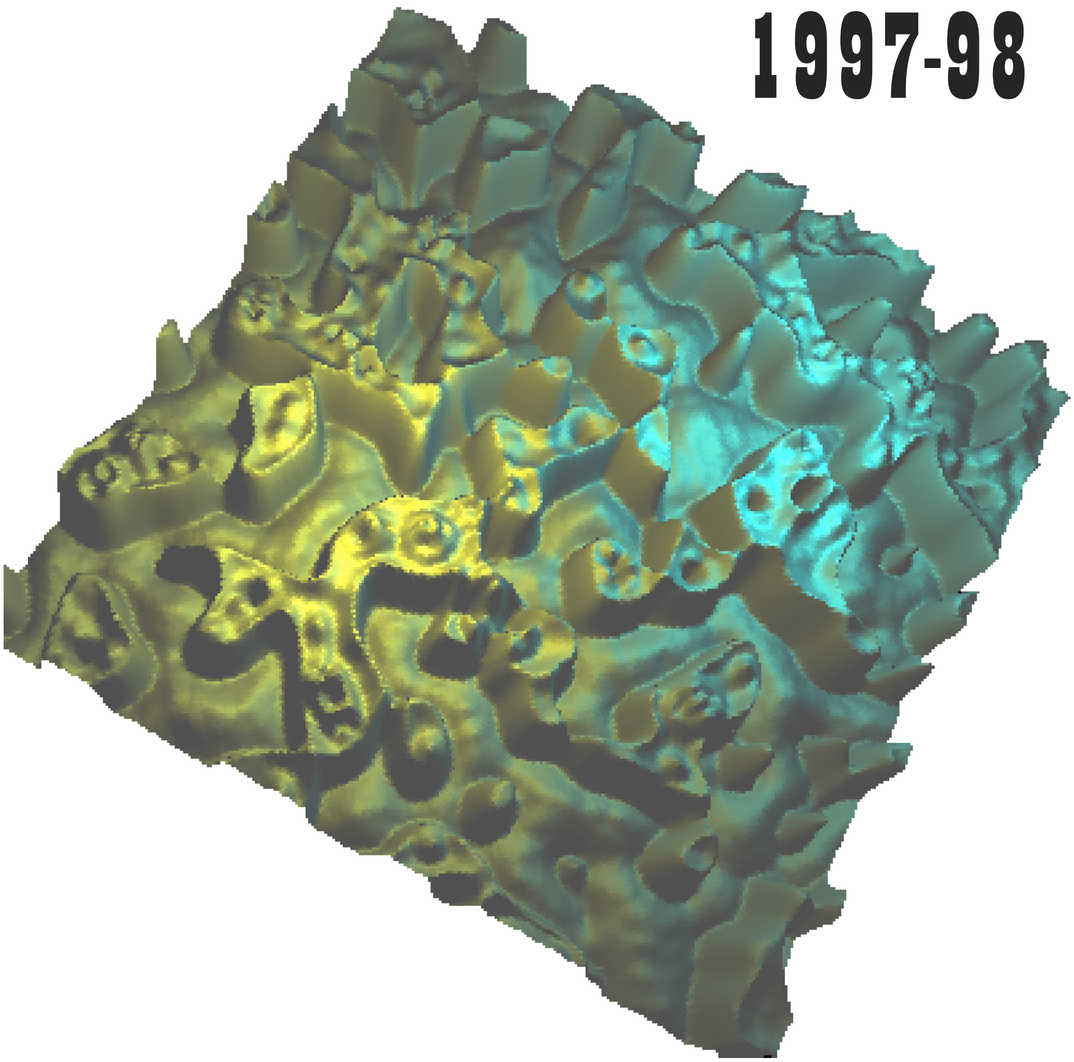
Department of Physics

Annual Report 1997-98



http://www.wooster.edu/Physics

On the cover: Amplitudes of a 128x128 array of coupled bistable oscillators. Photo courtesy of Mark Spano (U.S. Navy), William Ditto (Georgia Institute of Technology) and John Lindner (The College of Wooster). This computer graphic is featured on the 1998 calendar of the American Physical Society.

Contents

Dear Alumni and Friends:

Welcome to the second annual report of the Department of Physics at The College of Wooster. It is a pleasure for me to share with you the accomplishments and activities of our students and faculty during this past year. The department is continuing to grow with the active participation of students, staff and faculty in the process.

Our introductory labs have been upgraded thanks to the support of the College through internal grants. The external grants brought in by the faculty have helped us to upgrade research equipment for faculty and student projects. The physics library recently moved out of Taylor Hall to be a part of the Timken Science Library, which is nearing its completion.

Our students are continuing to work closely with faculty on research projects through the Sophomore Research Program, summer research, and Independent Study. In the past year there were seven C.O.W. students and three REU off-campus students who were co-authors of papers published by our faculty in refereed journals. It is becoming a fairly common sight to see a Wooster student presenting a poster at the March APS meeting. Our department also had the honor of producing the second Goldwater Scholar in three years. Junior Carrie Williams was a recipient of this prestigious scholarship. We are continuing our outreach efforts to encourage young women to pursue sciences. Our lab technician, Judith Elwell, has been an essential part of these efforts. I would like to acknowledge her role in making these events successful.

We were sorry to lose a colleague and alumna this summer to industry. We wish Anna Andrews all the best in her new career. We welcome a new colleague, Don Colladay, to the department and look forward to working with him. The department will be conducting a search to fill a tenure-track position in the coming year.

Finally, our thanks go to the department secretary, Jackie Middleton, who was primarily responsible for compiling this report of the past year's activities. Jackie has also been doing a great job of maintaining the departmental Web pages.

I would like to thank those who responded by sending back the alumni information sheet. There are still many of you out there that we have not heard from. We would like to hear from you in an effort to develop and maintain contact with our alumni.

Sincerely,

Shila Garg
Chair of Physics

The Class of 1998

Jason Darfus
Lancaster, Ohio

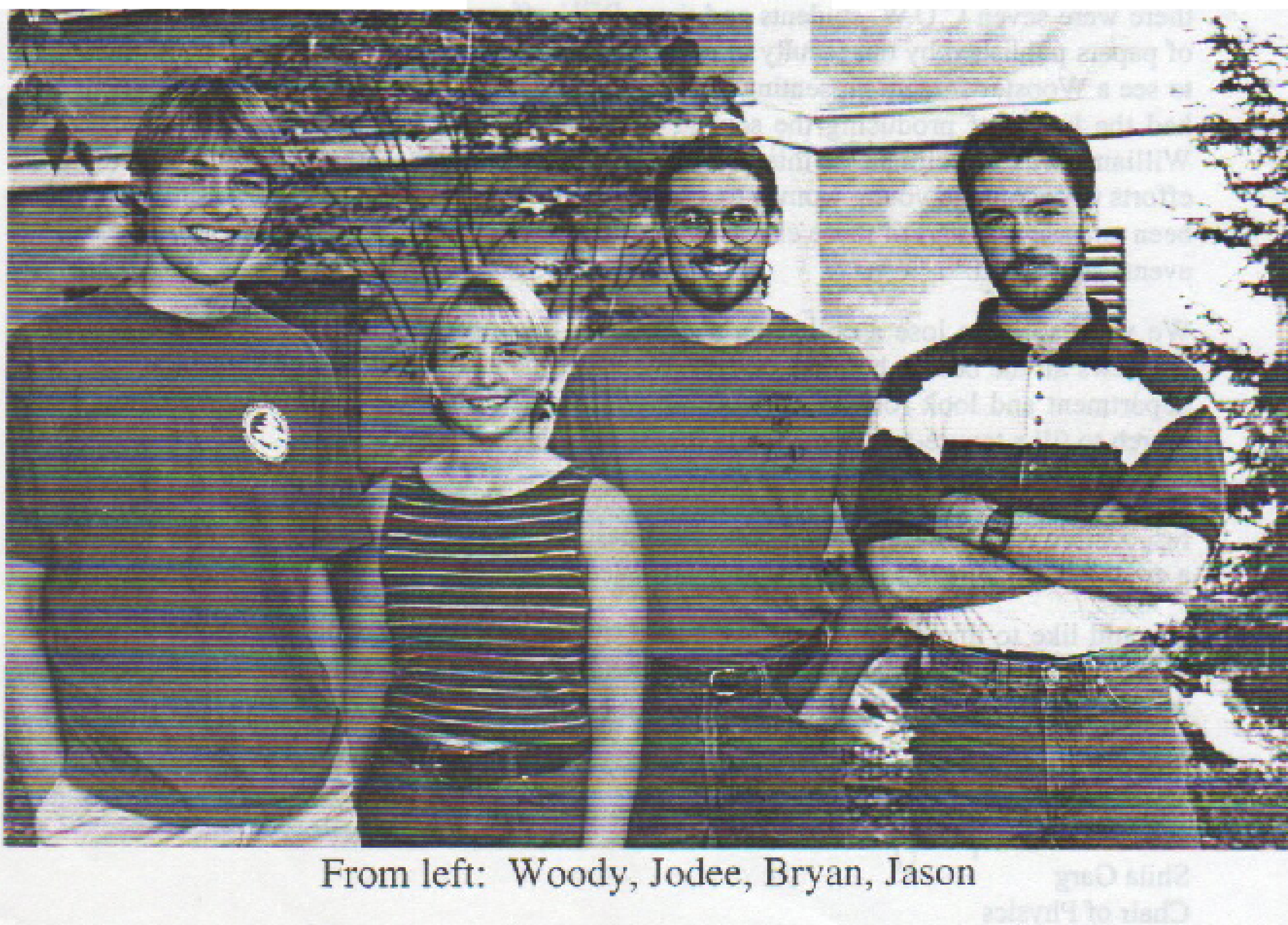
Sahibzada Amir Hassan
Lahore, Pakistan

Jodee Jones
Bay Village, Ohio

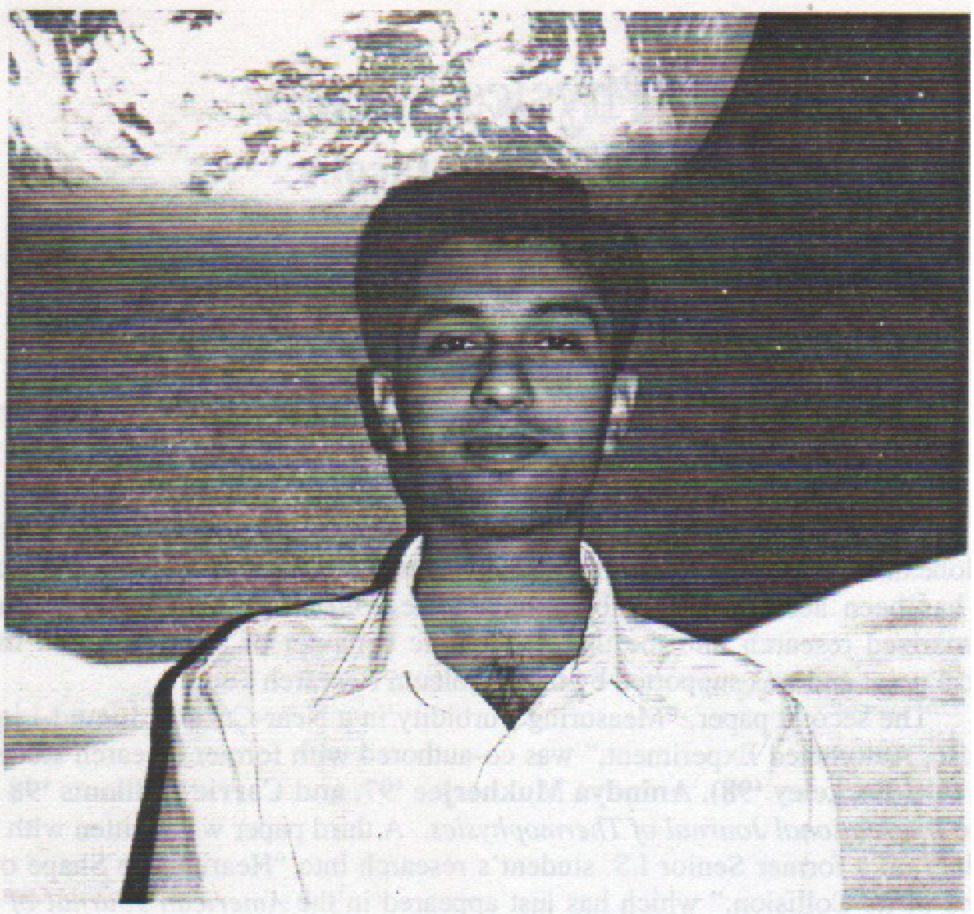
Jonathan Keim
Green Springs, Ohio

Bryan Prusha
Chardon, Ohio

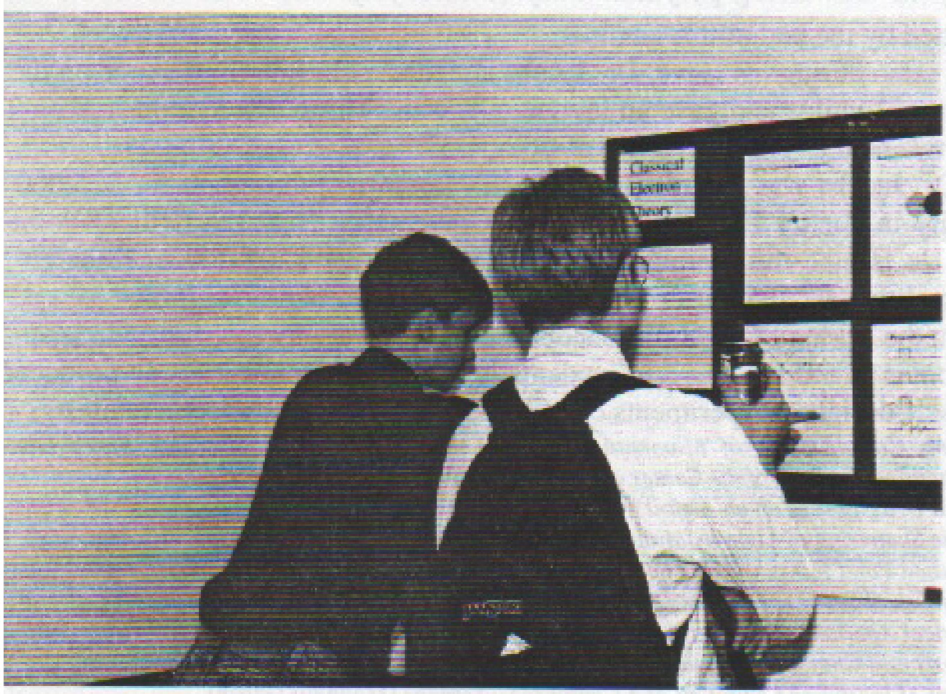
Woody Shew
Stockport, Ohio



From left: Woody, Jodee, Bryan, Jason



Amir, a 3/2 engineering student,
attends Washington University in St. Louis.



John (left) explains classical electron theory during
the Annual I.S. Poster Session.

Physics Faculty

Donald Jacobs

http://www.wooster.edu/Physics/Jacobs
Victor J. Andrew Professor of Physics
Faculty member at Wooster since 1976.
B.A., M.A. South Florida 1971, 1972;
Ph.D. Colorado 1976.

Dr. Jacobs spent a very productive research leave in the Fall of 1997. The leave, spent predominately at Wooster, gave him the opportunity to pursue several research projects and to complete two projects for publication.

The first paper, “Heat Capacity Anomaly Near the Critical Point of Aniline-Cyclohexane” was co-authored with his current student research assistant **Paul Rebillot ‘99** and has been accepted for publication in the *Journal of Chemical Physics*. This work summarized research into the thermodynamic behavior of a liquid-liquid mixture near its critical point and was supported by the Petroleum Research Fund.

The second paper, “Measuring Turbidity in a Near-Critical, Liquid-Liquid System: a Precise, Automated Experiment,” was co-authored with former research students **Stephanie Lau (UC Berkeley ‘98)**, **Anindya Mukherjee ‘97**, **and Carrie Williams ‘98** and submitted to the *International Journal of Thermophysics*. A third paper was written with Professor John Lindner on a former Senior I.S. student’s research into “Hearing the Shape of a Rod by the Sound of its Collision,” which has just appeared in the *American Journal of Physics*. 1997 graduate **Francesca Mascarenhas’** senior project used a spectrum analyzer to measure the harmonic content of colliding rods and to explain that spectrum with physical models.

A fourth work that resulted from Dr. Jacobs’ stay at the University of Maryland last October is a collaboration with Professor Sandra Greer on the surface tension, viscosity, and density of the “living polymer” Poly (α-methystyrene). An article on this work will be submitted by the end of this summer.

Also during his leave, Dr. Jacobs attended a Gordon Conference on the Chemistry and Physics of Liquids and gave an invited talk at the Thirteenth Symposium on Thermophysical Properties held at The University of Colorado.

Dr. Jacobs was awarded a Petroleum Research Fund grant for $25,000 to study “Heat Capacity in Binary Fluid Mixtures and Universality Near the Critical Point” during 1997-1999. He is also the recipient of a NASA grant for $202,000 to research "Turbidity and Universality Near and Far From the Critical Point" during 1998-2002.

In the Spring of 1998, Dr. Jacobs taught General Physics, Junior Independent Study, and Electronics II and its lab. His students in Junior Independent Study produced an interesting set of self-designed experiments chosen according to each student’s interests:

- *Applying Conservation of Momentum to Systems of Particles in Two and Three Dimensions and Determining the Path of the Center of Mass* (Manon Grugel)
- *Lift and Drag Forces on an Airfoil in a Wind Tunnel* (Nathan Schiffrik)
- *Chaotic Scattering of Light by Multiple Mirrored Cylinders* (Zakir Thaver)
- *Frustrated Total Internal Reflection: Optical Tunneling in Two Right Angle Prisms* (Paul Rebillot)
- *A Biophysical Study of Sprinting* (David Walkenhorst)
- *Numerical Aperture of a Fiber Optic Cable* (Josh Bozeday)
- *Synthesis and Characterization of a PVA-PAA Gel in an Electric Field* (Carrie Williams)
- *Moment of Inertia and Nutation of a Captured Gyroscope* (Madhujit Ghosh)
- *The Dynamics of a Flat Body Falling Through a Fluid: Looking for Chaos* (Christy Rauch)
- *Approximating a Gravitational Field* (Andrew Kuck)

Shila Garg

http://www.wooster.edu/Physics/Garg
Associate Professor and Chairperson of Physics
Faculty member at Wooster since 1987.
B.S. Madras (India) 1970;
M.S. Sussex (U.K.) 1972;
Ph.D. Kent (U.K.) 1975.

In the Fall of 1997, Dr. Garg taught General Physics and its lab, as well as Modern Physics and its lab. In the Spring of 1998, she taught Foundations of Physics and its lab. She also taught the Modern Optics course and modified it considerably by incorporating significant new material on atomic physics.

Dr. Garg's areas of current research include:

1) Periodic Instabilities in Nematic Liquid Crystals Subjected to Electric and Magnetic Fields (Collaborator: Dr. U.D. Kini, Raman Research Institute, India)
2) Focal Conic Domain Growth in Smectic A Liquid Crystal Subjected to an Electric Field (Collaborator: Dr. Oleg Lavrentovich, Liquid Crystal Institute, Kent State University)
3) Phase Transitions in a Physiological Mixture of Lyotropic Liquid Crystals (Collaborator: Dr. Phil Westerman, NEOUCOM)

Two of Dr. Garg's publications have appeared during the period of this report. "Frequency Variation of Periodic Distortion Thresholds in a Nematic Liquid Crystal appeared *Liquid Crystals* and was coauthored by former students **Steven Wild (Baldwin Wallace '96)**, **Ben Zurn (Hamline University '97)** and **Salman Saeed '96**, as well as U.D. Kini. "Frequency Dependent Threshold in Bend Geometry of 5CB" appeared in *Molecular Crystals Liquid Crystals* and was coauthored by former students Saeed, Wild, **Erica Bramley '97**, and U.D. Kini. A third paper, "Electric Field Induced Walls in the Bend Geometry of a Nematic Liquid Crystal," has been accepted for publication in *Molecular Crystals Liquid Crystals* and was coauthored by Bramley and Kini.

Dr. Garg is the recipient of a National Science Foundation/Research at Undergraduate Institutions grant of $64,000 to study "Electric Field Induced Periodic Deformations in Nematic Liquid Crystals." She is also the project director for the department's NSF/Research Experience for Undergraduates for the fifth summer in a row.

Throughout the past year, Dr. Garg served as CUR Councilor for Physics and Astronomy and attended a CUR Councilor's Annual Meeting at Lafayette College, PA. She participated in three review panels for the National Science Foundations in Washington DC where she read grant proposals and evaluated them. As well as serving as Chairperson of the Physics Department, Dr. Garg also served on the College's Teaching Staff and Tenure Committee, Academic Planning Committee, and is a member of the Survivor Support System for victims of sexual assault. She was the advisor of the South Asia Committee and was responsible for planning South Asia Week events and the annual India Dinner.

John Lindner

http://www.wooster.edu/Physics/Lindner
Associate Professor of Physics
Faculty member at Wooster since 1988.
B.S. Vermont 1982;
Ph.D. California Institute of Technology 1989.

In the Fall of 1997, Dr. Lindner taught Mechanics, General Physics lab, and a section of First Year Seminar. His seminar, entitled "The Conscious Universe," revisited many of the great metaphysical problems of philosophy and religion and viewed them through the lens of modern science, especially late 20th century physics. His students examined the emergence of matter from spacetime, life from matter, and mind from life. They also speculated on the future and presented their visions of life on Earth in the year 2050.

In the Spring, Dr. Lindner taught Astronomy, Astrophysics, General Physics lab, and directed the Junior I.S. computer simulations (see page 14)

Dr. Lindner's current research involves the use of disorder and noise to regularize extended nonlinear systems, chaotic neurons, and computer visualization. His Macintosh program "Chaotic Flows" was given an Honorable Mention Award by *Computers in Physics* annual software competition. This program was coauthored by students **Bryan Prusha '98** and **Josh Bozeday '99**. Dr. Lindner's research was featured on the cover of the 1998 calendar of the American Physical Society (see cover of this report). In addition, his patent application "Noise—And Coupling—Tuned Signal Processor With Arrays Of Nonlinear Dynamic Elements," submitted by Dr. Lindner and colleagues at the Georgia Tech Applied Chaos Lab, was approved (US Patent #5,789,961). He recently received a $10,000 grant from Georgia Tech and the U.S. Navy to purchase computing equipment for his research. In addition, he reviewed papers for *Physics Essays, American Journal of Physics,* and *Chaos*.

For committee service, Dr. Lindner served on the Copeland Fund for Independent Study committee, the College Scholar Exam committee, and the Goldwater Scholarship committee. In fact, this year, all four of Wooster's Goldwater Scholarship nominees were physics majors. Dr. Lindner also served as advisor to the Society of Physics Students.

Dr. Lindner gave several talks on campus this year. Last fall he presented a talk at Douglass Hall on "The Cassini Mission to Saturn." He spoke on "The Conscious Universe" to a Women in Science group and presented "Chaos in the Clockwork" to a Faculty Lunch Seminar.

Dr. Lindner had two publications appear during the period of this report:

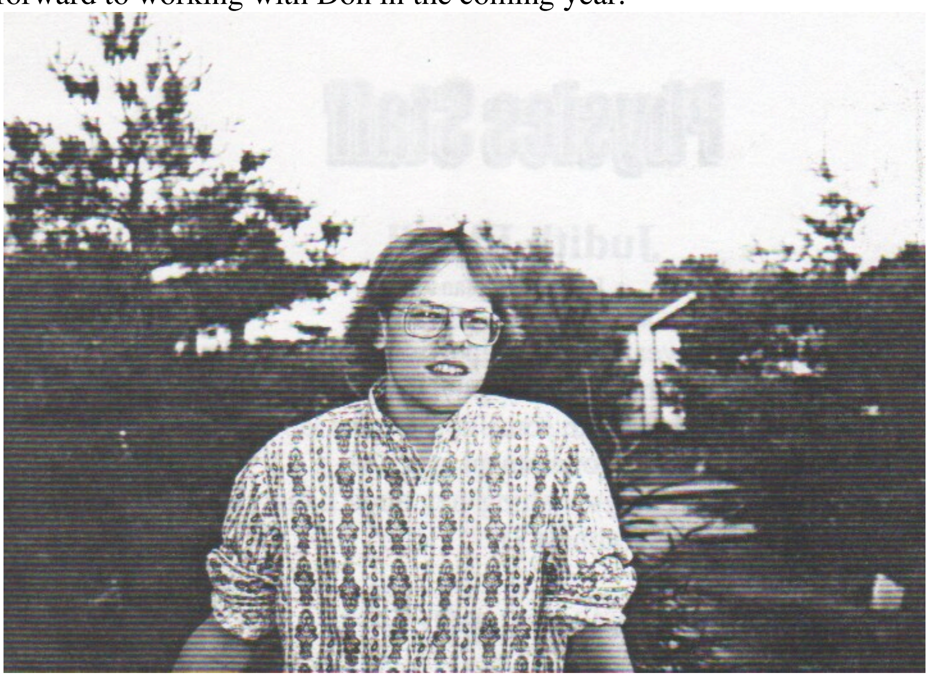
1) J. Lindner, B. Meadows, T. Marsh, W. Ditto, A. Bulsara
"Can A Neuron Distinguish Chaos From Noise?"
International Journal of Bifurcation and Chaos, to appear summer1998.
2) F. Mascarenhas*, C. Spillmann*, J. Lindner, D. Jacobs
"Hearing The Shape Of A Rod By The Sound Of Its Collision"
American Journal of Physics, **66** (8) 692-697 (1998).
*student co-author

Farewell....

The Department of Physics bids a fond goodbye to Professor Anna Andrews, who left The College of Wooster this past spring to become an industrial scientist at Ferro Corporation. Dr. Andrews was a faculty member of Wooster's Physics Department since 1993. We wish Anna, husband Kevin, and daughter Gwynneth a happy and healthy future.

and Welcome....

Don Colladay joins the Physics Department faculty for the 1998-99 year as a visiting assistant professor. He received his B.S. from Rensselaer Polytechnic Institute in 1992 and his Ph.D. from Indiana University in 1998. During the year 1997-1998, Don taught Introductory Acoustics Laboratory sections as well as served as a research assistant at Indiana University. During the summer he taught General Physics II. We are looking forward to working with Don in the coming year.



Dr. Colladay's Research Interests

Modern particle physics models strive to unify the various forces and interactions in nature. Symmetries are fundamental in this process. For example, assumed symmetry of the laws of physics under time translations (the fundamental laws of physics will be the same tomorrow as they are today) leads to conservation of energy, one of the most basic laws of physics. One symmetry of the standard model of particle physics is CPT, the combined action of charge conjugation, parity reflection, and time reversal. CPT is known to be an exact symmetry of any local, relativistic field theory describing point particles.

In recent attempts to unify gravity with the other fundamental forces (for example, string theory) the possibility of violating CPT arises due to the presence of new interactions not present in conventional particle physics models. The CPT-violating effects at presently attainable energy scales appear as tiny remnants of the unified underlying theory. In collaboration with Alan Kostelecky at Indiana University, a consistent theoretical framework has been developed for handling such terms in the context of conventional particle physics involving quarks, leptons, and force mediators of the standard model.

Our studies of effects in oscillations of neutral-B mesons have led to the first bounds of CPT violation in this system by the OPAL and DELPHI collaborations at the high-energy collider at CERN. We have also investigated the implications of CPT violation for baryogenesis, the study of the predominance of matter over antimatter in the universe. CPT-violating effects allow the production of matter to be energetically favorable to the production of antimatter thus providing a possible mechanism for baryogenesis to occur. The presence of CPT violation has ramifications in atomic spectroscopy and optics as well as in high-energy particle physics. For example, certain terms can cause modifications to the conventional Maxwell equations that may have observable consequences for classical electrodynamics.

In addition to studying these effects in more detail, Dr. Colladay is also interested in expanding his research into musical acoustics. He spent two semesters at Indiana University teaching an introductory acoustics lab that utilized various analysis tools to explore the physics of sound. He has also been studying music for many years and would like to incorporate this knowledge into his research.

Physics Staff

Judith Elwell

Lab Technician
jelwell@acs.wooster.edu

Now in her eighteenth year as the department's lab technician, Judy's main responsibility is setting up the introductory physics labs. Since that setup is fairly straightforward, she has time to help with some upper-level lab setups and various record keeping responsibilities mandated by government agencies.

In her spare time, Judy enjoys visiting her three daughters as well as her two grandsons, Justin (age 4) and Adam (almost 2).

Jackie Middleton

Secretary
Departments of Physics and Mathematical Sciences
jmiddleton@acs.wooster.edu

Jackie has begun her tenth year as secretary to the departments in Taylor Hall. Each year brings new and exciting challenges to her job. The World Wide Web has added a new aspect to her work, and she has enjoyed learning how to create Web pages. Jackie looks forward to meeting new students each year and watching the changes (for the better!) that they go through as they progress from apprehensive first years to confident seniors. At home in Smithville, she stays busy with two sons, Gabe (age 16, new driver, yikes!) and Caleb (age 12), as well as two monster Labrador Retrievers, Jessie and Sienna.

Who's Who at a University (submitted by Jackie)

THE DEAN
Leaps tall buildings in a single bound
Is more powerful than a locomotive
Is faster than a speeding bullet
Walks on water
Gives policy to God

THE DEPARTMENT HEAD
Leaps short buildings in a single bound
Is more powerful than a switch engine
Is just as fast as a speeding bullet
Walks on a placid lake
Talks with God

PROFESSOR
Leaps short buildings with a running start and favorable winds
Is almost as powerful as a switch engine
Is faster than a speeding BB
Walks on water in an indoor swimming pool
Talks with God if a special request is honored

ASSOCIATE PROFESSOR
Barely clears a Quonset hut
Loses tug of war with a locomotive
Can fire a speeding bullet
Swims well
Is occasionally addressed by God

ASSISTANT PROFESSOR
Makes high marks on the walls when trying to leap tall buildings
Is run over by locomotives
Can sometimes handle a gun without inflicting self-injury
Treads water
Talks to animals

INSTRUCTOR
Climbs walls continually
Rides the rails
Plays Russian Roulette
Walks on thin ice
Prays a lot

GRADUATE STUDENT
Runs into buildings
Recognizes locomotives two out of three times
Is not issued ammunition
Can stay afloat with a life jacket
Talks to walls

UNDERGRADUATE STUDENT
Falls over doorstep when trying to enter buildings
Says "Look at the choo-choo"
Wets himself with a water pistol
Plays in mud puddles
Mumbles to himself

DEPARTMENT SECRETARY
Lifts buildings and walks under them
Kicks locomotives off the tracks
Catches speeding bullets in her teeth and eats them
Freezes water with a single glance
She IS God.

A Look Back...

1988 Senior Independent Study Projects

Supratik Burman
An Analysis of the Wave/Particle Nature of Statistically Independent Photons

Sergio DeSouza-Machado (Math and Physics)
A Computer Simulation Study of Deterministic Dissipative Systems Exhibiting Chaotic Behavior

Gregory D. Elfring (Math and Physics)
An Introduction to Fractal Geometry and its Applications

Todd A. Ewers (Chemical Physics)
Observation of Phase Transitions in Ceramics, Cyclobutanes, and Cycloheptanes by DSC Methods

Vonda Fairbanks
The Excess Volume Effect of Methanol-Cyclohexane in the One-Phase Region

Ashok Mittal
A Study of Brownian Motion Using Photon Correlation Spectroscopy

Palani Sakthivel
Coefficient of Expansion of a Thin Aluminum Film

Stephen G. Stafford
Turbidity Measurements in the Near Critical Region for the Binary Mixture Polystyrene Diethyl Malonate

Andrew Yuen (Math and Physics)
3/2 Engineering Program

1993 Senior Independent Study Projects

Joshua Fagans
The Fourth Dimension Unveiled: A Preliminary Reconnaissance of Four Dimensional Objects From Mathematics and Physics

Peter Hourigan
New Nematic-Smectic-A Transition Instability in Di-Heptyl-Alkyl Azoxybenzene Liquid Crystal Focusing on Anchoring Breaks and Transitions

Prashant Jain (3/2 Engineering Program)

Nikfar A. Khaleeli
Adiabatic Calorimetry Measurement of the Heat Capacity of the Binary Fluid Triethylamine-Water Near the Critical Point

Asad Khan
The Chaotic Behavior of a Single-Mode Semiconductor Injection Laser Coupled with an External Feedback Cavity

Linda D. King
An Investigation of the Excess Volume Effect of the Binary Liquid Mixture Perfluoromethylcyclohexane + Isopropyl Alcohol

Taka Kumashiro (Physics and Philosophy)
Quantum Metaphysics: A Dialogue in Search of Knowledge

Christopher J. Levy
Self-Organized Criticality in a Conical Sandpile

Mark McKinney
Chaos in Polymer Dispersed Liquid Crystals

Joseph Neff
Signal Recognition Using Chaos and Control Algorithms

1998 Senior Independent Study

Photometric Measurements of Variable Stars as a Tool to Determine Astronomical Distances

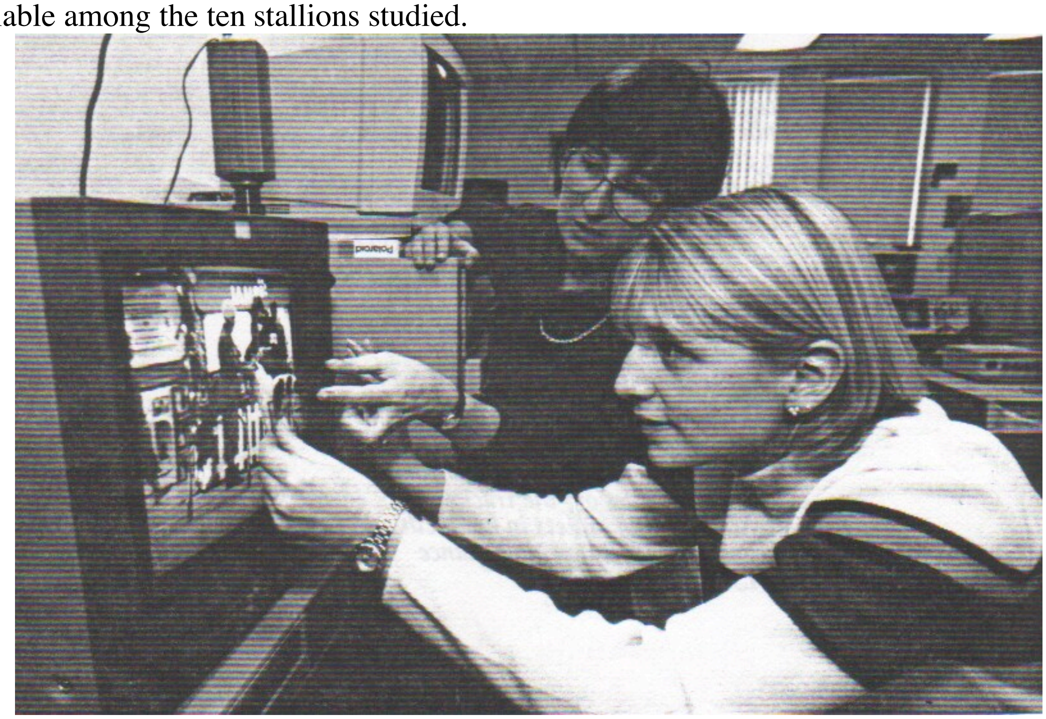
by Jason Darfus   Advisor: Shila Garg

Abstract: A period-luminosity relationship for variable stars exists which makes it possible to find distances to remote regions of the universe. By studying a variable star located within a distant object such as another galaxy and determining the period by which its apparent brightness changes, it is possible to obtain a reasonable estimate for its luminosity, or actual power output. From these two quantities of stellar luminosity and apparent brightness, a distance can be calculated by using the inverse-square law — that the apparent brightness of a star as seen on Earth is proportional to the star's luminosity and inversely proportional to the square of its distance.

Kinematic Parameters Important to Biological Motion: A Macroscopic and Microscopic Analysis

by Jodee Jones   Advisor: Anna Ploplis Andrews

Abstract: Lure coursing events and conformation trials both provide an excellent source of data for canine gait analysis. In this study both the trot and the gallop frequencies are related to leg length for a variety of breeds of dogs. The experimental slope for the trot is -0.61 ± 0.002, compared to the expected value of -0.5 for a pendulum-like gait. The experimental slope for the gallop is -0.86 ± 0.006, compared to the expected value of -1 for a maximum torque model. Stallion spermatozoa provide an ideal source of data for a microscopic study of motion. Antibiotics, temperature, and time each affect the velocity and percent motility of stallion sperm. Various doses of gentomicin sulfate decrease both average velocity and percent motility, but the effects vary for each stallion. A time period of 24 hours also has a detrimental effect on percent motility. Again, the effect is variable among the ten stallions studied.



Classical Electron Theory For a Non-point Charge

by John Keim Advisor: John Lindner

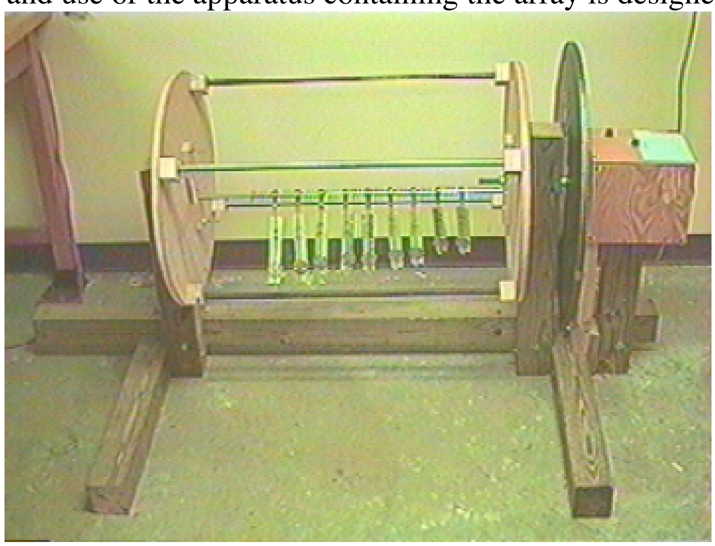
Advisor: John Lindner

Abstract: Here, I have tried to outline the main attempts to restore consistency to the classical model of the electron. Fortunately, pre-acceleration can be removed if the electron is larger than $4e^2/3m_ec^2$, but a solution to the "4/3 problem," which I derive, requires integrating the properly covariant densities, and is left as an exercise.

Taming Chaos in an Array of Pendulums

by Woody Shew Advisor: John Lindner

Abstract: A real coupled array of ten damped, driven, nonlinear pendulums was designed, built, and studied. When the pivot was driven in a circle of radius 3 cm at a frequency of 8.5 rad/sec, the homogeneous array behaved chaotically. The pendulums were then randomly disordered so that their lengths fell in a range of 12 to 20 cm. Then the same driving parameters forcing this heterogeneous array produced periodic motion. Taming chaos with disorder in this parameter regime was determined to depend upon the arrangement of long and short pendulums in the disordered array and was independent of the initial conditions (initial positions and velocities between ±0.1 rad and ±0.1 rad/sec). The construction and use of the apparatus containing the array is designed in detail.



Woody's experimental apparatus

Nonlinearity and Computation:
Implementing Logic as a Nonlinear, Dynamical System

by Bryan Prusha

Advisor: John Lindner (Physics) and Denise Byrnes (Comp Sci)

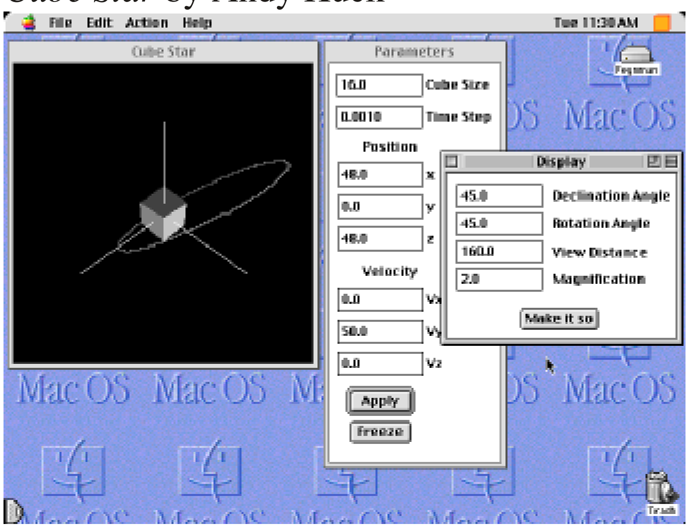
Abstract: The areas of nonlinear dynamics and computation have typically been regarded as separate areas of study. This thesis explores the intersection of these disciplines. I first investigate a recent model that attempts to emulate logic with an array of threshold coupled nonlinear elements. I design a variation of this system which overcomes some of its inherent limitations. However, other limitations remain. I then consider a second system in which a single nonlinear, multivariate map is used to implement all logic gates. The logic "hardware" described by this multivariate map can be reprogrammed with "software" parameters applied to the update map. This system illustrates why logic requires nonlinearity.

Junior Independent Study

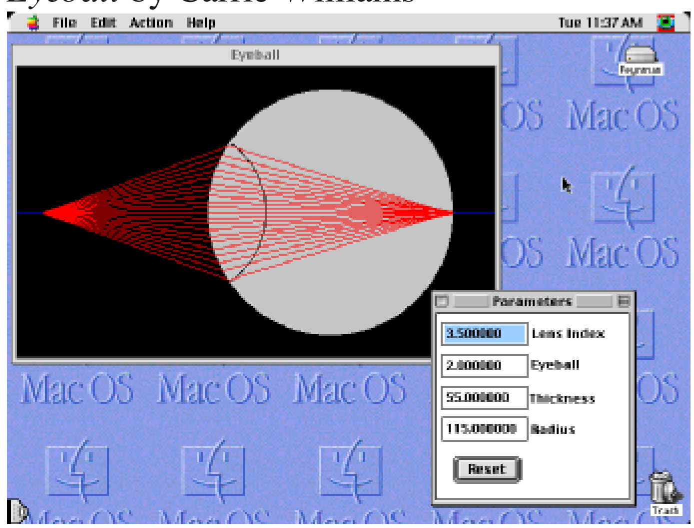
With ten students in Junior I.S. this past spring, Dr. Jacobs, with help from Dr. Andrews, had his hands full. A total of five experiments are required, including one self-designed experiment and a computer simulation of a physical phenomenon. The computer simulation projects were under the direction of Dr. Lindner. During this portion of the course, students get the opportunity to learn or improve programming skills and are required to fully document their program and software. Students present their simulations to faculty and students in what always turns out be a dazzling array of computerized physics.

1998 Junior I.S. Computer Simulations

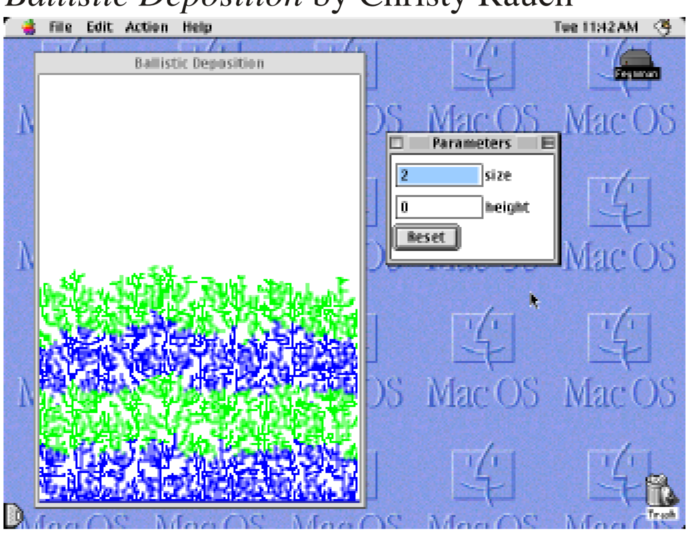
Cube Star by Andy Kuck



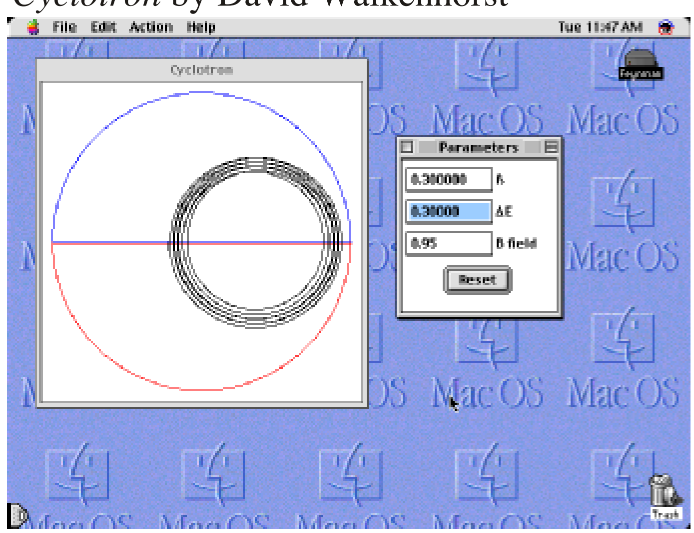
Eyeball by Carrie Williams



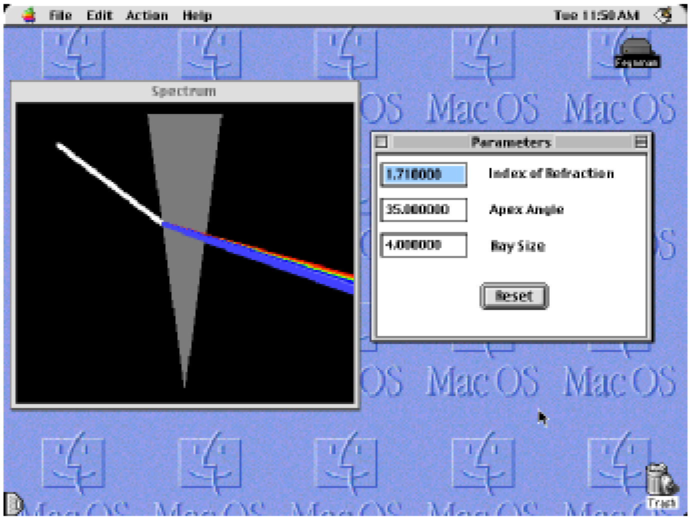
Ballistic Deposition by Christy Rauch



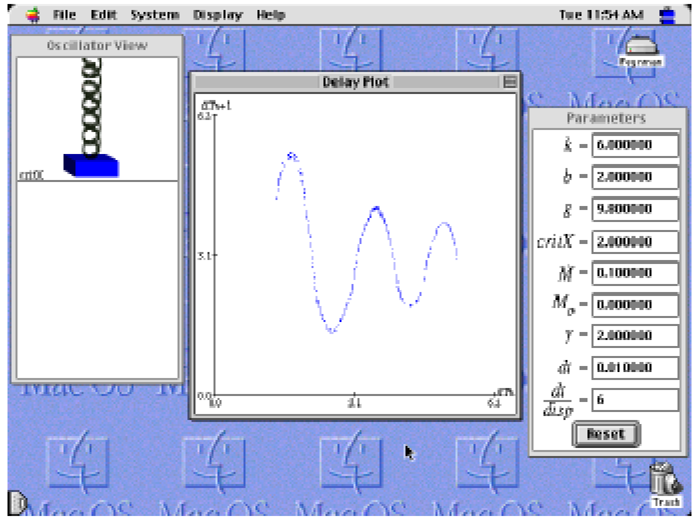
Cyclotron by David Walkenhorst



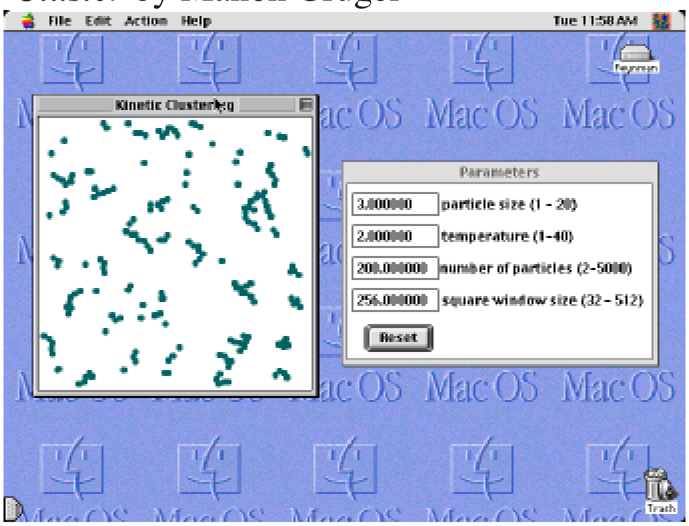
Spectrum by Dinki Ghosh



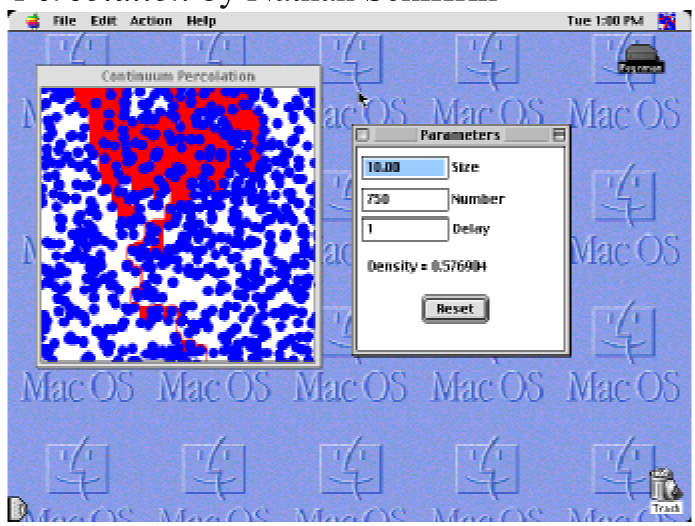
Drip Drop by Josh Bozeday



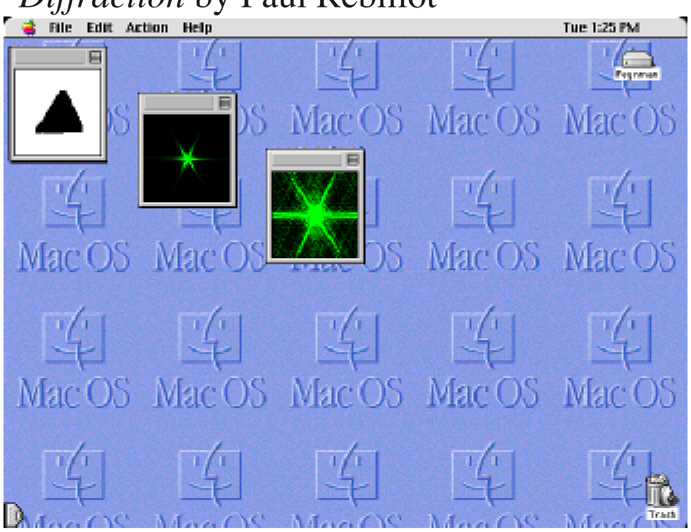
Cluster by Manon Grugel



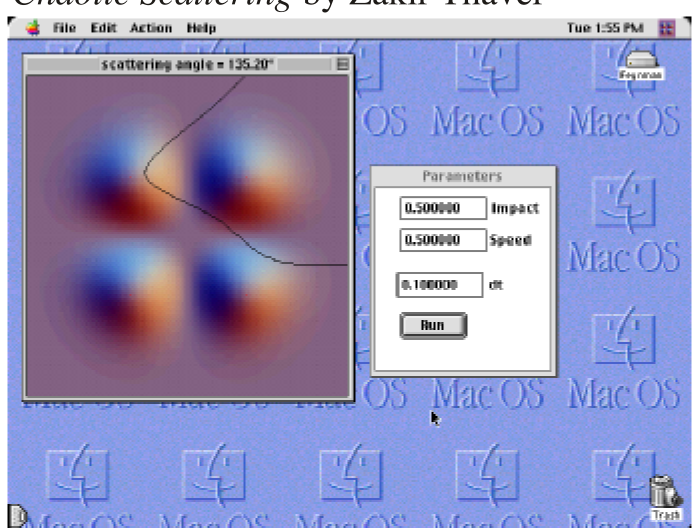
Percolation by Nathan Schiffrik



Diffraction by Paul Rebillot



Chaotic Scattering by Zakir Thaver



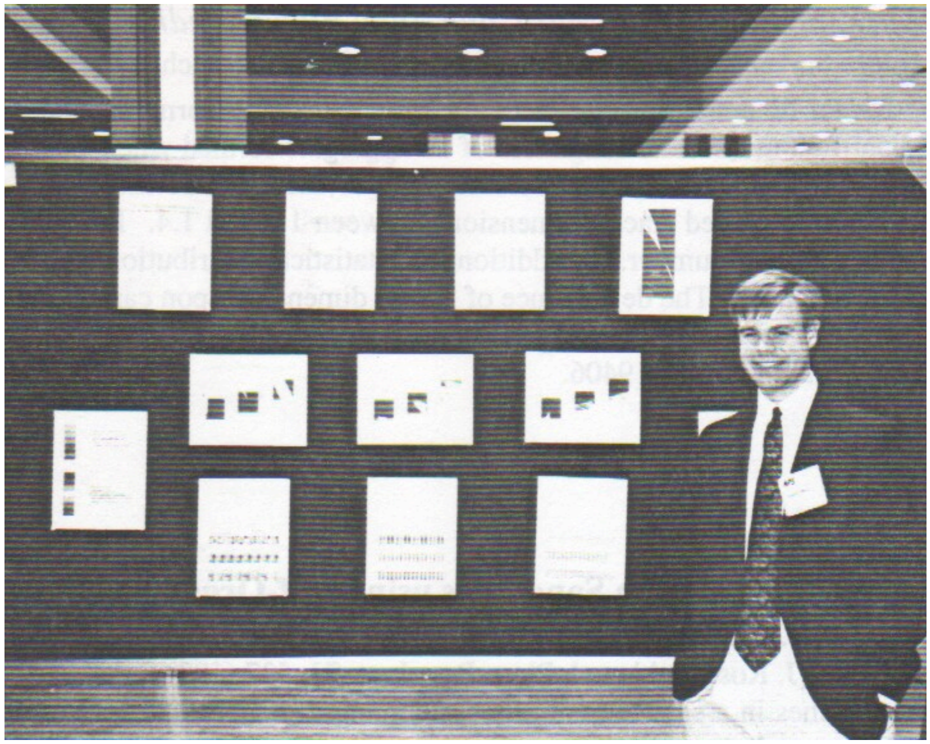
National Meeting of the American Physical Society
Los Angeles Convention Center
Los Angeles, CA
March 16-18, 1998

Dr. Garg and Dr. Lindner had the privilege of accompanying five students to the National APS meeting last March. At the undergraduate poster session, our five students presented their research from last summer's REU program. Wooster research was very well represented, along with schools such as Occidental, Swarthmore, and Caltech. The students were also treated to a tour of Los Angeles with Dr. Lindner (a Caltech grad!) as their personal guide.

The Wooster Crew

The sign behind them says "Do not walk on the grass." How did they get there?

From left: Kelle Cruz, University of Pennsylvania '00; Kirstin Purdy, Carnegie Mellon '99; Dr. Lindner; Carrie Williams, College of Wooster '99; Josh Bozeday, College of Wooster '99; Andrew Kuck College of Wooster '99; Dr. Garg



Josh proudly displays his research results.

ABSTRACTS:

Taming Chaos with Disorder in Arrays of Phase Lock Loops

Josh Bozeday and John Lindner

Disordering certain coupled arrays of nonlinear elements can convert chaotic motion to periodic motion. We investigate this phenomenon in several ways. First, we create parameter space portraits of the dynamics, locating fingers of chaos in seas of periodicity. Second, we tame chaos with disorder in arrays of coupled pendulums and, for the first time, in arrays of phase lock loops. The latter success may have applications in detector arrays. This research was supported by NSF grant DMR-9619406.

Growth of Focal Conic Domains in a Smectic A Liquid Crystal

Kirstin Purdy, Erica Bramley, and Shila Garg

The growth of focal conic domains in the smectic-A phase of liquid crystal CCN-47 due to an applied electric field was investigated at two different temperatures [Z. Li and O. Lavrentovich, Phys. Rev. Lett. 73, 280 (1994)]. The growth rate of the focal conic domains was measured and plotted as a function of the applied voltage. The initially stable domains are observed to change very slowly until at a threshold voltage a critical domain size is reached and it begins to nucleate. Once nucleated, the domain growth rate changes drastically. The growth patterns and dynamics in the pure liquid crystal are compared with those of the same material doped with kunipia-f nanoparticles. This research was performed at The College of Wooster and supported by REU grant NSF-DMR 9619406.

Examination of the Fractal Dimension of Fatty Acid Aggregates

Andrew J. Kuck, Michele C. Hayward, and Anna Ploplis Andrews

This study explore the relationship between the length of the carbon chain on various η-alkanoic acids and the fractal dimension of the resulting aggregates they form. Fractal dimension was chosen as a quantified measure of roughness of an aggregate formed when a solution of acid in chloroform is evaporated from a water surface. Measurements of 11 fatty acids were made at room temperature and yielded fractal dimensions between 1.0 and 1.4. Fractal dimension was found to vary with carbon number. In addition, the statistical distribution of fractal dimension for each acid was recorded. The dependence of fractal dimension upon carbon number follows a trend similar to that seen in bulk-melting point versus carbon number. This research was supported by NSF grant DMR-9619406.

Predicting Earthquakes from Sand Piles using Self-Organized Criticality

K.L. Cruz and D.T. Jacobs

It has been proposed [J. Rosendahl et.al, Phys. Rev. Lett. 73, 537 (1994)] that earthquakes can be modeled by avalanches in a simple sand pile system and that increased activity before a major avalanche could be used to predict the onset of major earthquakes. With smooth glass beads forming a conical pile, we find experimentally that adding one bead at a time causes many small, and a few large, avalanches consistent with the predictions of Self-Organized Criticality. In particular, the number of avalanches of a given size is proportional to the size of the avalanche to the power (-1.43 ± 0.05). We do not see any increased activity before a major avalanche, which is consistent with the behavior of earthquakes associated with some faults, but inconsistent with Rosendahl's results and the behavior of other faults. We also compare our results with a recent simulation that showed a characteristic time between major avalanches. This research was performed at The College of Wooster and supported by REU grant NSF-DMR 9619406.

Turbidity in a Near-Critical, Liquid-Liquid System

C.A. Williams, D.T. Jacobs, S.M.Y. Lau, and A. Mukherjee

A ground based (1-g) experiment is in progress that measures the turbidity of the density-matched, binary fluid mixture Methanol-Cyclohexane extremely close to its liquid-liquid critical point. By covering the range of reduced temperatures $t = (T-T_c)/T_c$ from 10^{-8} to 10^{-2}, the turbidity measurements will allow the critical exponent η to be determined. The transmitted and reference light intensities can be measured to 0.1 percent, the fluid temperature can be controlled to 6.5 microKelvins near room temperature, and preliminary turbidity data show a non-zero η consistent with theoretical predictions. No experiment has precisely determined a value of the critical exponent η, yet its value is significant to theorists in critical phenomena. Relatively simple critical phenomena, as in the liquid-liquid system studied here, serve as model systems for more complex behavior near a critical point. This research was supported by NASA grants NAG3-1404 and NAG8-1433 and C.A.W. and S.M.Y.L. acknowledge summer support from NSF DMR-9619406.

REU

Research Experience for Undergraduates
Summer 1998

Front, from left: Sri Chandramouli, Chris Templeman, Rachel Costello, Geoff Bonvallet, Hannah Coy, Dr. Garg. Back, from left: Paul Rebillot, Shaun Burdette-McClellan, Dr. Lindner, Steve Troyer, Scott Hughes, Dr. Jacobs.

Taming Chaos in an Array of Pendulums

Hanna Coy (University of Arizona ‘00) and John Lindner

For his senior thesis, Woody Shew ’98 designed and built an array of forced, damped, coupled pendulums. This fascinating apparatus exhibits the following surprising behavior: if the pendulums all have the same lengths, the motion is chaotic; but if the lengths are disordered, so that some are short and some are long, the motion is periodic. This summer, we are extending Woody’s work by taking more and better data. We analyze the complex spatiotemporal dynamics by downloading video of the apparatus to a G3 PowerMac. Hanna has enlarged the radius of the apparatus and recalibrated the motor. She is enjoying working in the former Fobes library—but moving the massive apparatus upstairs from its birthplace in the shop downstairs was an adventure!

Chaotic Brownian Motion

Scott Hughes '01 and John Lindner

We are investigating a novel form of chaotic billiards that is reminiscent of Brownian motion. Imagine a moving point particle confined to a closed two-dimensional region. If the region is square or circular, the motion is quite regular. However, place a fixed disk in the center of a rectangular region, like bumper pool, and almost every trajectory is chaotic. Now suppose the disk can recoil, like a small particle suspended in a liquid and jostled by the liquid's molecules. What happens to the motion of the disk as we vary the shape of the boundary? We have created computer simulations to analyze this question. For some boundaries, we observe the random walk that characterizes true Brownian motion; for other boundaries, we observe much more regular motion.

Noise Enhanced Propagation

Sridhar Chandramouli '00 and John Lindner

Noise and disorder are often thought of negatively as being destructive to spatial regularity and temporal periodicity. However, in certain nonlinear systems, the opposite can be true. In computer experiments, we are using noise to enhance the propagation of waves in arrays of coupled bistable elements. The data indicate that intermediate noise can significantly extend the propagation, whereas little noise or too much noise cannot. How does the optimal noise vary with parameters like the coupling or the width and height of the potential barrier? This work may have important implications in biology and communication technology.

Turbidity as a Measure of the Critical Exponent η

Geoff Bonvallet '00 and Dr. Don Jacobs

A density matched, liquid-liquid mixture provides an intriguing system to investigate due to the small effects of Earth's gravity. Taking such a mixture very close to the critical point and measuring the amount of light transmitted (not scattered) through the liquids should allow a test of Renormalization Group Theory.

Heat Capacity in a Succinonitrile-Water Mixture

Shaun Burdette-McClellan (Mt. Union '99) and Dr. Don Jacobs

The entropy and enthalpy of a liquid-liquid mixture near its critical point can be determined from a heat capacity measurement. Because the mixture goes from a homogenous one-phase mixture to two phases very abruptly at the second order phase transition, the heat capacity exhibits an anomalous increase at the critical point. This increase is described by a power-law with an exponent α. The critical exponent α and the amplitudes of the leading divergence are essential quantities that can be used to predict the behavior of many other effects.

Self-Organized Criticality in a Model Bead Pile

Rachel Costello '01 and Dr. Don Jacobs

SOC is a new paradigm that describes how complex dynamical systems evolve and has applications to earthquake prediction (and the stock market!). By collecting data on a model 'sand pile' system made of a conical pile of beads as one bead is added at a time, a history and distribution of avalanche sizes can be measured. An extension can be made to other more complicated systems. In particular, we wish to determine if enhanced seismic activity occurs prior to the occurrence of a large earthquake and thus be used as a predictor. At this point, we think not.

Magnetic Freedericksz Transition of the Nematic Liquid Crystal CCN 47 in the Presence of a Stabilizing Electric Field

Steven Troyer (Goshen College '00) and Dr. Shila Garg

This project deals with the electric field induced orientational transitions in the bend Freedericksz geometry under the action of a stabilizing magnetic field. We have investigated this effect in the nematic liquid crystal 5CB and our results are published. The liquid crystal 5CB has a positive dielectric anisotropy and thus the destabilizing electric field is applied perpendicular to the initial alignment of the molecules. The current project utilizes a different liquid crystal system which has a negative dielectric anisotropy, for which the geometry of the fields will be different. The threshold voltages for the periodic distortions will be measured as a function of electric field frequency and magnetic field strength.

Electrical Conductivity Anisotropy in 5CB Liquid Crystals

Paul Rebillot '99 and Dr. Shila Garg

Nematic liquid crystals are approximated as insulators since they have very high electrical resistivity. In practice, ionic impurities make the conductivity of these systems non-negligible. Particularly, the frequency dependence of the conductivity anisotropy is an important physical measurement since it will help to construct a more realistic theoretical model for electric field transitions

Wave Distortions in Nematic Liquid Crystals

Chris Templeman '01 and Dr. Shila Garg

A homeotropic nematic sample is subjected to the action of an ac voltage applied between plane electrodes with surfaces parallel to the initial alignment. When voltage is increased, walls separate out from the electrodes, approach each other and merge near the sample middle. A subsequent decrease of voltage to zero causes the reverse process to occur except for hysteresis whose width enables an approximate estimate of the adhesion surface energy density of the walls which is of the same order as the anisotropy in surface tension. The square of the inverse wall thickness is approximately a linear function of the square of the voltage showing that the walls are similar to the well known alignment inversion walls produced by magnetic fields. The walls exhibit curvature in the sample plane, the distortion being regular at sufficiently elevated frequencies (f). The walls undergo considerable deformation prior to (or after) their merger (or separation) during voltage increase (or decrease). The walls are decorated along their length by a zigzag defect pattern which is being reported in this geometry for the first time. The observed phenomena exhibit irregularities at low frequency indicating possible intervention from electrical conductivity.

Carrie Williams Wins Goldwater Scholarship

Physics major Carrie Williams, a junior from Mentor, has been awarded a scholarship from the Barry M. Goldwater Scholarship and Excellence in Education Foundation. Williams is one of 316 college sophomores and juniors nationwide to be named a Goldwater Scholar by the foundation's trustees for the 1998-99 academic year. She is one of 14 students selected from Ohio.

This year's Goldwater Scholars were chosen on the basis of academic merit from a field of 1,186 mathematics, science and engineering students who were nominated by the faculties of colleges and universities nationwide. The one- and two-year scholarships will cover the cost of tuition, fees, books, and room and board up to a maximum of $7,500 per year for each student.

Williams, who is the daughter of James and Roxana Williams of Mentor, is a graduate of Mentor High School. She is enrolled in Wooster's 3-2 engineering program and will attend Washington University in St. Louis this fall to study biomedical engineering.

"During high school I worked at a camp for orthopedically handicapped children," said Williams. "I was amazed at how much trouble they had just accomplishing some routine tasks. Right then, I decided that I wanted to spend my life helping them and others with physical disabilities. So, I went to the library and tried to learn as much as I could about orthopedic handicaps. All of this led me to an intense interest in biomedical engineering."

Like Williams, virtually all of this year's Goldwater Scholars intend to obtain Ph.D.s in their chosen fields. Nineteen of the scholars are mathematics majors, 215 are science majors, 20 are majoring in engineering and 62 have dual majors in a variety of mathematics, science and engineering disciplines. The Goldwater Scholarship is the premier undergraduate award of its type in these fields.

Williams is the second Wooster student and physics major to be awarded a Goldwater Scholarship in the past three years. Christopher Ditchman, a 1997 graduate of Wooster who also is from Mentor, was awarded one of the scholarships in 1996.

Society of Physics Students 1997-98

Officers

President	Jodee Jones
Vice-President	Carrie Williams
Treasurer	Dave Walkenhorst
Secretary	Christy Rauch
Advisor	John Lindner

Activities

Spring Senior I.S. Poster Session (Friday 1 May 1998)

Lecture by Dr. Adi Bulsara (Thursday 23 April 1998)
SPAWAR and UC San Diego
Stochastic Resonance: Tuning to the Noise

Taylor Bowl 9 (Sunday 19 April 1998)

Lecture by Dr. William Trimmer (Tuesday 14 April 1998)
President, Belle Mead Research, Inc.
World of Micro (Mechanics, that is)

Lecture by Dr. Phil Bos (Thursday 19 February 1998)
Kent State University Liquid Crystal Institute
Liquid Crystals and the TN-LCD
(Accompanied by **Asad Khan '93** and **Salman Saeed '96**)

Fall Senior I.S. Oral Reports (Thursday 4 December 1997)

Lecture by Dr. Paula Turner (Thursday 20 November 1997)
Physics professor, Kenyon College
Astrophotometry: Good Science from Bad Detectors

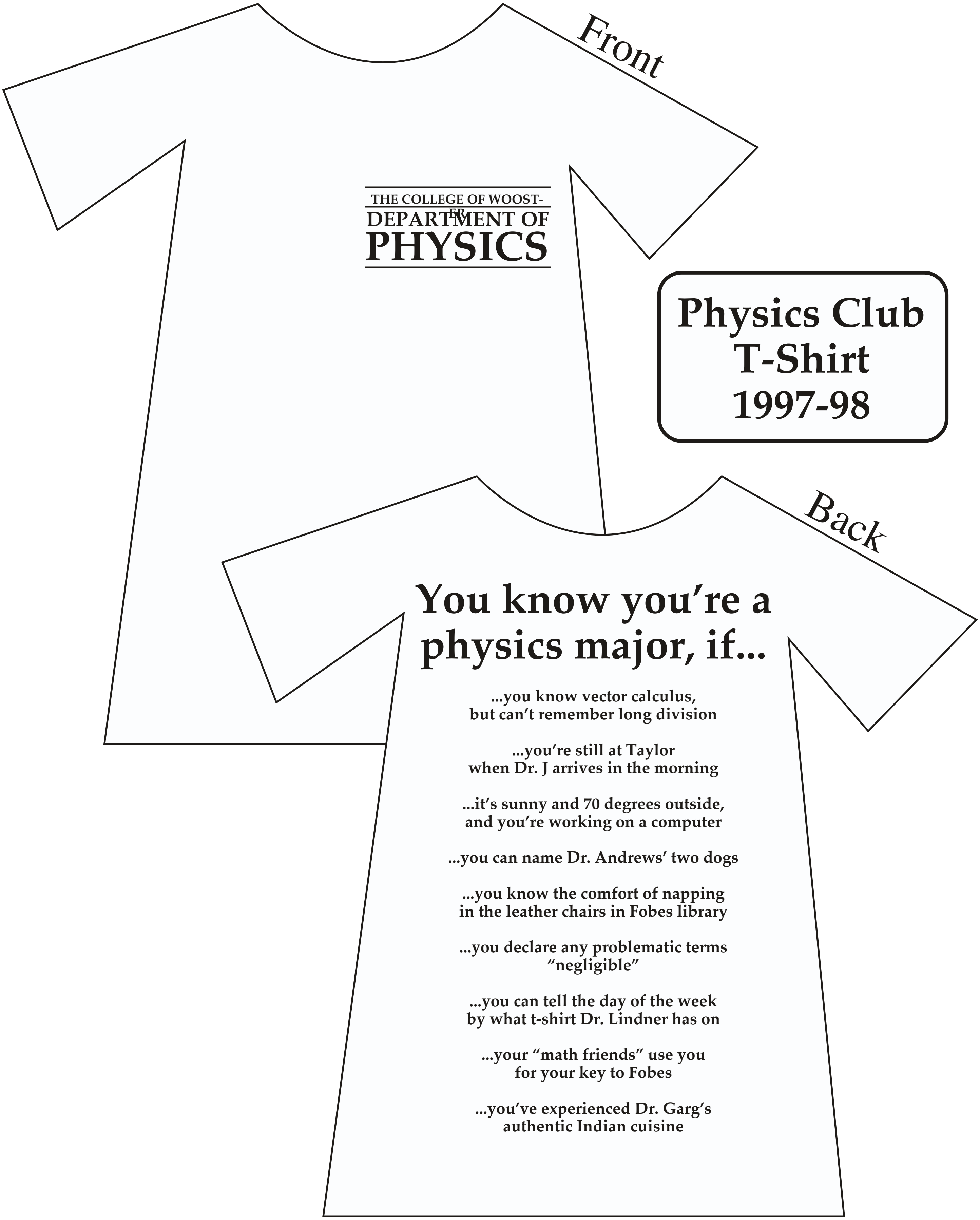
Trip to Great Lakes Science Center (Saturday 15 November 1997)

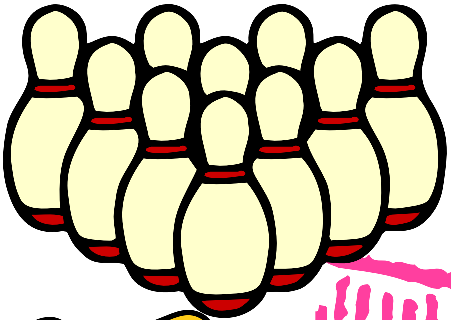
Lecture by Dr. Joseph Taylor (Wednesday 5 November 1997) in honor of the memory of Arthur Compton '13 on the 70th anniversary of his Nobel Prize
James S. McDonnell Distinguished University Professor of Physics
Dean of the Faculty, Princeton University
Recipient of the 1993 Nobel Prize in Physics
Binary Pulsars and Relativistic Gravity
Lunch with Dr. Taylor at Wooster Inn for students, faculty, & staff

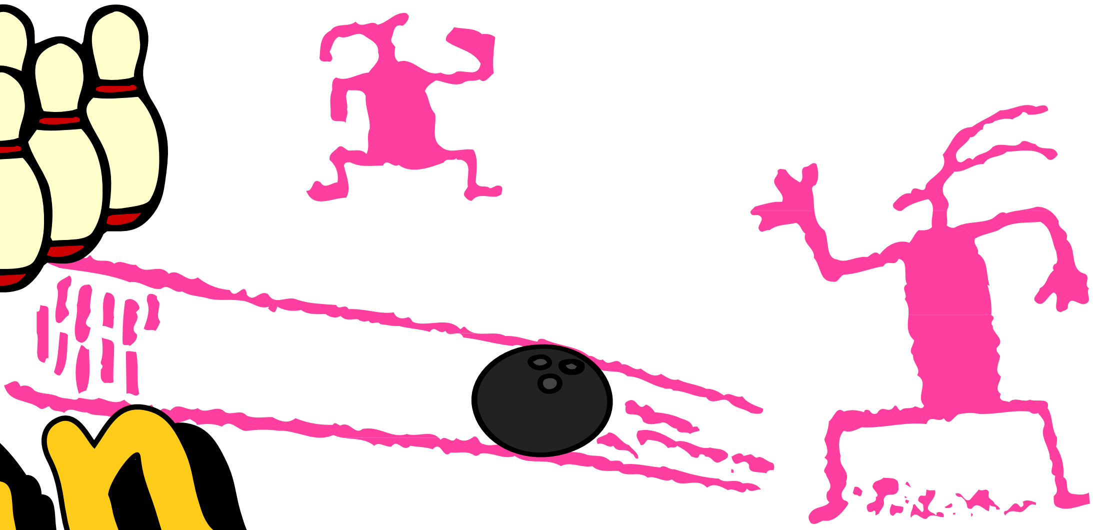
Pizza & Dessert Night (Wednesday 24 September 1997)

Science Block Party (Friday 12 September 1997)

Physics Club T-Shirt 1997-98







Fun Taylor Bowl IX

1990
Math 119.1
Phys 109.0

1991
Phys 107.27
Math 107.03

1992
Math 127.4
Phys 104.7

1993
Math 107.59
Phys 107.44

1994
Math 104.76
Phys 104.26

1995
Math 118.61
Phys 117

1996
Math 103.24
Phys 101.95

1997
Phys 109.2
Math 97.65

Sunday, April 19, 1998

Physics vs. Math Sciences

Every year, physics students and faculty bowl against math students and faculty in a fierce and intense competition at Scot Lanes. The winning department gets possession of the "giant slide rule" trophy for the following year. This year, unfortunately, physics lost retention of the slide rule to the math department. The first floor hallway definitely looks emptier without it suspended from the ceiling. Oh well, we'll get 'em next year!

1998 RESULTS

TWO SAMPLE T FOR MATH VS PHYSICS

	N	MEAN	STDEV
Math	30	120.9	27.6
Physics	28	115.8	30.9

HIGH SCORE: Physics Major BRYAN PRUSHA, 182

Reaching Out...

Bringing Science to Young Women

THE MARE'S HAIR LASER AFFAIR

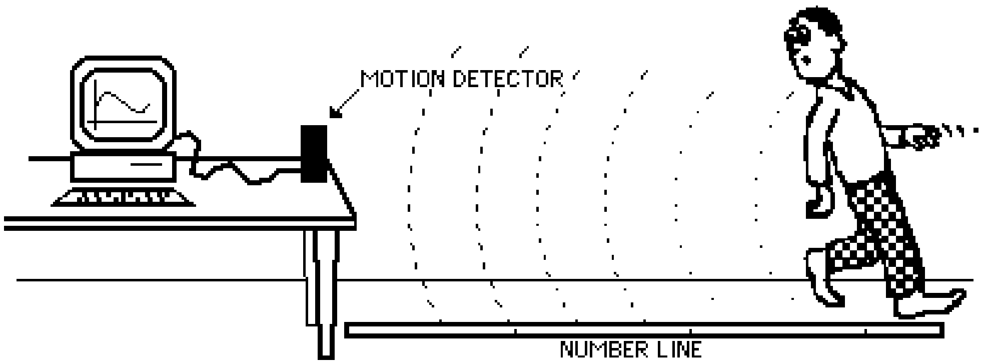
This past spring, Dr. Anna Andrews, along with Dr. Karen Wimbush of OSU Agricultural Technical Institute, took part in the Expanding Your Horizons program for young women of junior high age. The students were able to measure the thickness of a horse hair using a laser. First, the students snipped a long strand of hair from the tail of a horse (who just happened to be in Taylor Hall parking lot!). Next, they made hair holders out of index cards. After shining a laser on the hair and measuring the thickness of the red strips that resulted from the diffraction of the light, the students could apply a mathematical formula to calculate the width of the horse's hair. The event was a wonderful way to expose young women to some fun physics. In addition, Dr. Wimbush provided insight into her career in animal science.

B-WISER (BUCKEYE WOMEN IN SCIENCE)

Each June, the Physics Department takes part in the Buckeye Women in Science camp for eighth graders. This year, 80 young women visited our department and were hosted by Dr. Shila Garg, lab technician Judith Elwell, and 10 REU researchers and physics majors.

Here are some of the experiments and demonstrations the students were able to participate in:

• **Introduction to Motion**: to discover how to measure your motion with a motion detector and to see how your motion looks as a position-time graph.



• **Sound Waves Using Computers:** to examine the 'tone content' of a musical sound by watching the graph of the frequency spectrum of the sound sensor signal that is displayed on the computer screen.

• **Liquid lasers and Phosphorescence:** to show an example of a liquid laser (gin and tonic laser) and the principle of how it works.

• **Total Internal Reflection and Fiber Optics:** to demonstrate total internal reflection and the applications of fiber optics.

• **Student-made holograms:** to view reflection and transmission holograms made by Wooster students and to discuss the process of making them.

• **Cylindrical Holograms:** to further illustrate holography.

• **Diffraction and Interference:** to examine patterns resulting from single slit, double slit, diffraction gratings, etc. and discuss the wave nature of light.

• **Argon laser:** to demonstrate the seven primary transitions of this laser system and to explain the operation of a laser.

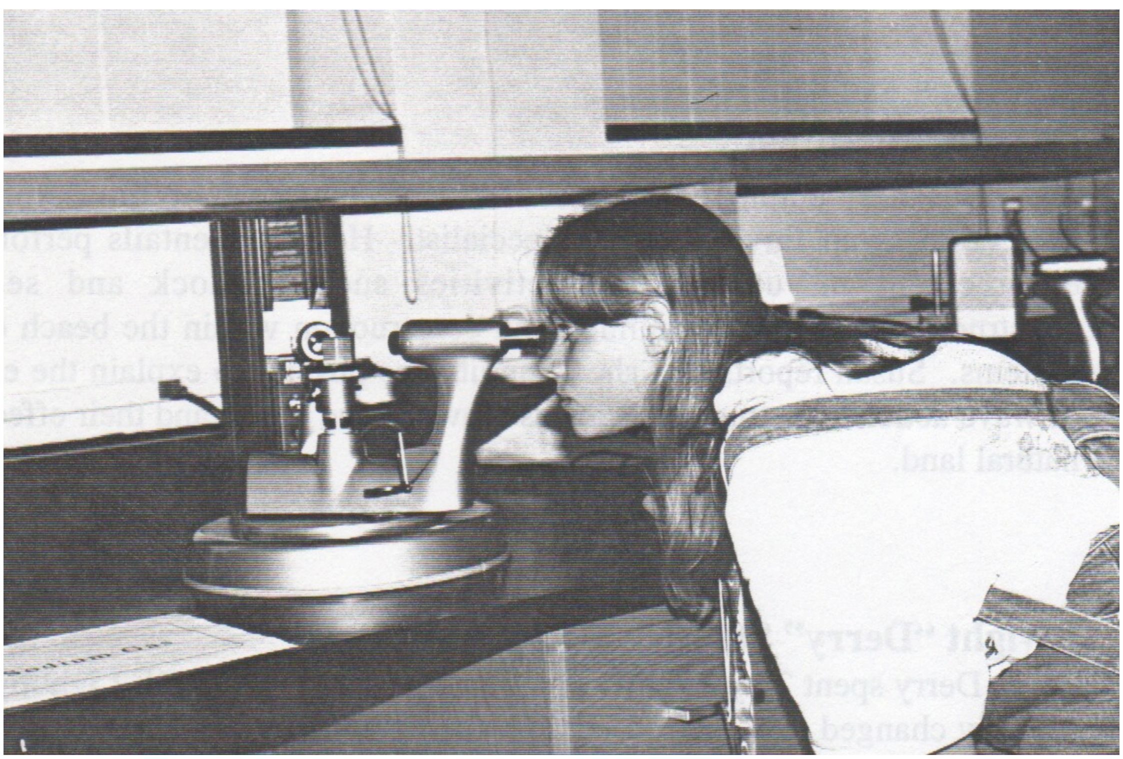
• **Spectral lines:** to illustrate the unique atomic structure of each element by examining the spectral lines of hydrogen, helium, neon, mercury, and sodium sources.

• **Sinusoidal Waves:** a mechanical wave machine is used to discuss periodic waves.

• **Sound Waves and Fast Fourier Transform:** a keyboard is used whose output is fed into a spectrum analyzer to illustrate the frequency content of music and to view the harmonics of a pure tone.

• **Polarization:** using linear polarizers and a laser, the concept of polarization is explained. Students then examine stressed objects, Karo syrup, etc. under crossed polarizers with a white light source.

• **Frequency and Period:** a function generator, microphone, speaker, and oscilloscope are used to explain the concepts of frequency and period of a sound wave.



A budding young scientist checks out the spectra of sodium.

Alumni Spotlight

Asad Khan ’93

After receiving his Master’s degree in physics from Kent State University, Asad began working for Kent Displays doing research work in the bistable cholesteric liquid crystal display technology. His work involves improving liquid crystal materials and optimizing device configurations for improvements in display update rates, optical characteristics, contract, and temperature ranges. He also develops and supports an optics laboratory for electro-optical and optical characterization of LCDs. Now a senior R&D engineer for Kent Displays, Asad is also a student in Kent State University’s Ph.D. program in chemical physics.

Susan Leitholf ’90

Susan is employed by the Florida Department of Environmental Protection as an Environmental Specialist. Her work entails performing enforcement on unpermitted activities such as dock and seawall construction, mangrove trimming and construction within the beach dunes systems. Susan reports that she often utilizes physics to explain the effects of wave actions on structures such as seawalls and jetties and their effects on natural land.

Dwight “Derry” Stauffer ‘71

Derry spent 24 years in various engineering jobs for GE Lighting, and recently changed to Venture Lighting International in Solon, Ohio. Venture is a fast-growing producer of metal halide lighting products, and Derry is one of five design physicists in the Product Engineering Department. Derry says that his work at Venture is a challenging mix of engineering and various scientific disciplines.

Khalid Sherdil ‘91

After Wooster, Khalid went to Washington University in St. Louis on the 3-2 engineering program and received a bachelor of science degree in electrical/computer engineering as well as computer science. He also received his master’s degree in computer science from McGill University. Now, Khalid is back home working for the federal government of Pakistan as an Assistant Commissioner (an administrative bureaucratic post) and enjoying it a lot.

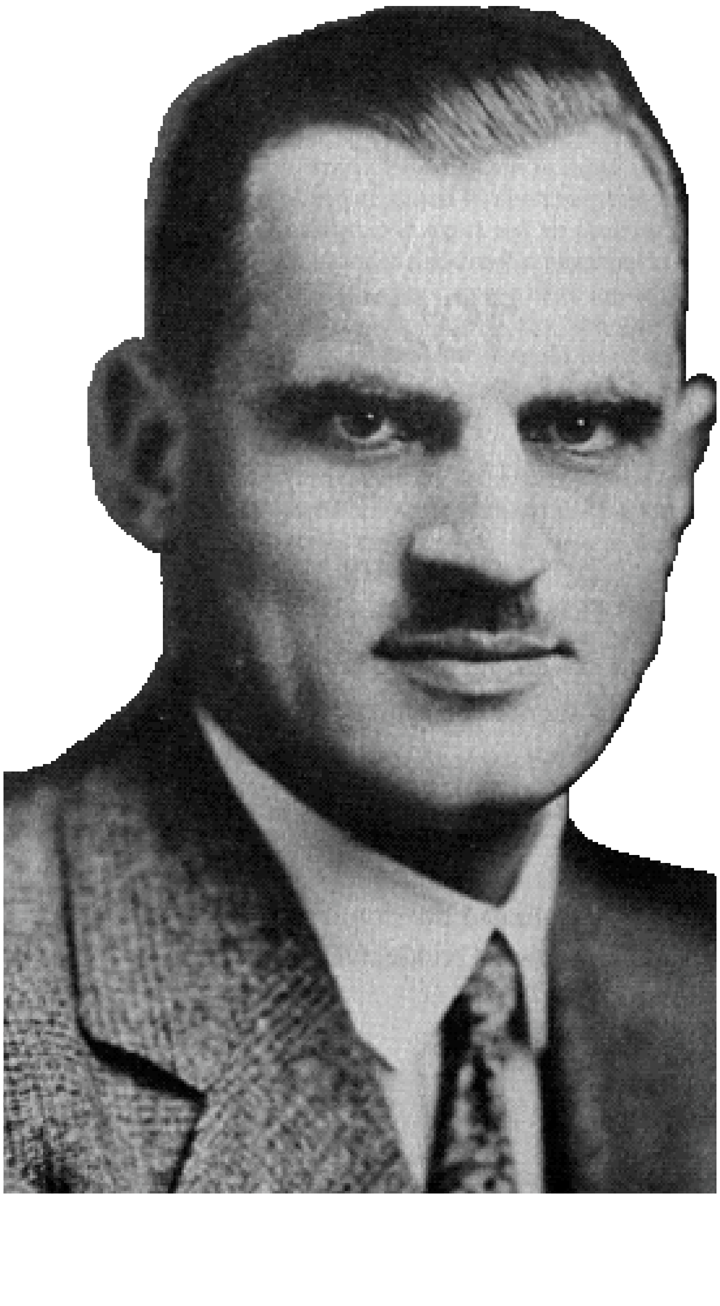
Ali “the mighty Turk” Özgenç ‘96

After graduating from Wooster, Ali enrolled in the Biophysics Ph.D. program at the University of Rochester, Department of Biophysics and Biochemistry. After two years of taking courses in Molecular Biology, Structural Biophysics, Membrane Biophysics, Biochemistry, and Genetics, he decided to join the lab of Dr. Chris Lawrence who does molecular biology work on induced mutagenesis. Currently Ali is working on his thesis proposal that he will defend in September in order to continue with the Ph.D. program. The long term goal of his proposed research is to further the understanding of the molecular biological and biophysical processes underlying the production of mutations caused by the replication of mutagen-treated DNA, and the cellular responses to the DNA damage in a variety of model systems.

Jeffrey Close ‘78

Jeff is the founder, president, and CEO of Tri-Quad Enterprises, Inc., which produces intuitive graphical pricing and rate element databases software to telecommunications carriers and large business users. Tri-Quad operates from a renovated barn in the middle of ten acres of pasture and woodlands atop a small picturesque mountain in Manchester, Connecticut. Jeff has 20 years experience in Telecommunications, including 7 years with the internationally known DMW Group. Prior to DMW, he was the designer for Xerox's private voice network. Jeff is often quoted in the trade press and is a published author in the field of telecommunications. After Wooster, he received his master’s degree in telecommunications from the University of Colorado, Boulder. While in Boulder, he also authored several FCC filings for NTIA in the area of broadcast spectrum utilization.

1997 marked the 50th anniversary of Arthur Holly Compton's (COW '13) Nobel Prize in Physics



Arthur Holly Compton
1927
X-Ray Radiation and Optics

Born: Wooster, OH Sept. 10, 1892
Died: Berkeley, CA March 15, 1962

"Compton effect" is named for his discovery and interpretation of the change in wavelength of scattered x-rays, the scattering of photons and electrons, of matter and light.

"The prime problem faced by this generation is that of preventing major war while at the same time securing the widespread freedom that gives value to life."

—A. H. Compton

Department of Physics
Annual Report
1997-98

Alumni Information Sheet

Name ____

Home Address ____

____

Telephone ______________________ Class ___________

Business Address____

____

____

Telephone ___________________________ e-mail:______________________

Occupation
____

Title
____
(Include business card, if available)

If your occupation is related to the field of physics, please attach a brief description of the area you are working in.

Anything else you would like to share with us for our files is also welcome.

fax: (330) 263-2516 or e-mail: *sgarg@acs.wooster.edu*

or mail to: Shila Garg
Physics Department
College of Wooster
Wooster, OH 44691

Are you willing to act as an information resource for our students & alumni who would like advice about graduate school/careers?
Yes _______ Best way to reach me: ______________________________

Thank you for responding to this request!

There's no place like home...

Taylor Hall

THE COLLEGE OF WOOSTER