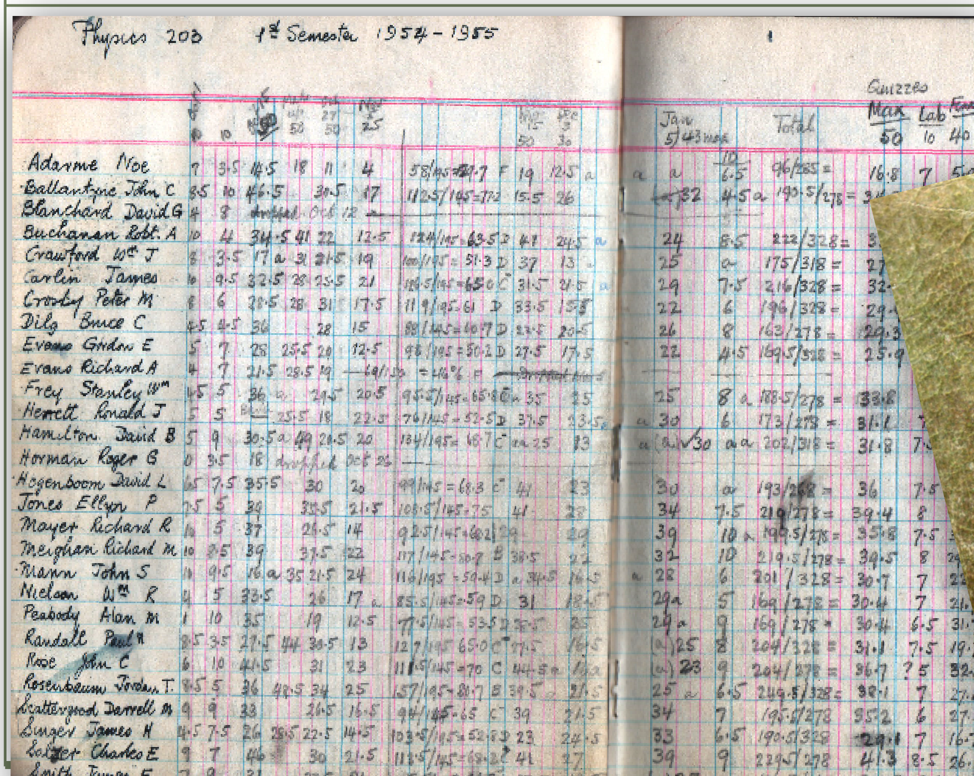
Khalid works with RBS in New York while pursuing a PhD in Computer Science & Environmental Science at University of Western Ontario.

Steve "Grey" Stafford '88

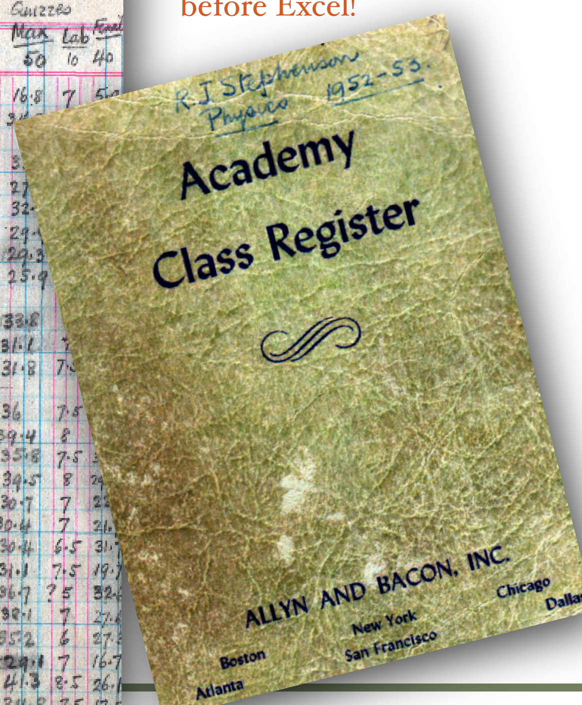
Grey and his book "ZOOmility" were recently featured on NBC's *The Tonight Show with Jay Leno*. Visit www.ireinforce.com/about.shtml to find out more about Grey's method of training animals with positive reinforcement.

A Bit of History

A page from the grade book of Reginald J. Stephenson, early 1950s



So *that's* what they used before Excel!



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[WWW3.WOOSTER.EDU/PHYSICS/ALUMNI]

CLICK ON ALUMNI UPDATE FORM OR EMAIL:

JMIDDLETON@WOOSTER.EDU

SLEHMAN@WOOSTER.EDU

Our website has moved!

The College of Wooster has launched its beautiful, newly designed web site at www.wooster.edu, but for the time being, the Department of Physics will continue to maintain its "old" site at

WWW3.WOOSTER.EDU/PHYSICS

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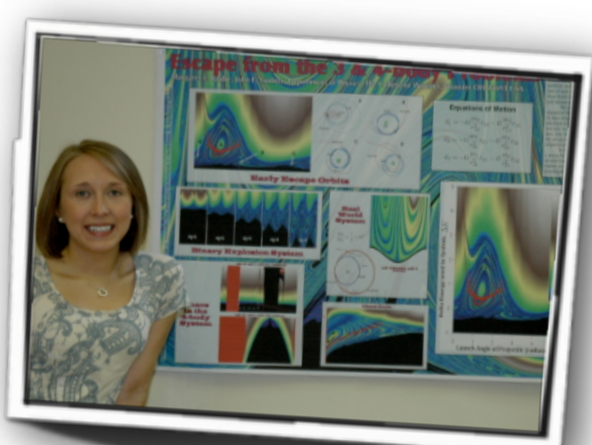

TO:
WOOSTER PHYSICS ALUMNI & FRIENDS