Annual Report
2005-2006

THE COLLEGE OF
WOOSTER

Department of Physics

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Jeremy Hohertz '06
gyrates at Scot Spirit Day

Stephen Poprocki '07
finds out what happens
when you fall asleep
in the student reading
room.

http://www.wooster.edu/physics/Alumni/

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THE COLLEGE OF WOOSTER

Tenth Annual Report
September 2006

Produced by Jackie S. Middleton

On the front cover:
Martha Roseberry '09 and Danny Tremblay '07
use Nathan Utt's '07 good nature during an Outreach demo on Newton's Laws.

On the back cover:
Top: Physics majors and friends pose at 4:00 a.m. in Taylor Hall after "ballooning" Jackie's and Judy's offices.
Bottom: Andrew Kindschuch '06 made sure he stood out at the Senior I.S. parade
by wearing horizontal stripes.

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From: **John Lindner, Chair**

CC: **College of Wooster Community**

To: **Alumni and Friends**

BC:

Subject: **Greetings from the Chair**

Wooster Physics Veterans & Friends:

Welcome to the Tenth Annual Report from The College of Wooster Department of Physics. The 2005-2006 academic year and the summer of 2006 have been exciting and eventful.

I returned from a productive Georgia Tech sabbatical, resumed my duties as Department Chair, and (again) completely redesigned the Physics Web site. After three years at Wooster, Lowell Boone accepted a tenure-track position at the University of Evansville in Indiania. He will be missed! Next year, 2006-2007, Lowell will be replaced by Todd McAlpine, who has a Ph.D. from University of Kansas and is a specialist in semiconductor lasers. Also next year, Susan Lehman and Don Jacobs will take successive one semester research leaves. They will be replaced by Doug Armstead, who has a Ph.D. from the University of Maryland at College Park and is a specialist in nonlinear dynamics. Shila Garg has accepted a second term as Dean of the Faculty, but she remains active in physics, advising one of our seniors in the coming year.

Our thirteenth consecutive summer REU program was very successful, with eight students from four different institutions participating, Our summer research program, funded by NSF and REU, has now attracted over one hundred students from 33 colleges or universities in 17 states. In addition, our majors performed summer research at Purdue, Michigan State, University of Akron, University of Madison-Wisconsin, Penn State, UC San Diego, Caltech, University of Alaska Fairbanks, and The Joseph Fourier University in Grenoble, France!

The fifth year of our Physics Club's outreach program was also fun and successful, and it has now performed 38 presentations to local elementary school children.

Congratulations to physics majors Stephen Poprocki for winning a Goldwater Scholarship and to Danny Shai for being awarded a Goldwater honorable mention. Thus, four of our recent physics majors are recipients of 1996, 1998, 2002, & 2006 Goldwater Scholarships, the premier undergraduate awards of their type in the fields of mathematics, science and engineering.

Our majors were well represented at the March meeting of the American Physical Society in Baltimore. The weather was great, and we enjoyed lunch by the harbor and talks by recent physics Nobel prize winners.

While Kauke Hall received an 18 million dollor renovation this last year, physics received 10 thousand dollar new carpet for our offices and lectures halls -- for which we are very grateful, 20 years after the renovation of Taylor Hall.

Judy celebrated her 25th anniversary at Wooster and continues to do a marvelous job keeping our labs and many other aspects of the department and Taylor Hall running. Jackie was promoted to Administrative Coordinator and, with this volume, celebrates the production of her tenth annual physics report.

Please email us or visit if you're in the area -- we love to hear how you are doing!

John Lindner
Czar of Physics

Faculty & Staff

John Lindner
Professor and Chair

B.S. Vermont 1982, Ph.D. California Institute of Technology 1988;
at Wooster since 1988.

Courses taught:

Fall 2005
Physics 122: Astronomy of the Solar System
Physics 205: Modern Physics
Physics 205L: Modern Physics Lab
Physics 204L: Foundations of Physics Lab

Spring 2006
Physics 121: Astronomy of Stars and Galaxies
Physics 320: Astrophysics (Cosmology)

- Advised one senior independent study project (Katherine Olaksen) and two junior self-designed I.S. projects (Stephen Poprocki and Sarah Suddendorf)

- Areas of current focus and projects in progress:
  Stochastic resonance in hair cells and arrays; coupling-induced spatiotemporal patterns; chaos in the restricted 3-body problem and the 2-body problem on a sphere

- Professional meetings attended:
  March 2006 meeting of the American Physical Society in Baltimore MD (with 5 students, see ‘Nat’l Meetings’)

- Review panels, services, professional committees etc:
  Reviewed articles for Physical Review Letters, Physical Review E, Physics Letters A, American Journal of Physics, among others

- Publications appearing during period of report:

J. Lindner, M. Bennett, K. Wiesenfeld, ‘Stochastic Resonance in the Mechanoelectrical Transduction of Hair Cells’, Physical Review E, volume 72, 051911(1-4) (2005).

J. Lindner, M. Bennett, K. Wiesenfeld, ‘Potential energy landscape and finite-state models of array-enhanced stochastic resonance’, Physical Review E, volume 73, 031107(1-8) (2006).

A. Bulsara, J. Lindner, V. In, A. Kho, S. Baglio, V. Sacco, B. Ando, P. Longhini, A. Palacios, W. Rappel “Coupling-Induced Cooperative Behavior in Dynamics Ferromagnetic Cores in the Presence of a Noise Floor”, Physics Letters A, volume 353, pages 4-10 (2006).

A. Bulsara, V. In, A. Kho, J. Lindner, S. Baglio, B. Ando, V. Sacco, “Coupling-induced oscillations in overdamped bistable dynamic systems” (to appear in the American Institute of Physics proceeding on the conference UPoN 2005: 4th International Conference on Unsolved Problems of Noise and Fluctuations in Physics, Biology, and High Technology).

- Committee service:
  Copeland Committee, Goldwater Committee (Chair), Grievance Committee (Chair)
  Admissions Liaison for Physics

- Redesigned and re-coded the Physics Department web pages
- Physics Club (SPS) Advisor
- Gave the invited talk "Can Noise Improve Hearing? Stochastic Resonance in Hair Cells" at a Faculty Lunch Seminar, Science Round Table, and at a Kenyon College Physics Seminar
- Gave a Philosophy Round Table talk "Time and Causation"

Jackie Middleton and Judith Elwell

Administrative Coordinator **Lab Technician**

Judy (right) has enjoyed the fact that all her children and grandchildren were in Iowa. She could see them all in one visit. However, recently, the daughter with the grandchildren moved to Colorado. She is now plotting how to see them.

This past spring, Judy received her award for **25 years** of service to the College. **Congratulations, Judy!**

Jackie (left) is in her 18th year with the Departments of Physics, Mathematics, and Computer Science. She enjoys visiting her two sons at The Ohio State University, going to high school football games with her husband Randy, and taking care of her mother. Jackie is also obsessed with Sudoku puzzles.

Shila Garg

Professor of Physics and Dean of the Faculty

B.S. Madras (India) 1970; M.S. Sussex (U.K.) 1972; Ph.D. Kent (U.K.) 1975; at Wooster since 1984.

Course taught:
Fall 2005
Physics 203-2: Foundations of Physics

Dr. Garg will be serving another term as Dean of the Faculty, but she plans to continue advising an I.S. student or teaching a course in the Department of Physics as her schedule allows.


Dr. Boone enjoys using the Department's 3D optical illusion toy to play tricks on young children

Lowell Boone
Visiting Assistant Professor

B.A. (Literature) UC Santa Cruz 1992, M.S., Ph.D. (Physics) UC Santa Cruz 1998, 2002; at Wooster since 2003.

Courses taught:
Fall 2005
Physics 203: Foundations of Physics
Physics 203L: Foundations of Physics Labs
Physics 377: Computational Physics
Physics 204L: Foundations of Physics Lab

Spring 2006
Physics 204: Foundations of Physics
Physics 208: Math Methods
Physics 350: Quantum Mechanics

- Advised two senior independent study projects (Jeremy Hohertz and Angela Triplett)

- Areas of current focus and projects in progress:
  Relativistic particle dynamics and radiative losses in jet environments

- Research talks given at:
  University of Wisconsin at LaCrosse, Lawrence University, California Polytechnic University, California Lutheran University, Roanoke College, University of Evansville, Hartwick College, and Denison University

- Professional meetings attended:
  207th American Astronomical Society (Washington DC, with 3 students)
  Computational Modeling in the Undergraduate Arena (Oberlin College, with 2 students)

- Papers presented at professional meetings:
  "Simulating Particle Dynamics in Tangled Magnetic Fields" (AAS)

- Committee service:
  Computing & Information Technology, Howard Hughes Medical Institute Steering Committee, College Scholars Committee

- Organized the Physics Department Colloquium series

- Gave a Faculty-at-Large lecture at CoW entitled "Heaven and Earth: Participating in the Cosmic Process"

- Dr. Boone has moved to Indiana to begin his new position at the University of Evansville this fall. Best wishes to Lowell, Barbara, and Collin!

Donald Jacobs
Victor J. Andrew Professor

B.A., M.A. University of South Florida 1971, 1972, Ph.D. Colorado 1976; at Wooster since 1976.

Dr. J with his granddaughter

Courses taught:
Fall 2005
Physics 101: General Physics
Physics 101L: General Physics labs
Physics 301: Mechanics

Spring 2006
Physics 102: General Physics
Physics 102L: General Physics lab
Physics 400: Mechanics tutorial
Physics 401: Junior Independent Study

❃ Advised Andrew Kindschuh in his senior independent study project.

❃ Areas of current attention and projects in progress:
Experimental research in phase transitions of binary fluid mixtures, polymer-solvent systems, living polymers, and biological proteins including measurements of turbidity, heat capacity, viscosity, density, and the coexistence curve on these systems. Also conducting experiments in the emerging area of self-organized criticality in granular materials.

❃ Professional meetings attended: *student co-author
Thermo International 2006, 16th Symposium on Thermophysical Properties, gave two talks:
• Universal Behavior in Star Polystyrene + Methylcyclohexane Systems Near the Critical Point
D.T. Jacobs, M.T. Wellons*, S.J. Suddendorf*, A.L. Triplett*, M. Lightfoot*, and N.L. Venkataraman*
•Anomaly in the Heat Capacity of Triethylamine and Water
D.T. Jacobs, R.A. Shewmon* and R. Hartschuh*
Chaired a session on "Properties of Mesoscopic, Self-Assembled, and Strongly Fluctuating Systems"
D.T. Jacobs and M.A. Anisimov
March 2006 meeting of the American Physical Society, Baltimore, MD (with 5 students, see "Nat'l Meetings")

❃ Review panels, services, professional committees, etc.:
Reviewed articles for the American Journal of Physics, Journal of Chemical Physics, Physical Review B
Reviewed the physics department at James Madison University (part of a review team for Research Corporation)

❃ Publications appearing during period of report:
Jeremy N. A. Matthews, Peter B. Yim, D. T. Jacobs, Necoise D. Peters, Jeffrey G. Forbes, and S. C. Greer, "The polymerization of actin", J. Chem. Phys. 123, 074904 (2005).

❃ Grants awarded:
Co-Principal Investigator on a recently awarded NSF-MRI equipment grant for an Isothermal Titration Calorimeter (proposal written by Paul Bonvallet & Mark Snider, Chemistry Department).
Awarded an internal grant proposal for a William H. Wilson Award titled "Prolonging the shelf life of vaccines"

❃ Committee service:
Financial Advisory Committee, Digital Output Management Work Group, Hewlett-Mellon Committee

Susan Lehman
Clare Boothe Luce Assistant Professor

Dr. Lehman and son William, who was born March 5, 2006.

B.A. Goshen 1993, M.S., Ph.D. North Carolina Chapel Hill 1996, 1999; at Wooster since 2003.

❃ Courses taught:
Fall 2005
First Year Seminar:
"Science and Technology: Power for Good...or Evil?"
Physics 220: Electronics for Scientists and lab

Spring 2006
Physics 102L: General Physics lab
Physics 204L: Foundations labs

❃ Advised Kathy McCreary in her senior independent study project.

❃ Areas of current attention and projects in progress:

Modifying the College's scanning tunneling microscope to add the capability to perform ballistic electron emission microscopy (BEEM), a technique utilized to investigate the electronic properties of semiconductor quantum dots.

Using the microscope in atomic force microscope mode to investigate the self-ordering of these quantum dots on the substrate.

Developing a cavity ring-down optical system to investigate the properties of high-reflectivity semiconductor mirrors.

❃ Publications appearing during period of report:
"GaAs Buffer Layer Morphology and Lateral Distributions of InGaAs Quantum Dots"
A. Roshko, T. E. Harvey, S. Y. Lehman, R. P Mirin, K. A. Bertness and B. L. Hyland,
The Journal of Vacuum Science and Technology B 23:3, 1226 (2005).

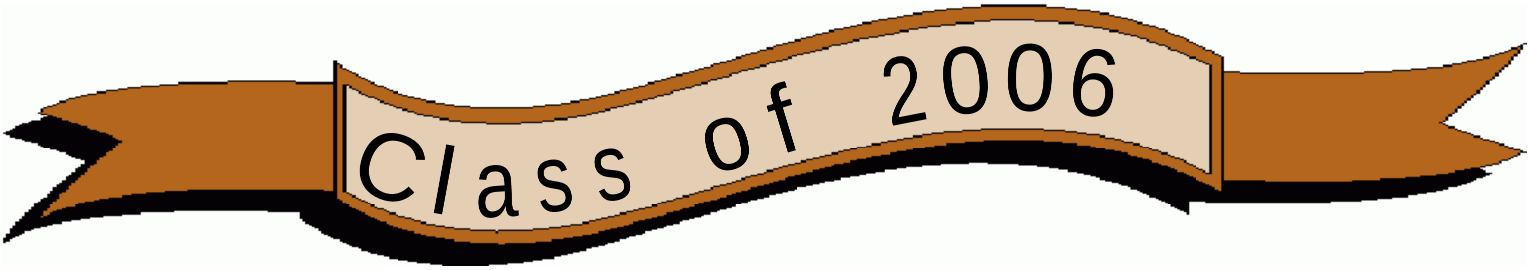
❃ Committee service:
Committee on Committees, Women's Studies Curriculum Committee

❃ Physics Outreach Coordinator for the College's Society of Physics Students

❃ Participant in a panel discussion on General Value to the College at a New Faculty Orientation Session

❃ Participated in a Symposium on Diversity in the Sciences at Harvard University. Dr. Lehman is currently working with the other College participants to incorporate insights from the Symposium into our efforts to improve recruiting and retention of students historically under-represented in the sciences.

❃ Coordinated the physics demonstration evening program for the BWISER (Buckeye Women in Science, Engineering and Research) summer institute for 7th grade girls



Kathy, Angie, Jeremy, Katherine, Andrew

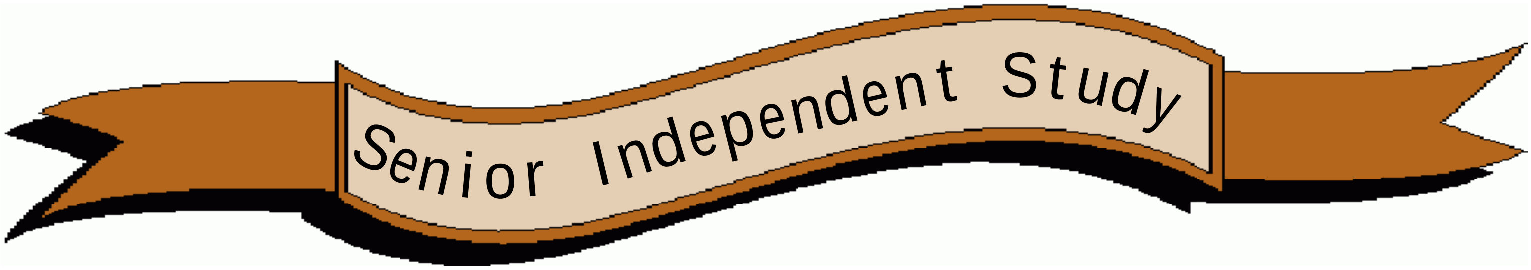
Kathleen Michelle McCreary
(Double major - Physics / Math)
Rocky River, OH
University of California, Riverside

Angela Lynn Triplett
Sunbury, OH
University of Akron

Jeremy David Hohertz
Cleveland, OH
Miami University of Ohio

Katherine Duvivier Olaksen
Wellesley, MA
Employment

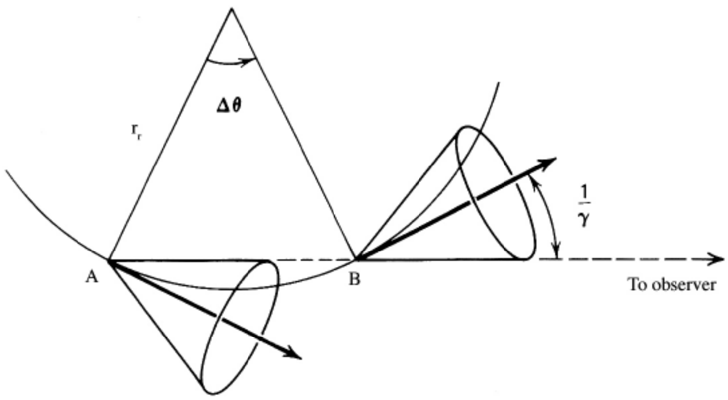
Andrew Jon Kindschuh
Portland, OR
Employment



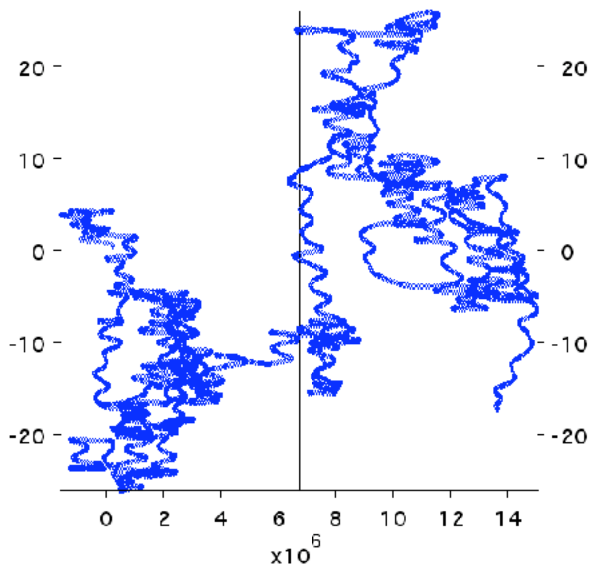
Simulation of Synchrotron Radiation from Relativistic Particles in Tangled Magnetic Fields

Jeremy D. Hohertz
Advisor: Lowell Boone

We discuss the simulation of a charged particle traveling through tangled magnetic fields, emitting synchrotron radiation. Studies on the containment of particles in a given volume indicate that the characteristic escape time for a population will increase as the containment volume, magnetic field strength and tangle parameter increase, although there is an upper limit to the size of the magnetic field strength and tangle parameter. We qualitatively propose that for a single observer studying the synchrotron radiation of one particle, more radiation will be observed when the tangle parameter is greater in value than the relativistic gyroradius of the particle. The particles in this simulation emit the correct spectrum of frequencies, but do not lose energy in any appreciable amount.



As a particle travels between A and B, the observer (to the right) will observe the greatest amount of radiation. The cones are of half angle $1/\gamma$.

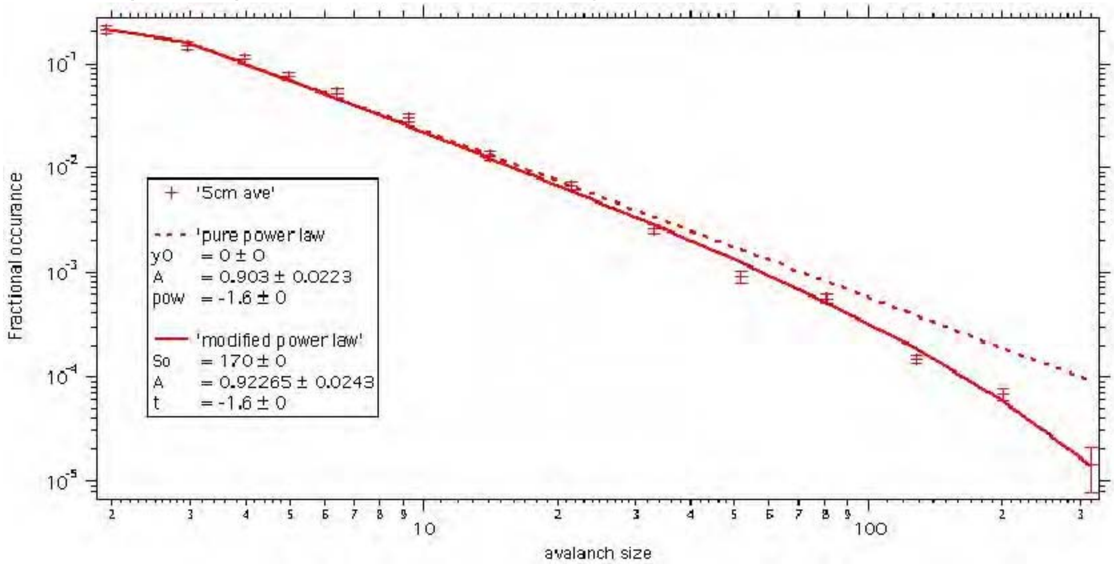


The trajectory of a particle as seen by an observer along the positive x-axis. The axes display arbitrary units, but the radius of the containment volume in this simulation was R = $100r_r$.

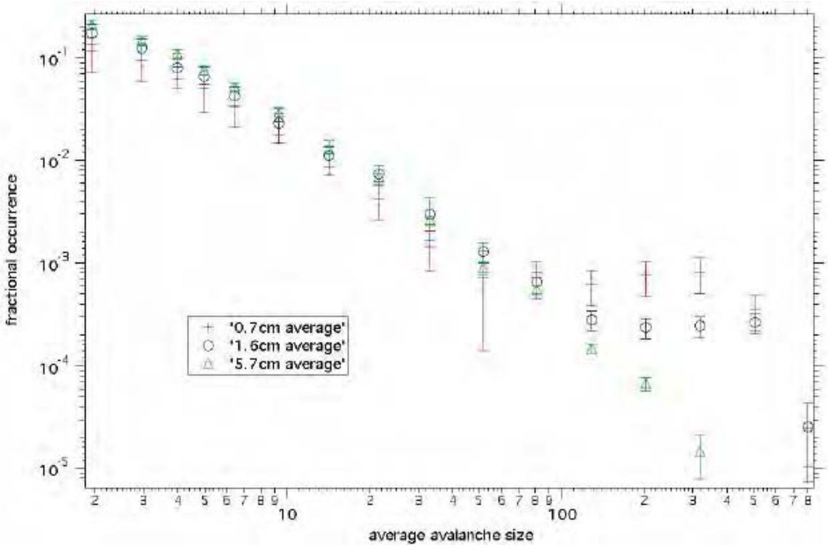
Self-Organized Criticality: An Investigation of Energy Dissipation and Bead Pile Dynamics

Andrew Kindschuh Advisor: Donald Jacobs

Self-organized criticality (SOC) is a theory first proposed by Bak, Tang, and Wiesenfeld to describe systems displaying 1/f noise and fractals. It has since been suggested to describe a vast array of additional systems that are not well described by simple causality. These complex, dynamical systems self-organize to critical states characterized by scale invariance (both spatial and temporal) and power law behavior. Bak, Tang, and Wiesenfeld first modeled SOC in a numerical simulation of a sand pile, and the sand pile has since become the quintessential example of an SOC system, being extensively studied both in the literature and at The College of Wooster. Sand pile experiments at The College of Wooster have consisted of a uniform, spherical, glass or steel beads dropped singly from a constant height onto the apex of a conical pile of beads. Different sizes, shapes, and surfaces of bases have been investigated, as well as beads glued to the base in different patterns, and different drop heights. In this experiment two investigations are undertaken. Firstly the effects of drop location are investigated by dropping stainless steel beads from a constant height of 2.0 cm onto the pile at three locations, horizontally offset 0, 1, or 2 cm from the center of the pile. Each location consisted of multiple runs lasting 54 hours each. It was found that while small variations (~10% the base diameter) in horizontal drop location h ad negligible effects on the distribution of avalanches coming off the pile, larger horizontal displacements displayed finite size effects that mimicked the effects of a smaller base. The second investigation further explored the effects of bead material and density on avalanche distribution by using zirconium beads. Zirconium beads were dropped onto the apex of the pile from three different heights: 0.7 cm, 1.6 cm, and 5.7 cm. Zirconium has a density approximately halfway between those of glass and stainless steel, and thus a zirconium bead of similar size will impart a quantity of energy approximately halfway between the densities of glass and stainless steel upon impact. The energy of this impact was previously suspected to govern the cut-off large size avalanches, but a dependence on bead density was not found.



Average fractional occurrences of avalanches for all three 5.7cm zirconium data runs. Error, pure power law fit and modified power law fit shown.

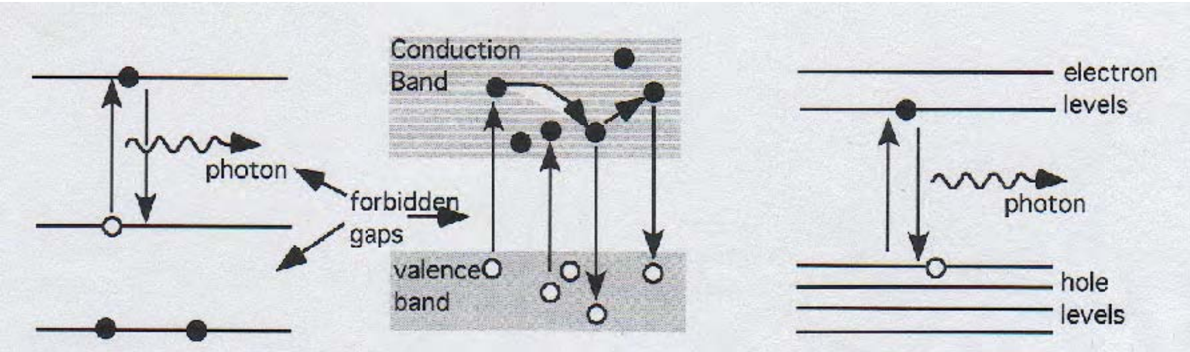


Average fractional occurrence of all runs for each zirconium drop height

Characterization of BEEM Performance

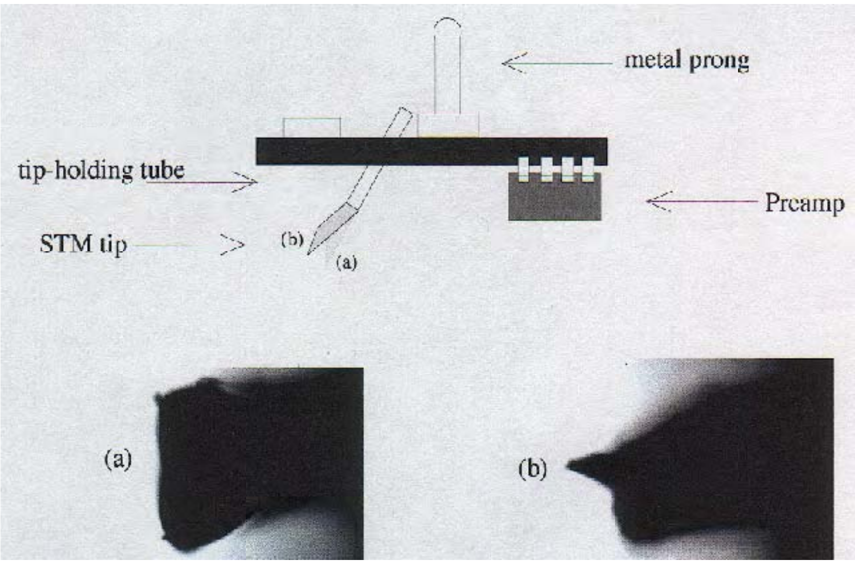
Kathleen McCreary
Advisor: Susan Lehman

Previous work done at Wooster, completed by Austin Carter in 2005, focused on converting the scanning tunneling microscope (STM) to a ballistic electron emission microscope (BEEM). The performance of the BEEM was analyzed using a Au/GaAs sample obtained from Dr. Jon Pelz at Ohio State University. When functioning properly, the measured collector current for the Au/GaAs sample should be in the range of a few hundred pico amps. For the majority of data recorded, the collector currents were a few nano-amps or larger. The only data which displayed collector currents in the expected range were those in which the BEEM probe had been set down very hard on the top gold contact. This leads us to believe that poor electrical contact is the main contributor to the high collector current. To consistently achieve good electrical contact between the BEEM probe and the top gold layer, the experimental setup will need to be altered in the future.



Atom Bulk Semiconductor Quantum dot

Schematic representation of the energy diagrams for a single atom, bulk crystal, and quantum dot



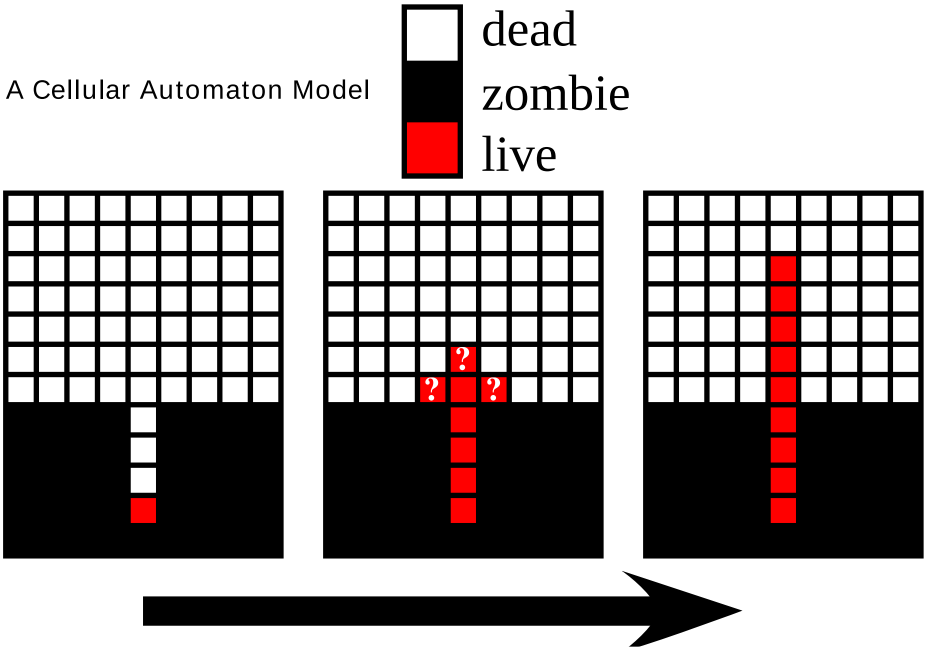
A schematic of the side view of the tip holder and STM tip. Position (a) has no bend. The corresponding optical microscope image of the tip is displayed. Position (b) shows the direction of the bend and the corresponding image of the tip. The difference in images is a result only of bending the tip.

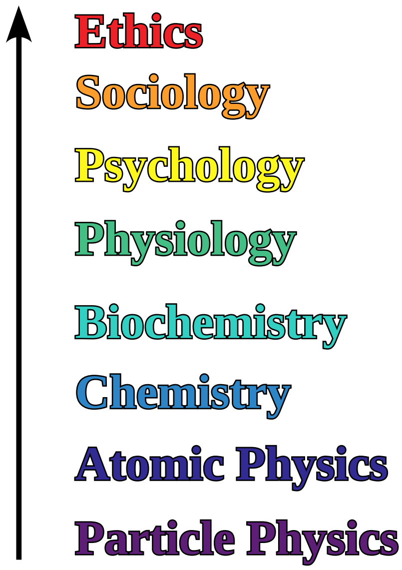
Physics and Free Will: Models of Top-Down Causation in Physics

Katherine Duvivier Olaksen
Advisor: John Lindner

Traditional physics suggests that history is merely the uncoiling of the Big Bang, but is this reductionism sufficient to explain our experience of the real world? The concept of emergent phenomena is a fresh response to the development of complexity in the universe.

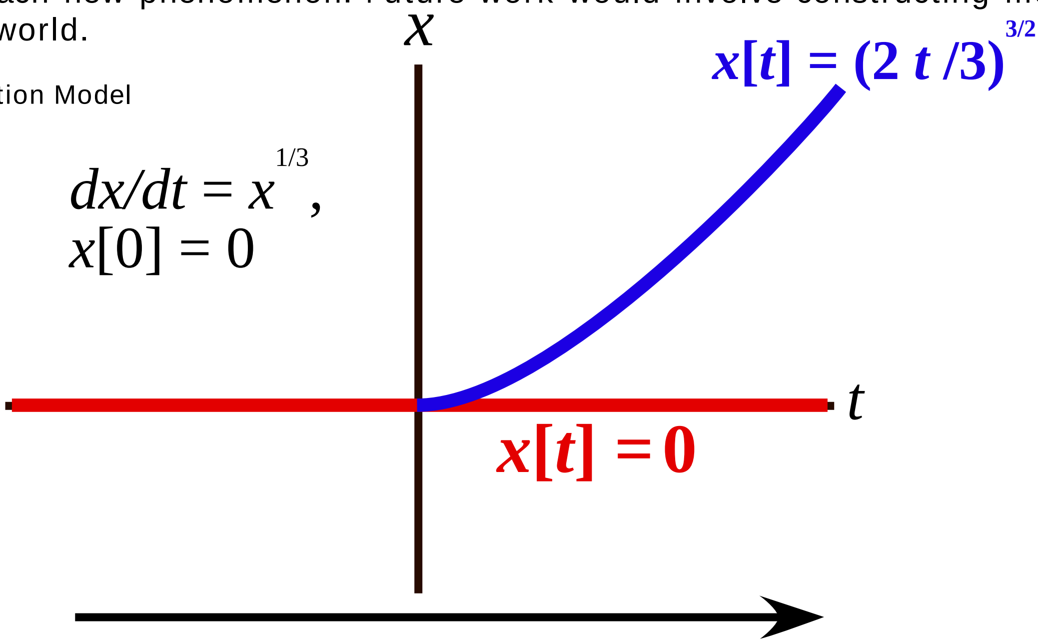
A Cellular Automaton Model





This thesis reviews the complexity that has emerged in the universe, which many have found so surprising and unexpected. It introduces the idea of top-down causation to supplement lower-level laws of physics and generate the emergence of complexity. It reviews the foundations of quantum mechanics, focusing on how quantum randomness may provide the freedom that enables such higher-level laws to imbue the universe with creativity and variety of free will. It then critically analyzes the uniqueness theorems that underlie the initial value problems of traditional physics and demonstrate exceptions to them. Finally, it demonstrates the coherence of higher-level laws by explicitly creating models of emergent phenomena and top-down causation, in simple example universes. In the models, a new higher-level law must immediately accompany the emergence of each new phenomenon. Future work would involve constructing models testable in the real world.

A Differential Equation Model

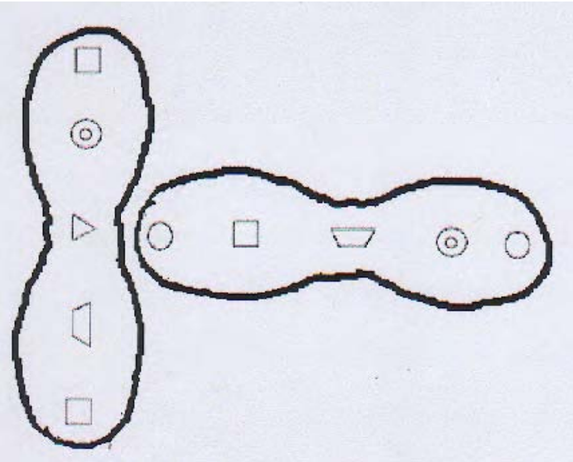


Simulating the Path of a Fastpitch Softball Pitch

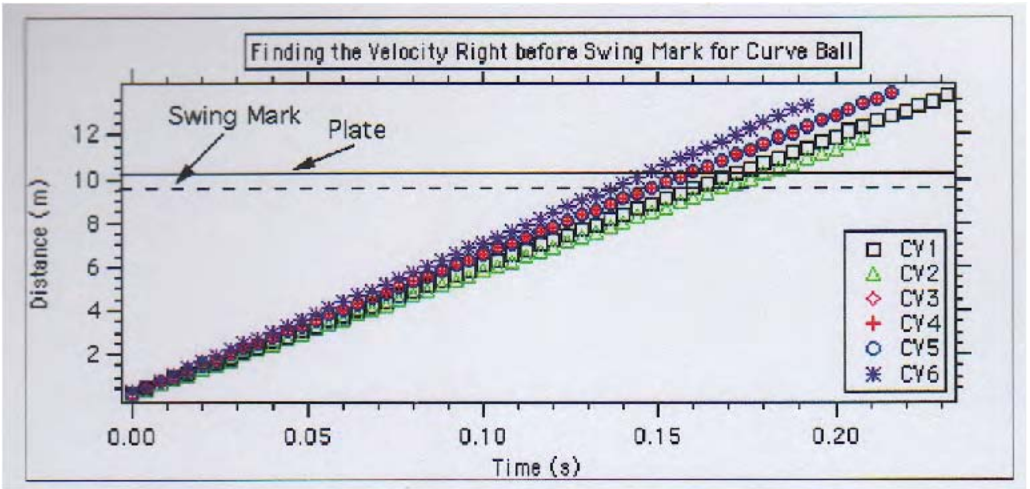
Angela Lynn Triplett

Advisor: Lowell Boone

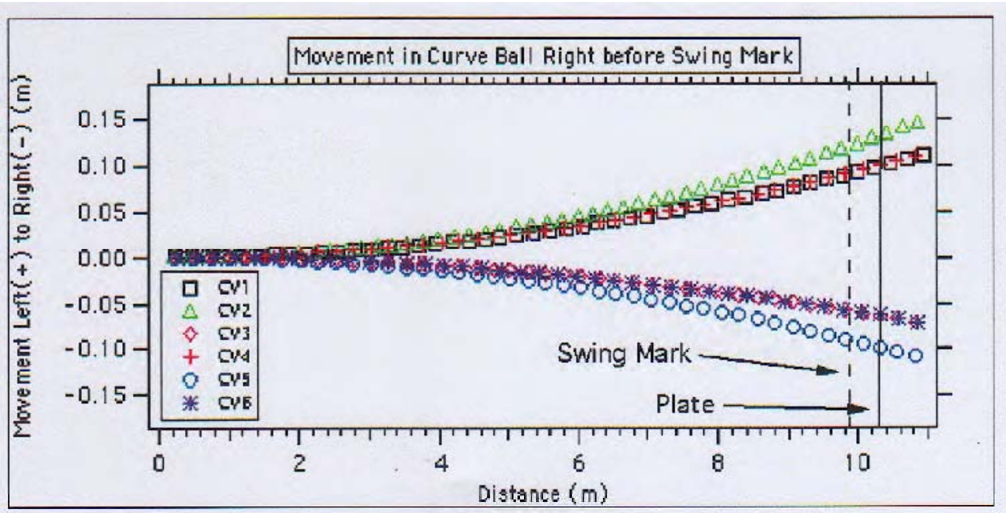
Many studies have been conducted on the path of a baseball pitch, but very few studies have been done on the path of a fastpitch softball pitch. This paper focuses on the forces that act upon a softball while in flight and how the resulting path is used to deceive the batter. The purpose of this project was to investigate and understand the physics of a fastpitch softball pitch and to determine whether the drag force is dependent on laminar (v) or turbulent (v^2) flow. A high-speed camera was used to collect two-dimensional movement of a soft ball immediately after release from the pitcher's hand. These data were then extrapolated into three dimensions. Then a program was created using Eulerian angles to find the angular velocities (ω) in the x, y, and z direction for each pitch. A comparison of how a laminar drag force and turbulent drag force affected the flight of the ball revealed a turbulent drag force dampened the pitch 0.51% more than the laminar drag force. Using a turbulent drag force and the angular velocities, a program was created to compare the collected data's trajectories and the trajectories of actual pitches. These trajectories provided insight as to when the ball should begin to deflect from its original path to effectively deceive the batter.



This is how the ball was marked in order to identify the spin correctly.



This graph displays how the velocity changes as the deflection of the ball begins to accelerate.



This graph displays the deflection left to right for a curve ball.

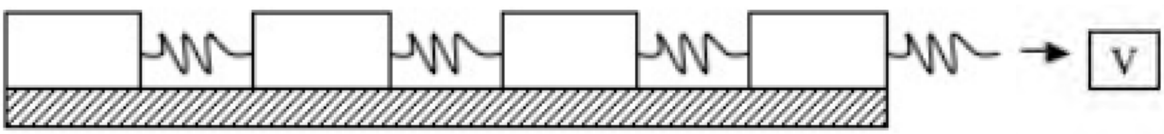
Junior Independent Study

Chillin 'after Junior I.S.

Self-Designed Projects

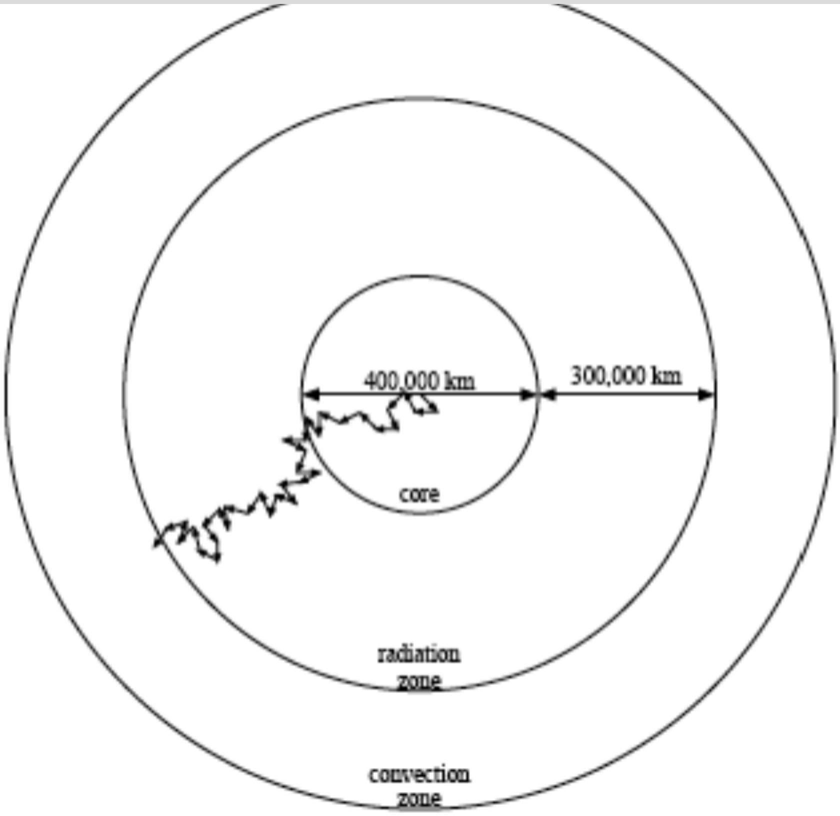
The Spring-Block Model of Earthquakes
Mike Davis

The purpose of this experiment was to determine if a simple spring-block model using stick-slip friction could be used to model complex events such as earthquakes. Four wooden blocks were connected in a row using springs. Then a reel was used to pull a string attached to the first block at a constant velocity adding energy to the system. When enough energy was added, the blocks moved. The distance the blocks moved was related to the amount of energy the blocks released. A distribution of the distance the blocks moved versus the number of times that distance was seen showed that the spring-block model successfully mimicked a plot of the Gutenberg-Richter law. This verified that the spring-block model was able to illustrate trends seen in the behavior of earthquakes.



Random Walk of Radiation from the Sun

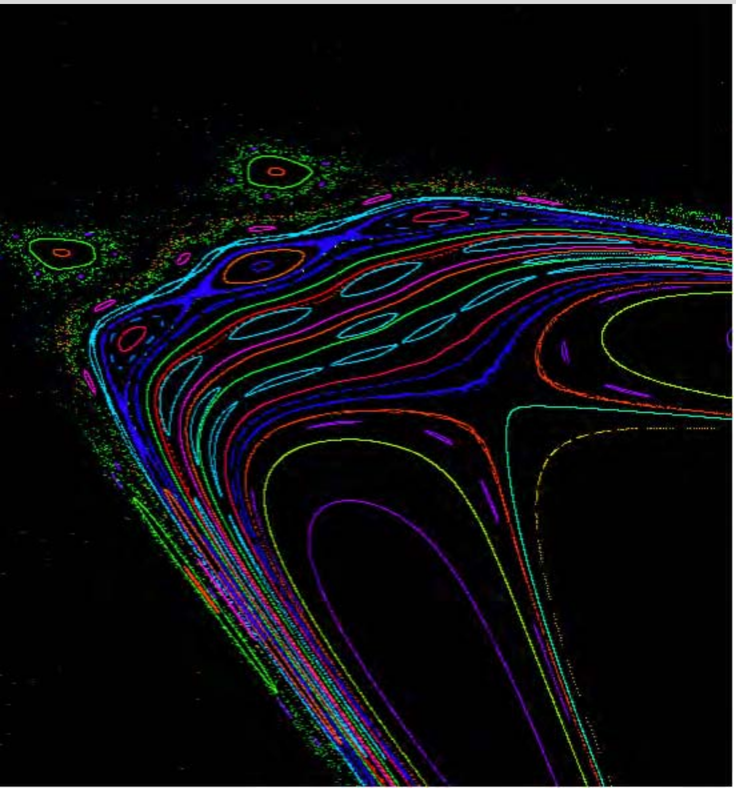
Lisa May Walker



A simulation was run to find the average escape time of photons from the radiation of the Sun. An escape time of t_{mode} = (4.9±1.4) x10^4 years was found for a constant-density Sun and t_{mode} = (2.9±0.6) x 10^6 yrs for a linear density gradient Sun by extrapolation from smaller radii. These values are respectively less than and greater than the expected value by an order of magnitude.

Chaotic dynamics in the two-circle billiard

Stephen Poprocki

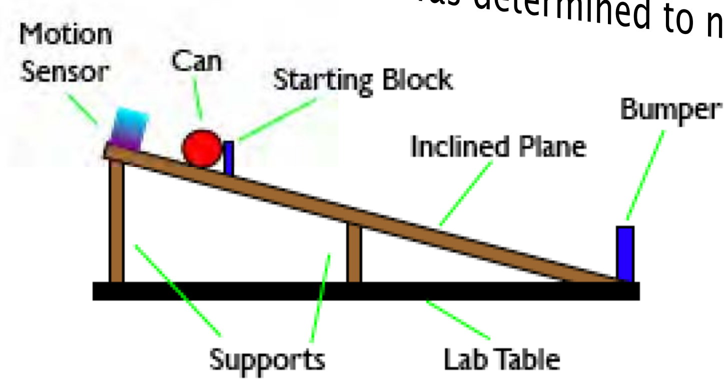


Classical billiards are an example of a simple, exact system that can exhibit both order and chaos. The two-circle billiard consists of two circles: one of fixed radius centered at the origin and the other of varying radius and offset from the origin. A point particle bounces specularly between the circles. In order to learn more about the orbits, a third dimension of color was added to the Poincaré section through various metrics. The metrics implemented were the random, period, and fraction of space metrics. A program for Mac OS X was developed in order to simulate the billiard. By zooming in on the phase space, significant evidence for self similar fractal behavior was found. The program allows for the creation of animations which show how the system varies with the radius and central offset parameters. A number of these animations were created to further understand the dynamics of the two-circle billiard.

The Effects of Fluid in a Can Rolling Down an Incline

Jon Rosch

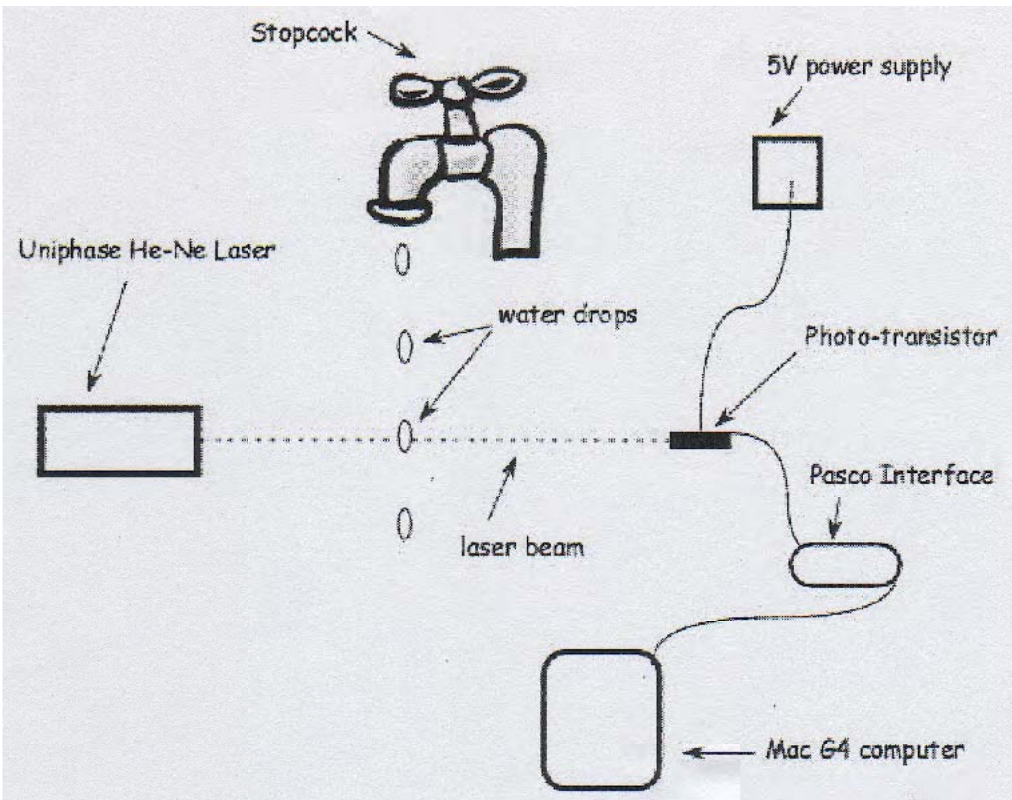
An aluminum can containing variable amounts of fluid was rolled down an incline. A decrease in the acceleration of the can was observed when approximately 10mL of fluid were present. This is theorized to be due to a torque from a droplet acting opposite to the direction of rolling motion of the can. Oscillatory motion was observed when between 30 and 80mL of fluid were present. This was believed to be due to fluid traversing back and forth within the can, although no direct observations were made. The rotational inertia of the can with fluid as a function of its total mass was determined to not be a linear function.



Finding periodic and chaotic behaviors in a dripping water faucet

Myat Tun

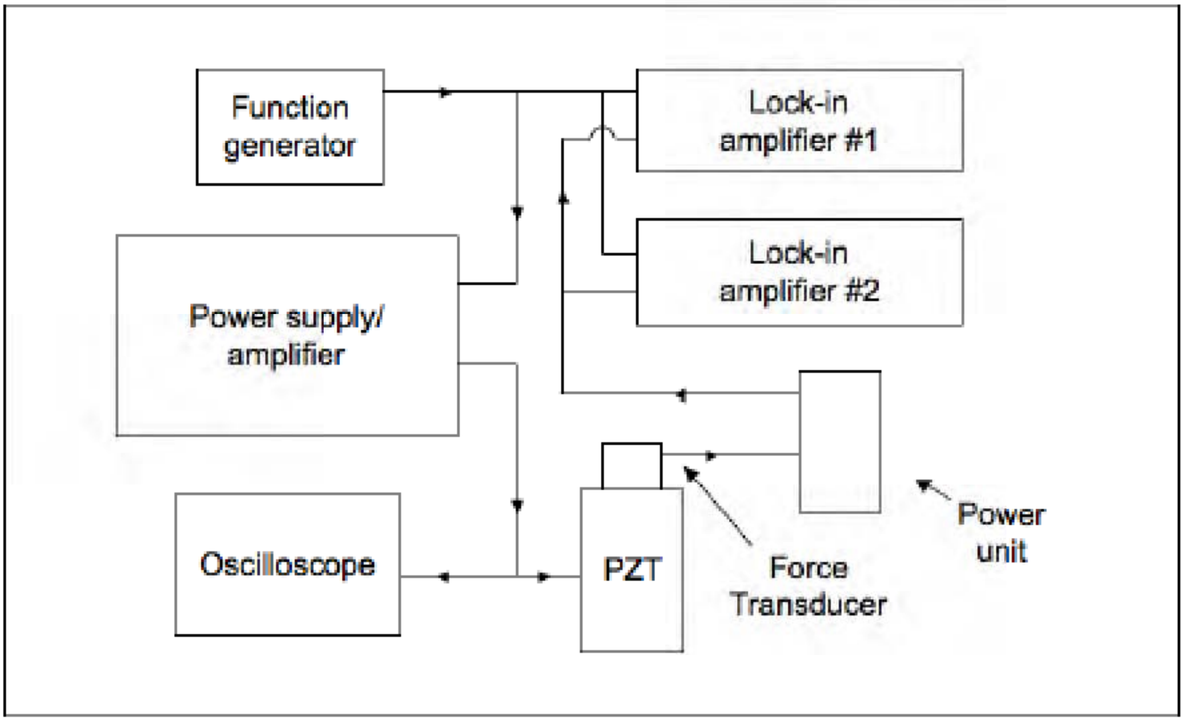
This experiment shows how a simple physical system can demonstrate chaotic behavior. Water drops falling from a faucet can either be periodic or chaotic. The time intervals T_n between successive drops are measured. To express the dynamics of the dripping faucet, return or Poincare maps (T_{n+1} versus T_n) are plotted. By varying the control parameter, flow rate, the system changes from periodic to chaotic as flow rate increases. Period-1 and period-2 attractors are presented as well as several strange attractors including a period-3 attractor and L-shaped attractor within the chaotic regime.



Resonance in a piezoelectric material

Danny Tremblay

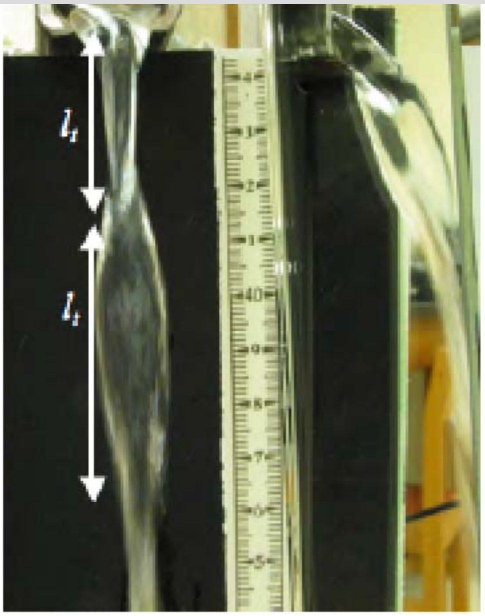
An AC voltage was used in conjunction with a piezoelectric material consisting of lead, titanium, and zirconium to investigate the resonant mechanical frequencies and patterns of the piezoelectric sample. Both longitudinal and flexural oscillatory modes were examined. Resonant frequencies were found at ~42.1 x 10^3 rad/s, ~96.1 x 10^3 rad/s, and ~135.7 x 10^3 rad/s. These resonant frequencies correspond to the first flexural mode, second flexural mode, and first longitudinal mode respectively. Further investigation is needed to verify the model being used for the overall resonant frequencies. However, this model enabled the speed of sound in the piezoelectric sample to be determined as (3291 ± 6) m/s. In addition, two methods were used in modeling a particular resonance in greater detail. Analyzing the amplitude and phase shift of oscillation yielded a resonant frequency as well as damping coefficient which correspond to a Q factor of (25.30 ± 0.13).



Contraction of a Free Falling Liquid Jet

Nathan Utt

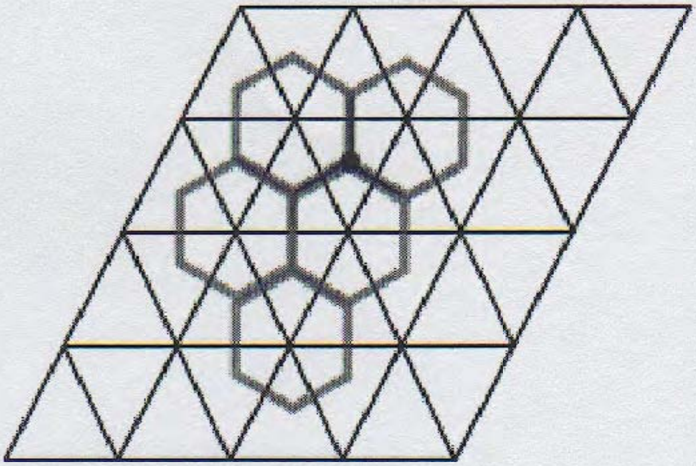
This experiment tested the theory that as a liquid stream falls it contracts in response to gravitational acceleration. This was observed by analyzing digital photographs of a stream falling from a rectangular trough. The theory was found to accurately describe the shape of the falling stream. It was also found that viscosity, flow rate, and the width of the trough does not affect this gravitational contraction. It was also found that the initial contraction of the stream is caused by the convergence of streamlines, which may rely heavily on those three factors. This convergence can also have an overriding affect on the shape of the falling stream.



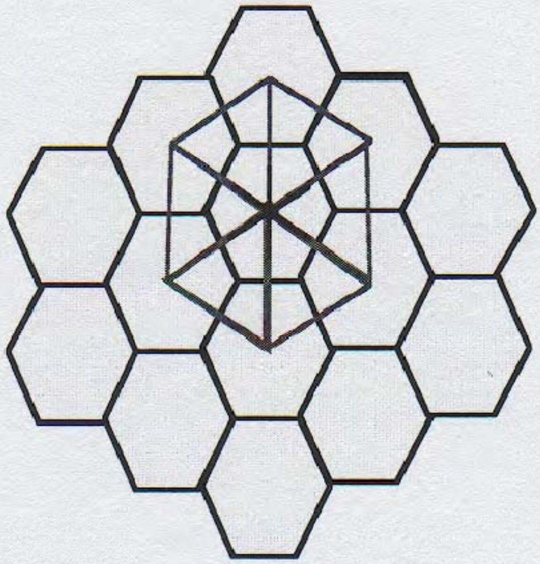
Notice that as the stream widens in one plane it contracts in the other.

Percolation

Sarah Suddendorf

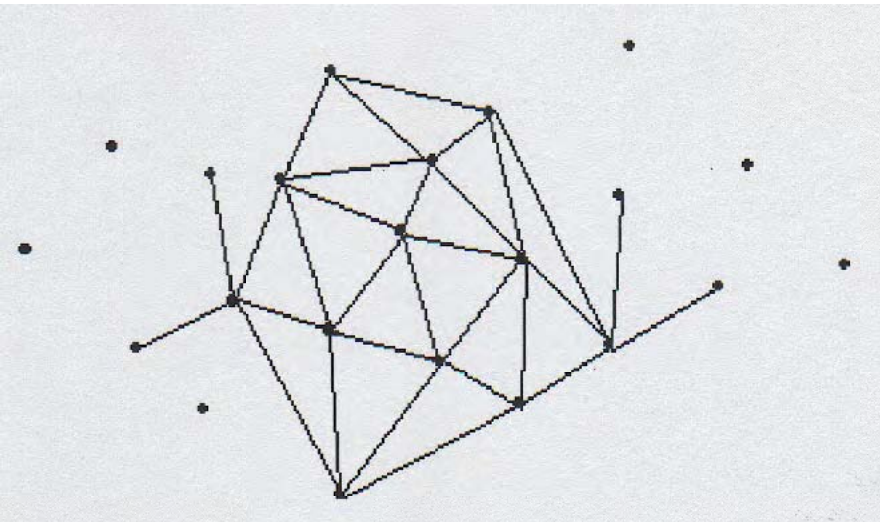


Three Fold Honeycomb



Six Fold Triangular

Percolation is enriched in mathematical theory, and also shows phase transition behavior, which is of vast interest to physicists. Percolaton theory has many practical applications. This particular study used two computer simulations to investigate the properties of a two-dimensional square lattice along with a two-dimensional three-fold lattice. After calculating the theory for a 2x2 and 3x3 sized square grid, data was collected, using the square lattice program, and compared. The collected data was almost a perfect fit to the theoretically calculated data for both grid sizes. The data collected for a large square lattice grid size showed a critical probability of 0.593 ± 0.012 which is accurate to the accepted value of 0.593. The data collected for a large three-fold lattice grid size showed a critical probability of 0.696 ± 0.010, which is also accurate to the accepted value of 0.696. The data collected in this study were very accurate and there are many directions to take this research in the future, such as whether the same critical phenomena is found for a random grid.



A diagram of the random grid lattice

Society of Physics Students

2005-2006 Officers
(Advisor, John Lindner)

- Jeremy Hohertz, President
- Danny Tremblay, Vice-President
- Kathy McCreary, Treasurer
- Danny Shai, Secretary

Events:

- Fri 2 Sep 05: Scot Spirit Day
- Wed 14 Sep 05: Bornhuetter pizza & ice cream dinner
- Wed 21 Sep 05: General meeting
- Sat 1 Oct 05: Outreach training
- Sat 5 Nov 05: Great Lakes Science Center & dinner in Cleveland
- Thu 8 Dec 05: Senior thesis progress reports
- Wed 1 Feb 06: Presentations by ambassadors to New Zealand & Japan
- Wed 22 Feb 06: General meeting selects T-Shirt finalists
- Wed 8 Mar 06: General meeting selects T-Shirts
- Sun 23 April 06: Taylor Bowl XVII

Colloquia

Todd McAlpine, University of Kansas
Experimental Characterization of W-OPIC Semiconductor Lasers, June 2006

Amy Lytle '01, University of Colorado, Boulder
Extreme Nonlinear Optics: Coherent X-Rays from Lasers, June 2006

Malcolm Rickard, University of Colorado, Boulder
Electronic Electrooptic Effects in Ferroelectric Liquid Crystals, June 2006

Daniel Styer, Oberlin College
105 Years of Quantum Mechanics, April 2006

Christopher LaSota, Kenyon College
Boolean Networks, Cellular Automata, and Biological Development, April 2006

Douglas Armstead, SUNY Oneonta
Long Time Relaxation in Chaotic Billiards, March 2006

Adelé Poynor, University of Illinois at Urbana-Champaign
Water at a Hydrophobic Surface, February 2006

Physics Seniors
The College of Wooster Senior I.S. Progress Reports, December 2005

Outreach

This year, members of our Society of Physics Students continued our fifth year of a program to bring exciting physics demonstrations to elementary school classrooms to help get students excited about science at an early age. We now have three different demo programs since we have added "Forces and Motion" to the existing "Pressure and Air" and "Electricity and Magnetism" demos. All of the demos are targeted for students in grades 3, 4, and 5.

2005-2006 School Visits

• 28 October 2005
Cornerstone Elementary, 52 3rd graders
THEME: Forces & Motion

• 4 November 2005
Cornerstone Elementary, 21 4th and 5th graders
THEME: Electricity & Magnetism

• 18 November 2005
Parkview Elementary, 52 3rd graders
THEME: Forces & Motion

• 2 December 2005
Kean Elementary. 25 5th graders
THEME: Electricity & Magnetism

• 3 March 2006
Oak St. Intermediate Orrville 5th grade
THEME: Electricity & Magnetism

• 7 April 2006
Apple Creek Elementary School, 21 3rd graders
THEME: Forces & Motion

• 21 April 2006
Kean Elementary School, 22 3rd graders
THEME: Forces & Motion

• 28 April 2006
Kean Elementary School, 23 3rd graders
THEME: Forces & Motion

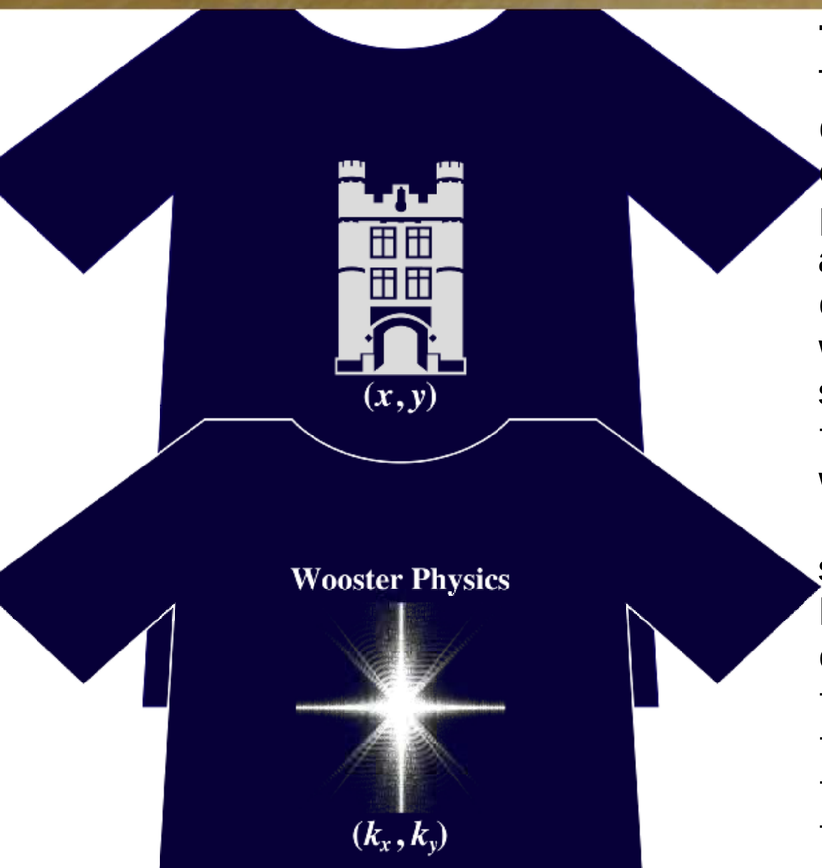
Danny Tremblay '06 did a fantastic job as outreach "team leader" this past year.

Taylor Bowl XVII

The bad news:

Math/CS	119.54
Physics	109.57

The good news:
82 bowlers participated!



T-Shirt
The "star burst" on the front is the diffraction pattern of the Kauke arch on the back. If the silver Kauke arch pattern were a transparent opening in an otherwise opaque mask, and if the opening were illuminated by light whose wavelength was similar to the size of the opening, the resulting far-field diffraction pattern (or "shadow") would be the star burst. (Simple masks produce simple geometric shadows only if the wavelength of light is much smaller than the size of of the mask.) We generated the diffraction pattern by using Mathematica to compute the absolute square of the two-dimensional Fourier transform of the Kauke arch.

"Ambassadorships"

On a mountain surrounding Grenoble, looking dapper in a Wooster Physics t-shirt

Jon Rosch, Ambassador to France

My summer research took me overseas to scenic Grenoble, France. There I was paired with a PhD student named Yannick and an advisor. My work involved constructing a laser using a Nd:YCOB sample cut as a sphere for the lasing medium to study luminescence and non-linear optical properties. I had to wear little booties everyday and sweet-looking goggles when the laser was on. The people I worked with were very fun to be around and they took me on excursions up into the mountains and through the city. The French find American humor to be of exceptional quality, even if the jokes are not very good.


Excuse me, I prefer "caver" over "spelunker".

Nathan Utt, Ambassador to New Zealand

I had the wonderful opportunity to spend fall semester 2005 studying at Massey University located in Palmerston North, New Zealand. While there, I took a course in Electromagnetism. Because New Zealand is located on the opposite end of the earth's magnetic field, all of Maxwell's Equations are written with the opposite sign. Ok, so that isn't true, but it was still a great experience. In addition to my physics and math courses I was able to take a class about the natural history (plants, animals, rocks, etc.) of New Zealand. Did you know that prior to the arrival of Polynesian and European explorers, the only mammals found in New Zealand were small bats? That is why there are so many flightless birds...they had no natural predators to fly away from. After the semester ended I stayed in the country for about five weeks to spend time backpacking and working on a sheep farm. New Zealand has a breathtaking landscape and beautiful culture, and I am still trying to figure out an excuse to go back.


Stephen and his little friend, お猿さん

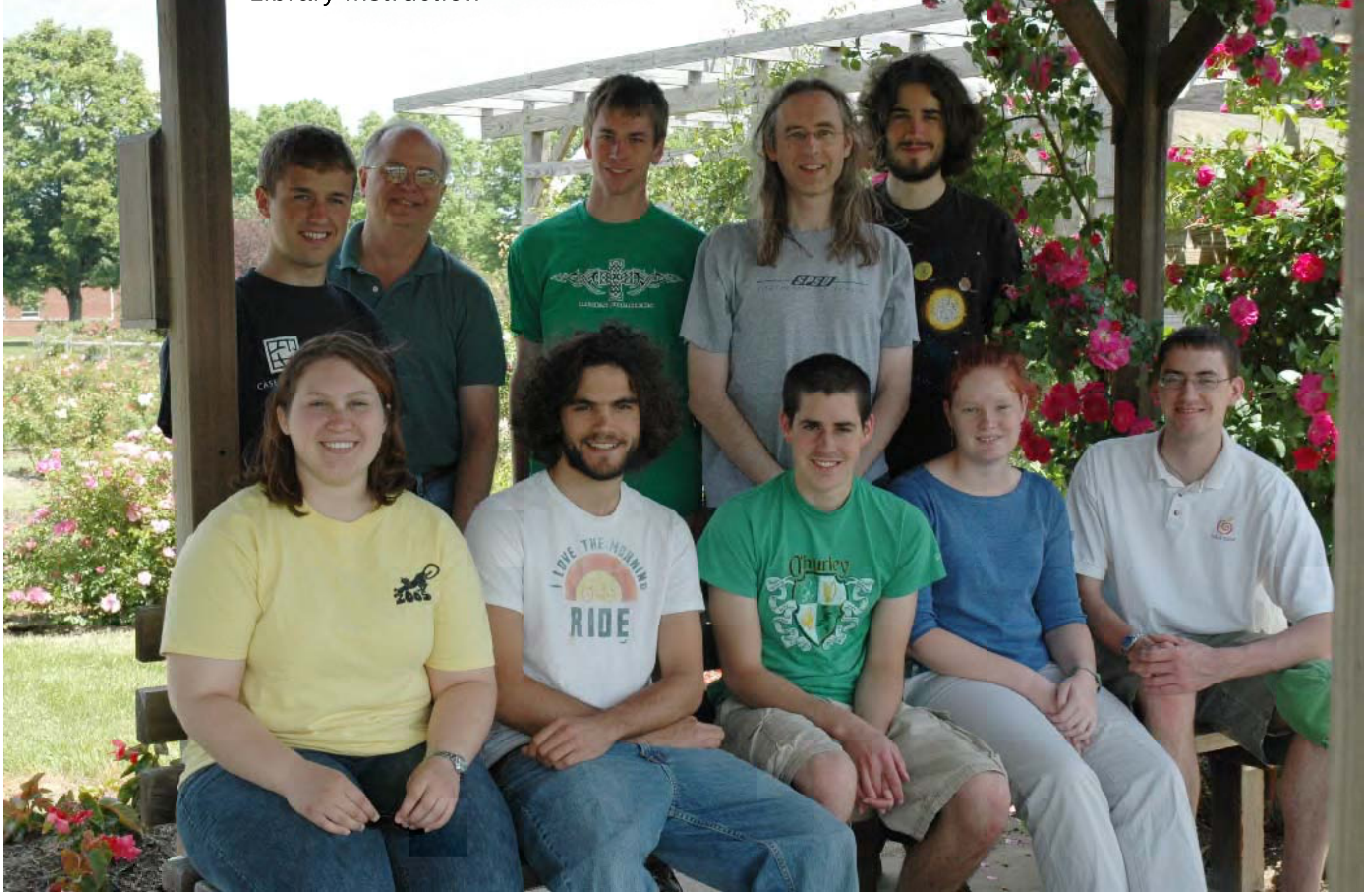
Stephen Poprocki, Ambassador to Japan

I spent the fall semester of my 2005 at Kanda University of International Studies in Chiba, Japan. My reason for going was to improve my Japanese, so I took as many language courses as possible. My experience was absolutely fantastic. I got along well with and learned much from my host family, improved my Japanese significantly, experienced Japanese culture, and explored much of Tokyo (which I believe is the most exciting place in the world). I also benefited from the experience in rather unexpected ways. Although I missed a few classes in my majors, it was definitely worth it. I would recommend study abroad to anyone who has the motivation and interest.

Summer Research

This summer marked the 13th consecutive year of the department's Research Experience for Undergraduates funded by the National Science Foundation and The College of Wooster. We target beginning students, often having completed just one year of college, and often from institutions where research opportunities are scarce. This past summer, John Lindner and Don Jacobs mentored four students each, three of whom came from other schools: Case Western Reserve University, Ohio Northern University, and Agnes Scott College in Decatur, Georgia. In addition to performing cutting-edge research, our program offers a whirlwind of other activities for the research students. This year's activities included:

First night dinner at Dr. J's
"REU Presents" (faculty or student presentations every Friday for the research group)
Picnic lunch every Wednesday at a Wooster park
Secret Life of Machines video every Monday
Buckeye Women in Science physics demos for junior high campers
Trip to Easton Towne Center (Columbus) and Pirates of the Caribbean
Ethics workshop with Dr. Sandra Greer of University of Maryland
Picnic and pie fest at Dr. Lehman's house
Peer writing review
Poster session for the campus community
Tutorials in Xcode, Mathematica, LabView, LaTeX, Igor, and Canvas
Library instruction



1st row, from left: Mary Mills, Mike Zappitello, Henry Timmers, Martha Roseberry, Nathan Utt
2nd row, from left: Andrew Hershberger, Don Jacobs, Kevin Hoyle, John Lindner, Evan Heidtmann

NSF-REU Projects: Summer of 2006

The Escape Set: Chaos in the Restricted Three-Body Problem
  Evan Heidtmann, CoW '09, advised by John Lindner
Modeling Stochastic Resonance in Hair Cells of the Inner Ear
  Andrew Hershberger, Case Western Reserve University '09, advised by John Lindner
Dynamics of Noisy One-Way Coupled Oscillators
  Kevin Hoyle, Ohio Northern University '09, advised by John Lindner
Self-Organized Criticality in a Zirconium Bead Pile
  Mary Mills, Agnes Scott College '09, advised by Don Jacobs
Precession & Chaos in a Spherical Universe
  Martha Roseberry, CoW '09, advised by John Lindner
Finding the Turbidity of 8-Arm Star Polystyrene in Methylcyclohexane
  Henry Timmers, CoW '09, advised by Don Jacobs
Heat Capacity of a Triethylamine-Water Mixture
  Nathan Utt, CoW '07, advised by Don Jacobs
Measuring the Coexistence Curve of an 8-Arm Star Polystyrene in Methylcyclohexane
  Mike Zappitello, CoW '09, advised by Don Jacobs

Off-Campus Summer Research 2006

Kelly Patton 08, Purdue wrote a computer program that looked at the cosmic ray exposure history of a meteorite that fell in Japan.
Jon Rosch 07 spent the summer at The Joseph Fourier University in Grenoble, France doing research in advanced optics that involved developing a new method to test both lasing and nonlinear optical properties of a Nd:YCOB sphere.
Stephen Poprocki 07 worked with Patrick Sutton at Caltech. He compared the ability of several coherent data analysis techniques, applied to the LIGO and LIGO-Virgo gravitational-wave observatory networks, to detect the gravitational-wave signal of merging binary black holes.
Lisa May Walker 07 was at Michigan State University studying HII regions. She made and analyzed a mosaic image of 30 Doradus, and modified a Fortran program to plot the locations of HST datasets.
Kirsten Larson 08 worked at University of Madison-Wisconsin on a multi-wavelength campaign of three TeV blazars using the WIYN .9m telescope, the VERITAS gamma ray telescope and the AMANDA neutrino telescope.
Danny Tremblay 07 worked at Penn State on the construction of an all solid-state heat pump using an electrocaloric material. Such a device could be used as a novel refrigerator or air conditioner.
Mark Wellons 08 spent the summer at the University of Alaska Fairbanks, where he worked on developing a simulation of solar wind.
Danny Shai 07 went to Penn State University and worked on two projects. The first involved using monte carlo computer simulations to study the heat capacity behavior of Ne and Xe adsorbing to the nanotube surface. He also studied the statistical mechanics of quantum gasses adsorbing on (a) a finite and infinite plane, (b) a circular disk, (c), a sphere, (d) a cylinder, and (e) a cone.
John Gamble 08 went to UC San Diego to numerically study the turbulence of the electron liquid in parallel nanoscale systems and develop a hydrodynamic picture of the electron transport in nanoscale systems.
Mike Davis 07 worked on time correlated single photon counting at the University of Akron.

Awards and Honors

The Arthur H. Compton Prize in Physics

Kathleen Michelle McCreary '06

Established in 1928 by members of the class of 1913 in honor of Dr. Compton, who received the Nobel Prize in Physics in 1927. Awarded to the senior physics major attaining the highest standing in that subject

The Mahesh K. Garg Prize in Physics

Daniel Lindell Tremblay '07

Awarded annually to an upperclass physics major who has displayed interest in and potential for applying physics beyond the classroom

The Josephe Albertus Culler Prize in Physics

John King Gamble '08

Kelly Marie Patton '08

Established in 1942, recognizes excellence in the field of physics and is awarded to the first- or second-year student who has attained the highest rank in general college physics

The Barry M. Goldwater Scholarship

Stephen Thomas Poprocki '07

Daniel Edward Shai '07 (honorable mention)

The Barry M. Goldwater Scholarship and Excellence in Education Program was established by Congress in 1986. Its goal is to provide a continuing source of highly qualified scientists, mathematicians, and engineers by awarding scholarships to college students who intend to pursue careers in these fields. The scholarship is widely considered the most prestigious award in the U.S. conferred upon undergraduates studying the sciences.

Latin Honors

Kathleen Michelle McCreary '06

Summa cum laude

National Meetings

American Physical Society

The National Meeting of the American Physical Society was held March 13-17, 2006, at the Baltimore Convention Center by the harbor in Baltimore, MD. Dr. Jacobs, Dr. Lindner, and Dr. Garg accompanied five students who presented their work at the poster sessions:

Mark Wellons*, Mark Lightfoot*, D.T. Jacobs, "Coexistence curve of a near-critical, eight-arm star polystyrene in methylcyclohexane" Nat'l Meeting American Physical Society, Baltimore MD (March 2006)

John Gamble* and Shila Garg, "Dielectric Properties of Binary Mixtures of MBBA and 7CB"

Ruth Shewmon*, Ryan Hartschuh*, D.T. Jacobs, "Anomaly in the heat capacity of triethylamine and water"

Daniel Tremblay* and Susan Lehman, "Low-Cost Cavity Ring-Down System For Measurement Of High Reflectivity Semiconductor Mirrors"

Megan Miller*, Tuan Nguyen*, Elizabeth Baker*, D.T. Jacobs, "Self-Organized Criticality in a Bead Pile"
•student co-author

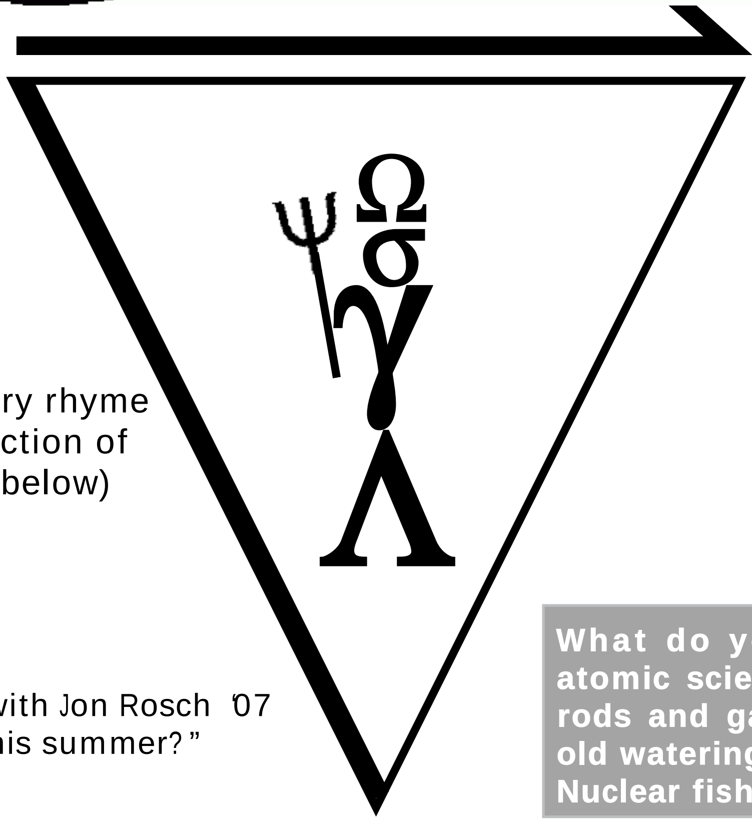
Danny Tremblay, Dr. Lindner, Ruth Shewmon, Mark Wellons, John Gamble, Dr. Jacobs, Megan Miller in Baltimore

American Astronomical Society

The 207th Meeting of the AAS was held in Washington DC in January. Lowell Boone accompanied his three 2005 REU students (Kirsten Larson, Christine O'Brien, and Lisa May Walker) who made the following poster presentations:

C.A. O'Brien*, L.M. Boone, and J.D. Hohertz*, Simulating Particle Dynamics in Tangled Magnetic Field
L.M. Walker*, K.L. Larson* and L.M. Boone, An INTEGRAL Archival Search for Microquasar Candidates

Physics Phun



Can you guess the nursery rhyme represented by this collection of Greek symbols? (answer below)

What do you call it when atomic scientists grab their rods and gather around the old watering hole? Nuclear fishin'

Conversation overheard with Jon Rosch '07
"So, Jon, what'd you do this summer?"

"I worked with lasers"

"How was it?"

"It was intense."

If a new wing were to be added to Taylor Hall, what would it be called?

$$T(x) = \sum_{k=0}^{\infty} \frac{f^{(k)}(a)}{k!}(x-a)^k$$

(a "Taylor Expansion")

So, up in Heaven, all of the physicists are pretty bored.
The physicists, being pretty bored, walk up to God and ask for something to do. God, busy as always, suggests that they play hide and seek. "But who's it?" they ask God. "I don't care! Why don't you make Einstein it?" So they all agree and Einstein is it.

Now, all of the physicists run off to some of the best hiding places in Heaven, except for Newton. Newton simply draws a square in the ground and stands on it. A little bit of time passes.

"Ready or not, here I come!" Yells out Einstein. After searching for a few minutes, he comes upon Newton, runs up, and tags him.

"You're it." says Einstein.

Newton replied with "But you caught a Newton per square meter! You caught PASCAL!"

What do you call a radioactive Wooster Physics major? A hot Scot!

Answer: The Farmer in the Dell

www.wooster.edu/physics