Annual Progress Report (Year 1)

Research Experiences for Undergraduates in
Physics and Astronomy

NSF-REU Grant PHY-0648963

Department of Physics & Astronomy
The University of Toledo
Toledo, Ohio 43606

December 2007

Richard E. Irving
Thomas J. Kvale

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I. REU RESEARCH PARTICIPANTS, SUMMER 2007

Left to Right (Front row): **Randy Patton, Mary Mills, Nicholas Reshetnikov, Tim Lou, Ryan Zeller**, Lawrence Anderson-Huang, Alvin Compaan, **Lindsey Weber, Lindsay Sanzenbacher, Shawn Witham, William Dirienzo, Jennifer Schanke**, Sylvain Marsillac

Left to Right (Back rows): Kyle Bednar, **Adam Gray, Craig McClellan, Ryan Hupe**, Rick Irving, Thomas Kvale

REU's, Grace Ong and Joel Pendery are not present in this picture.

REU participants in **boldface** type.

REU RESEARCH PARTICIPANTS, SUMMER 2007

NAME	INSTITUTION	MENTOR	RESEARCH
William Dirienzo	Univ. of .Wisconsin, Madison	Adolf Witt	Astronomy
Adam Gray	Uiv. of Toledo	Uma Vijh	Astronomy
Ryan Hupe	Univ. of Missouri, Rolla	Steven Federman	Astronomy
Hou Keon (Tim) Lou	Rutgers Univ.	Thomas Kvale	Atomic
Craig McClellan	Calif. U. of Pennsylvania	Alvin Compaan	Condensed Matter
Mary Mills	College of Wooster, OH	Jacques Amar	Condensed Matter
Grace Ong	Univ. of Oregon	X. Deng/ B. Ingler	Condensed Matter
Randy Patton	Bowling Green State Univ.	Sylvain Marsillac	Condensed Matter
Joel Pendery	Ohio State Univ.	C. Theodosiou	Atomic
Nicholas Reshetnikov	Harvard Univ.	Larry Curtis	Atomic
Lindsay Sanzenbacher	Univ. of Toledo	Terry Bigioni	Physical, Materials
Jennifer Schanke	SUNY-Buffalo	Sanjay Khare	Condensed Matter
Lindsey Weber	Fort Hayes St., KS	Michael Dennis	Bio/Medical
Shawn Witham	Kent State, OH	L. Anderson-Huang	Astronomy
Ryan Zeller	Univ. of Toledo	Steven Federman	Condensed Matter

II. SUMMARY OF SUMMER 2007

Introduction

The Summer 2007 NSF-REU program in Physics and Astronomy at Toledo gave enhanced research opportunities to 15 undergraduate students from 8 colleges and universities in 11 states spread from coast to coast. Student participants were chosen competitively from the 147 applications from students in 34 different states in all regions of the U.S. All the participants were serious and talented young scientists, who tackled substantial problems, participating in all stages of a project, from formulation to conclusion, including oral and written presentations of results. The initial web announcement (with secondary links to additional material) can be found at:

http://www.physics.utoledo.edu/~wwwreu/reusummer2007/nsf-reu2007.htm

We are pleased to report that Summer 2007 was a success from both the students' and faculty mentors' perspectives. At least one refereed manuscript has been submitted based on the research this past summer. It is anticipated that more manuscripts are in preparation and will be submitted shortly.

Advertisement and Selection

Again this year (Summer 2007) we utilized a web-based advertisement and application system. Based on a pattern of past applications and inquiries, we believe that the internet is the main search vehicle for the vast majority of students. Because of this pattern, paper announcements were sent to only a few targeted institutions. The mailings included a very brief letter alerting the prospective students to our website and a paper copy of our Application forms in case the students didn't have readily available access to the internet. The selection committee was composed of Richard Irving (PI), Thomas Kvale (Co-PI), David Ellis, and Adolf Witt . We also performed the initial matches of the prospective students with their faculty mentors. Various criteria were used for the selection and matching, including the student's course background and class performance, out-of-class experiences, research interests, faculty

recommendations, and personal goals. We also tried to select students with a variety of personal, educational, and geographical backgrounds.

Registration and Housing

All student participants were registered in PHYS4910, Research Problems in Physics and Astronomy, for 1 semester hour credit. The REU program paid all the instructional and other required fees. We find that there are many advantages to having the REU participants be registered UT students with all associated benefits and privileges. One of the major benefits is access to the university health center. Other benefits include: course credit to transfer back to the student's home institution if desired, access to recreational facilities, and borrowing privileges at the University library.

This year 13 of the fifteen student participants lived in the same campus dormitory with the NSF-REU grant providing the housing costs to these students. The students stayed in the International House. It is organized into suites adjoining a common area that encouraged social interactions among the REU students. This dorm also has kitchen facilities for the students to cook their meals if they choose to do so. One of the goals of the NSF-REU program is to enable social interactions among the students, who will become the scientists of tomorrow. This infrastructure of friendships leads to the fruitful exchange of ideas, which is useful in the advancement of physics and astronomy. We feel that we can best accomplish this goal by housing the students together on campus and to foster off-hours social activities. Additional details on this housing arrangement are included in the "University-Wide" Events section later in this Report.

Social Activities

Social activities were coordinated by three UT participants (Adam Gray, Lindsay Sanzenbacher and Ryan Zeller). The students again this year formed a close-knit group. Weekly activities included Wednesday nights at a local, family restaurant (Uncle John's Pancake House) and Thursday lunches at the Phoenicia restaurant. Some of the other special events included: windsurfing, several BBQ's, and trips to Cedar Point Amusement Park, Toledo Zoo, and COSI. Many of the evaluation comments mentioned these activities favorably. The calendar can be found at:

http://www.physics.utoledo.edu/~wwwreu/reusummer2007/reu2007calendar1.htm

Weekly Seminars

During the first week, the students attended an orientation seminar to cover the basic items such as ID cards, parking, health services, food services, stipend checks, etc. After that, a weekly "Brown Bag Lunch" seminar series played an important part of our summer program. Faculty members and/or outside speakers presented a talk over their research during the lunch hour for their chosen day. This bag lunch format fosters more of an informal atmosphere, which the students appreciate when it is their turn to give a presentation at the close of the summer session. This weekly meeting of the entire REU group also provided an opportunity to plan social events and field trips, and discuss any topics of interest to the group. In addition, the whole department was invited to attend the Bag Lunches, and the participation was good with many graduate students and faculty members also attending each week. The Bag lunches provided a useful departmental weekly gathering, otherwise absent in the summer. The talks at these weekly meetings were for the most part similar to standard physics research talks, but chosen to be appropriate for the REU audience, and with all the speakers being careful to give

undergraduate-level introductions. We also required the students to give a 5 minute presentation of their research about midway into their summer period. These midway progress talks went well and kept the students focused on their projects. We plan to repeat the mid-term Progress talks for this coming summer.

NSF-REU SUMMER 2007 BROWN BAG SEMINARS

TUESDAY NOON – MH 4009

May 31	Orientation & Pizza Lunch
June 05	Sylvain Marsillac , "Renewable Energies & Photovoltaics"
June 12	Jacques Amar, “Simulating Thin Film Growth”
June19	Michael Dennis,”MRI: Medical Imaging with Magnets and Radio Waves.”
June 26	REU students midterm reports
July 06	Lawrence Anderson-Huang, "Color Perception." & Toledo Art Museum Trip”
July 10	Larry Curtis, "It's time to reinvent Introductory Physics."
July 17	Terry Bigioni, "Soft Matter Physics."
July 24	Steve Federman, "Origin of the Elements."
July 31	Student Final Reports.
August 01	Student Final Reports
August 02	Student Final Reports

University-Wide Events

This summer we also required the students to attend a second, university-wide seminar series that formed the basis of the course, ARS2908: Issues in Research and Scholarship. This course was coordinated by the Office of Undergraduate Research and the Honors Program. It was in a Bag Lunch seminar format and topics included safe and ethical practices in research as described in the following section.

The Co-P.I. (Thomas Kvale) served as the director of the UT Office of Undergraduate Research (OUR-UT). This office had an immediate, positive impact on our REU program. First, OUR-UT worked with the Office of Residence Life in creating a "Living/Researching" community for students living in the dorm. Thus, the REU-physics participants were housed on the same floor as participants in the REU-Lake Erie, USR&CAP, SURF, and SURP programs, as well as several students conducting research in individual faculty members' research. Second, the ARS2980 course syllabus for summer 2007 is reproduced below. Each bag lunch presentation lasted about an hour and there was ample time for Questions/Answers for each speaker. And third, we were able to fully integrate a first year student (Kyle Bednar) that was participating in an internally-funded program into our REU program.

ARS2980 Issues in Research and Scholarship
Summer Semester III

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Schedule: Thursday, 12:00pm - 1:00pm, 1 credit hour
Sullivan Hall David Hoch Conference Room, SL1030

Contact Persons:
Thomas Kvale Office: MH4023 Phone: x2980 Email: tkvale@utnet.utoledo.edu
Thomas Barden Office: SL1020 Phone: x6033 Email:tbarden@utnet.utoledo.edu

Suggested Texts:
1. "Introduction to the Responsible Conduct of Research," Nicholas H. Steneck, US HHSORI publication
2. "Little Book of Plagiarism," Richard A. Posner, Publisher: Pantheon (January 16, 2007), ISBN-10: 037542475X
3. selected readings provided by the speakers

Grade: Credit/NC

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Syllabus, Summer 2007

June 07:	Welcome Reception	Robert Sheehan, Interim Provost
June 14:	Laboratory Safety	Heather Lorenz, Safety and Health
June 21:	Ethical Issues in Research/ Scholarship/Publication I	Thomas Barden, Director, Honors Program Barb Schneider, Director, Writing Center
June 28:	Ethical Issues in Research/ Scholarship/Publication II	Thomas Barden, Director, Honors Program Barb Schneider, Director, Writing Center
July 05:	Technology Transfer & Intellectual Property Issues	Daniel Kory, Office of Research
July 12:	-- cancelled --	
July 19:	Research Compliance Issues	Jeffrey Busch, Office of Research
July 26:	Good Presentation Practices	Bernard Bopp, Director, CTL
Aug 02:	Research Week Presentations	Undergraduate student researchers

Catalog Description:

Seminar series addressing various issues in research, including safe laboratory practices, regulatory compliance issues, and ethics issues in research, scholarship, and creative activities. Topics are chosen to be relevant to students in both the STEMM (Science, Technology, Engineering, Mathematics, and Medicine) and the non-STEMM disciplines.

Reports and Conclusion

We feel it is important to involve the students with all aspects of the scientific research process. To the extent possible, depending on the nature of the project, students participate in the selection of the problem, the choice of research method, the collection and analysis of data, the formulation of conclusions, and the presentation of the results. The research problems are parts of ongoing faculty research programs, which are in most cases supported by external grants. At the same time, every effort is made to identify a piece of the research for which the REU student has the primary responsibility. The students are asked to write a final report, including a carefully-written abstract which could be submitted as a contribution to a regional or national meeting, as well as give a 20 minute presentation at a Bag Lunch in the final week of their research period. The typical length of the final reports is about 20 - 25 pages. These requirements have helped the students to become experienced in technical writing and presentations. The success of this philosophy is attested by the fact that our REU students are

authors on manuscripts that have been published, submitted, or are in preparation to be submitted this year.

We are very excited about this coming summer and beyond. The University of Toledo has merged with the Medical University of Ohio at Toledo (MUO). MUO (now, HSC - Health Science Campus) had a national reputation of being an excellent medical school. For several years now, our department of Physics and Astronomy has had a collaborative Ph.D. program in medical physics with the Medical Physics department at MUO. The merging of the two institutions into UT has provided enhanced opportunities for our REU students to select projects in the medical physics fields (radiation oncology and diagnostic radiology). We expect this area to grow into a very popular and rewarding area in the foreseeable future.

III. PHYSICS SUMMER CAMP 2007

The summer camp activities that were developed and performed this year with the help of our REU team were received well by the campers. A sampling of pictures from the summer camp activities (including other REU activities) is included in section VII: Summer 2007 Pictures. As part of the REU program, the Physics Summer Camp outreach activity for high school students interested in science took place during July 19-20, 2007 from 9 AM till 2:30 PM. The announcement, forms, calendar of activates as well as links to past events can be found at: http://www.physics.utoledo.edu/~rirving/Summer_Camp_2007.html

The REU group was informed about this event during the first "Brown Bag Lunch Seminar" and they were asked to participate by mentoring the high school participants. In addition they were asked to offer possible activities to perform with the participants. This is an outreach activity for high school students interested in science. The idea is to minimize the age-gap between organizers and participants in order to foster discussions about science in general and physics in particular. The REU team was very enthusiastic about this concept which helped make the Camp a success. Additionally, many thanks go to a science teacher from St. Ursula, Jackie Kane, for her help in developing activities and recruiting students for the Physics Summer Camp. We had a whopping 23 high school students attend. St Ursula, Northwood, Sylvania Southview, and State Line Christian high schools were represented.

The theme this year for the camp dealt with exploring alternative forms of energy that are utilized in our local area. During the Camp we took road trips using a University of Toledo bus to:

- Green by Design – a company that installs residential size wind turbines
- BGSU's Electric Vehicle Institute- to see the a battery powered race car, the Electric Falcon
- Don Scherer's house - to see his personal wind turbine.
- The 1.8 MegaWatt (MW) utility-scale wind turbines in Bowling Green
- Al Compaan's solar hybrid house and battery powered truck

Mixed in with the road trips we had fun playing in the lab. One day we had competitions to see who could make the best blade for their wind mill. The idea was to see how much load their design could lift with a standard fan (wind power) and mount for their blades. Another lab adventure had people investigating solar cells. Then the students used the solar cells to power their hand made race cars. Please visit:

http://www.physics.utoledo.edu/~rirving/Summer_Camp_2007.htm

for the Camp event details. The event culminated with a gathering of the entire REU group and the summer campers for LN2 ice-cream preparation and consumption.

IV. DEMOGRAPHICS

NSF-REU SUMMER 2007 APPLICATIONS

Geographical distribution by undergraduate institution

(Applications Received - 147 / REU Offers Made - 27 / REU Accepted - 15)

ALABAMA	
U. South Alabama	(1/0/0)
ARIZONA	
Northern Arizona Univ	(1/0/0)
U. Arizona, Honors College	(1/0/0)
CALIFORNIA	
Alan Hancock College	(1/0/0)
Calif. State, Fullerton	(1/0/0)
CSU San Bernardino	(1/0/0)
California Tech	(1/0/0)
Fresno State	(1/0/0)
Harvey Mudd College	(1/0/0)
Pomona College	(1/0/0)
UCLA	(2/0/0)
US San Diego	(3/0/0)
COLORADO	
U.Northern Colorado	(1/0/0)
FLORIDA	
Embry-Riddle Aeronautical U	(1/0/0)
Florida International Univ	(1/0/0)
Stetson Univ	(1/0/0)
Univ. of Central Florida	(1/0/0)
U.Florida	(1/0/0)
Univ. Southern Florida	(1/0/0)
GEORGIA	
Emory Univ	(2/0/0)
Univ. of Georgia	(1/1/0)
IDAHO	
U.Idaho	(1/0/0)
ILLINOIS	
Illinois Wesleyan U	(1/0/0)
Loyola Univ	(1/0/0)
Monmouth College	(1/0/0)
U.Chicago	(1/0/0)
U.Ill., Urbana Champaign	(1/0/0)
INDIANA	
Rose Hulman Inst. of Tech	(2/0/0)
Unov. of Notre Dame	(2/0/0)
IOWA	
Iowa State Univ.	(1/0/0)
U. Iowa	(1/0/0)
KANSAS	
Benedictine College	(1/0/0)
Fort Hays State Univ	(1/1/1)
KENTUCKY	
Berea College	(1/0/0)
U. Louisville	(1/0/0)
LOUISIANA	
Centenary College of Louisiana	(1/0/0)
Louisiana Tech. Univ	(1/0/0)
MAINE	
Colby College	(1/0/0)
MASSACHUSETTS	
Boston Univ	(1/0/0)
Harvard Univ	(1/1/1)
MIT	(1/0/0)
Mount Holyoke	(1/1/0)
Simon's Rock College	(1/0/0)
UMass,Dartmouth	(1/0/0)
Wheaton College	(1/1/0)
Worcester Polytechnic Inst.	(1/0/0)
MICHIGAN	
Albion College	(1/0/0)
Kalamazoo College	(1/0/0)
Michigan State Univ.	(4/0/0)
Michigan Technological Univ	(1/0/0)
Northern Michigan Univ	(1/0/0)
U.Mich., Ann Arbor	(2/1/0)
U.Mich., Dearborn	(2/0/0)

MINNESOTA

Hamline Univ	(1/0/0)
St. Cloud State Univ	(1/0/0)

MISSISSIPPI

U. Mississippi	(1/0/0)

MISSOURI

U.Missouri-Rolla	(2/2/1)

NEW JERSEY

Richard Stockton College of NJ	(1/0/0)
Rutgers Univ	(2/1/1)
Stevens Inst. of Tech	(1/0/0)

NEW YORK

Columbia Univ	(1/0/0)
New York Univ	(1/0/0)
Rensselaer Polytech.Inst.	(2/1/0)
Siena College	(1/1/0)
SUNY, Buffalo	(1/1/1)
SUNY, Geneseo	(2/1/0)
SUNY, Potsdam	(1/0/0)
SUNY, Stony Brook	(1/0/0)
Vassar College	(2/0/0)

NORTH CAROLINA

Elon Univ	(2/1/0)
North Carolina State	(1/0/0)
Western Carolina Univ	(1/0/0)

NORTH DAKOTA

U.North Dakota	(1/0/0)

OHIO

BGSU	(1/1/1)
College of Wooster	(1/1/0)
Kent State Univ	(1/1/1)
Kenyon College	(2/0/0)
Mount Union College	(1/0/0)
Ohio Northern	(2/0/0)
Ohio State Univ	(2/1/1)
Ohio Wesleyan Univ	(1/0/0)
The Univ. of Toledo	(3/3/3)

OREGON

Linfield College	(1/0/0)
Reed College	(3/0/0)
Univ. of Oregon	(1/1/1)

PENNSYLVANIA

Bryn Mawr College	(1/0/0)
Calif. U. of Pennsylvania	(1/1/0)
Carnegie Mellon Univ	(2/0/0)
Haverford College	(1/0/0)
Indiana U. of Pennsylvania	(1/0/0)
Slippery Rock Univ	(2/1/0)
St. Vincent College……....	(1/0/0)
Temple Univ	(1/0/0)
Ursinus College	(1/0/0)

RHODE ISLAND

Brown Univ	(2/1/0)
Providence College	(1/0/0)

SOUTH CAROLINA

Benedict College	(1/0/0)

TENNESSEE

Austin Peay State Univ	(1/0/0)
East Tennessee State Univ	(1/0/0)
Rhodes College	(1/1/0)
Union University	(1/0/0)

TEXAS

Austin Peay State U	(1/1/0)
Rice Univ	(2/0/0)
Southwestern Univ	(1/0/0)
U. Texas at Austin	(1/0/0)
U. North Texas	(1/0/0)

VIRGINIA

George Mason	(1/0/0)

WASHINGTON

Gonzaga Univ	(1/0/0)
U.Puget Sound	(1/0/0)
Whitman College	(1/0/0)

WEST VIRGINIA

West Virginia Univ	(1/0/0)

WISCONSIN

Beloit College	(1/0/0)
U.Wisconsin-Madison	(1/1/1)
U.Wisconsin-Stevens Point	(2/0/0)
U.Wisconsin-Whitewater	(2/0/0)

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FRANCE

Paris VII Jussieu Univ	(1/0/0)

IRAN

Shiraz Univ (US permanent resident)	(1/0/0)

RUSSIA

Moscow Inst.of Phys.&Tech.St.Univ	(1/0/0)

NSF-REU Participant**Demographics

Summer 2007

Gender

Female:	5
Male:	10

Class Rank

Freshman:	3
Sophomore:	3
Junior:	5
Senior:	1
Higher:	0

Ethnicity

International Student*:	0
American Indian:	0
Alaskan Native:	0
Asian American:	2
(or Pacific Islands)	
African American:	0
Hispanic American:	0
Caucasian/White:	13
Other:	

Home State

Florida	1
Kentucky	1
Kansas	1
Louisiana	1
Michigan	1
Minnesota	2
Missouri	1
New Jersey	1
New York	1
Ohio	4
Tennessee	1

Home Institution:

Calif. U. of Pennsylvania	1
SUNY - Buffalo	1
Univ. of MO - Rolla	1
Univ. of WI - Madison	1
Kent State, Ohio	1
Harvard Univ.	1
Bowling Green St. Univ.	1
Fort Hays State Univ.	1
Ohio State Univ.	1
Rutgers Univ.	1
Univ. of Oregon	1
Univ. of Toledo	3
College of Wooster	1

REU Students Grade Point Average: 3.72

* Supported by non-NSF funds, but fully participated in the summer research program.
** Includes all students participating in our program regardless of their source of support.

V. RESEARCH

REU 2007 Final Presentations

Each talk is scheduled for 12 minutes allowing 3 additional minutes for questions.

Tuesday, July 31

12:00 Shawn Witham: "Modeling Microturbulence in Stellar Atmospheres"

12:15 Bill Dirienzo: "Extended Red Emission as a Function of Optical Depth in MBM 6, MBM 25, & MBM 32"

12:30 Craig McClellan: "Accelerated Degradation of CdTe Solar Cells with Differing Semiconductor Film Thicknesses"

12:45 Tim Lou: "Vacuum system modeling of the UT-P/NIELS"

Wednesday, August 01

12:00 Adam Gray: "Optical Variability of Stars in the LMC"

12:15 Joel Pendery: "Backscattering of Secondary Electrons to the Cathode in the Oblique Electric Field in Dielectric Barrier Discharge Systems"

12:30 Lindsay Sanzenbacher: "Two-Dimensional Crystallization of Microspheres by Drop-Drying"

12:45 Ryan Zeller: "Optical Thickness Monitoring system for AJA High Vacuum Deposition Chamber"

Thursday, August 02

12:00 Randy Patton: "Modeling and simulation of the p-n Junction" and "Optimized Design of Front Contact Grids for CIGS Solar Cells"

12:15 Lindsey Weber: "Functional MRI Data Acquisition in Amputee Pain Study."

12:30 Jennifer Schanke: "Ab-initio Modeling of the Slippery Hexagonal Solids MoX_2 (X = O, S, Se, Te)"

12:45 Nick Reshetnikov: "The two-way bridge between transition lifetimes and dipole polarizability: A case study of Mg-like P (IV)."

1:00 Ryan Hupe: "Transitions of Interstellar C_2 in the UV"

1:15 Mary Mills: “Simulating Thin Films: The Effects of a Rotating Substrate on Surface Morphology in Oblique-Incidence Epitaxial Growth”

Scheduled for a later date, Grace Ong: “Sputter Deposition of Indium Iron Oxide Films for Photoelectrochemical Hydrogen Production”

ABSTRACTS OF REU FINAL REPORTS
The University of Toledo, Department of Physics & Astronomy
SUMMER 2007
(Faculty Mentor on parenthesis)

Astrophysics/Astronomy

William J. Dirienzo, *Extended Red Emission as a Function of Optical Depth in MBM 6, MBM 25, & MBM 32*, (A. N. Witt)

Extended Red Emission is a broad component of optical spectra observed in many interstellar clouds. It was first discovered about thirty years ago, yet it is still not completely understood. Through some process, carbon-rich clouds illuminated by ultraviolet light of sufficient energy emit this extra light which peaks in the red optical wavelength range. This paper describes a study of how the intensity of the ERE varies with optical depth of a cloud, and the photon conversion efficiency of the process. This study supports the idea of a two-stage process initiated by UV light between 120 and 250 nm. It is also shows that the number of ERE photons emitted is about 7% of the number of exciting UV photons illuminating the clouds, thus showing that the ERE carrier is abundant and should be incorporated more fully into comprehensive models of the interstellar medium. These results reaffirm earlier findings and show that current knowledge of the ERE is close to being able to describe it.

Adam Gray, *Optical Variability of Stars in the Large Magellanic Cloud*, (U. Vijh)

The majority of stars in the galaxy have constant properties for most of their lives; however, some stars vary constantly over a period of days, weeks, months, or even up to a year. Understanding how these variable stars are changing over time can help enhance the understanding of how stars in the universe evolve throughout their lifespan. By using both the infrared data collected from the nearby Large Magellanic Cloud by the SAGE survey, with two separate data epochs taken three months apart, and the optical data from the MACHO survey, with data taken from over eight years, more may be able to be understood about these varying stars.

Ryan Hupe, *Perturbations of Electronic Transitions of C_2 in the UV*, (:S. Federman)

Ultraviolet spectra of the D-X (0-0), F-X (0-0) and F-X (1-0) transitions of C_2 were obtained using the Hubble Space Telescope. These transitions have been analyzed in the past and the F-X (0-0) transition was found to consistently disagree with prediction in the J<20 levels. A study of the energy levels of the C_2 molecule suggests that the cause of these disagreements could be a perturbative state. The D-X (0-0) and F-X (1-0) bands were used to obtain information about the C2 column densities in interstellar clouds and oscillator strengths for the F-X bands. This information will be used to analyze the F-X (0-0) transitions and learn more about the perturbative state.

Shawn P. Witham, *Modeling Microturbulence in Stellar Atmospheres*, (L. Anderson-Huang)

Currently in the area of stellar atmospheric modeling, astronomers are able to accurately model atmospheres with observed spectral lines over all wavelengths with one area excepted: the width of the absorption lines. The theoretical line widths turn out more narrow than the observed absorption lines at any given temperature. This inconsistency can be resolved by using a distribution of velocities known as microturbulence. In current models, the values of microturbulent velocities are added ad hoc to compensate for the discrepancy in line widths. The

objectives of this research project were to create a computer code that worked in three dimensions to model the microturbulent velocities by using first principle equations of motion of a radiating fluid. The computer simulations were successfully formed and tested for theoretical models of gray stellar atmospheres which gave radiatively driven microturbulent velocities as a function of height in the atmosphere.

Atomic/Molecular/Optical Physics

Hou Keong Lou, *Vacuum System Modeling of the UT-P/NIELS*, (T. Kvale)

Recent studies at the UT-P/NIELS (University of Toledo Positive/Negative Ion Energy Loss Spectrometer) accelerator facility focused on measurements of total cross sections of various interactions occurring in H+ + helium collisions in the energy region of 10- to 50-keV. In those measurements, the experimental data were observed to contain large background noise signals. These enhanced background signals were hypothesized to originate from collisions of scattered protons with residual gas molecules in the decelerator/energy analyzer region. A computer model of the vacuum system using Vaktrak (a program coded by Volker Ziemann) predicted a poor vacuum (~$2x10^{-5}$ Torr) around the analyzing magnet and the decelerator/energy analyzer. Measurements conducted of the vacuum in this region confirmed the results of the test, with measured base vacuum attaining a pressure of ~$3x10^{-5}$ Torr. The study indicated that the low vacuum was a result of low conductance from the diffusion pump responsible for producing the vacuum in this region and the decelerator/energy analyzer region. The vacuum system was redesigned to increase conductance in this region. According to the Vaktrak simulation, this change should result in the vacuum be improved by at least a factor of ten. The improved vacuum should reduce the background noise in the data, which will allow better signal to noise ratios in the ion energy loss measurements.

Joel Pendery, *Backscattering of Secondary Electrons to the Cathode in the Oblique Electric Field in Dielectric Barrier Discharge Systems Using Monte Carlo Simulation*, (V. Khudik & C. Theodosiou)

In contrast to electric field lines in gas discharge systems with bare electrodes, electric field lines in dielectric barrier discharge systems, where the cathode is covered with the dielectric layer, may cross the dielectric surface at an oblique angle. The secondary electrons emitted from this surface either return to the cathode due to collisions with background gas atoms or eventually escape from the region near the cathode. Using the diffusion P1-approximation to the kinetic equation for electrons, we have found analytically the electron escape factor k for different limiting cases. Monte-Carlo simulations of backscattering of electrons have been performed for noble gases and the dependence of the escape factor on the angle between the electric filed lines and the dielectric surface have been found. The analytical theory has been used to explain unexpected peculiarities in results of Monte-Carlo simulations.

Nicholas Reshetnikov, *The two-way bridge between transition lifetimes and dipole polarizability: A case study of Mg-like P (IV)*, (L. J. Curtis)

For atoms and ions with the ground state electron configuration of $ns^2\ ^1S_0$, a remarkable approximation of the dipole polarizability can be made from just one transition lifetime measurement. Particularly, since the $ns^2\ ^1S_0 - nsnp\ ^1P_1^o$ intrashell transition dominates the total oscillator strength of transitions to the ground state, it in turn dominates the dipole polarizability of the ion. The oscillator strength serves as the quantum mechanical link between the two empirical quantities, allowing knowledge of both from a precise measurement of one. This

relationship is especially useful for studying atoms for which precise measurements of either the lifetime or dipole polarizability are difficult or impossible to make. What is more, with just a few such precise measurements of either quantity, isoelectronic linearities can be exploited to interpolate to ions beyond empirical study. The Mg-like P (IV) ion, with two old and conflicting lifetime measurements and one precise dipole polarizability measurement, gave an excellent opportunity to test the two-way relationship. However, difficulty caused by cascading from higher energy states and blending from higher charged ions made the lifetime measure of 0.35(2) ns an unsatisfactory upper limit. If the blending can be removed by running the phosphorus beam at lower energies, the ANDC method can be used to decouple the cascades. Whether or not this attempt succeeds, the problems in precise lifetime determination of P (IV) underscore the usefulness of the two-way lifetime-dipole polarizability bridge and isoelectronic interpolation to sidestep empirical constraints on precise measurement.

Biological, Health, and Medical Physics

Lindsey Weber, *Functional MRI Data Acquisition in Amputee Pain Study*, (M. Dennis)

Over one million Americans have experienced the loss of a limb, yet little is understood about what specific areas of the brain are affected by amputation. As a result, clinical treatment of the chronic pain experienced by many amputees is currently based on symptoms alone, which has limited effectiveness. In a study using functional magnetic resonance imaging (fMRI), amputated subjects with variable pain will be scanned while continuously reporting the intensity of their pain; the data will be analyzed to find correlations between brain activity and pain level. This project focused on creating the method of data acquisition that will be used in the fMRI setting. One of the main tasks in this project included using LabVIEW 8.2 Student Edition software to import, manipulate and store the pain intensity data reported by amputee subjects. Other tasks included designing an MRI compatible electrical system and hardware interfacing with an NI USB-6008 analog/digital converter.

Condensed Matter Physics

Craig McClellan, *Accelerated Degradation of CdTe Solar Cells With Differing Semiconductor Film Thicknesses,* (A. Compaan)

CdTe solar cells are second generation thin film cells. The cells are composed of a soda lime superstrate, a TCO coating, CdS n-junction layer, a CdTe p-junction layer, and copper/gold back contacts. The accelerated lifetime of cells with differing thicknesses of CdTe and CdS were studied this summer. Controls were set aside for reference while test modules were soaked in a light stress simulator to accelerate degradation of the cell attributes. An IV system, with software to collect the J-V curve, measure the open circuit voltage, short circuit current, and calculate the efficiency, and fill factor, was used in the study. Degradations of those attributes were studied to investigate correlations between the different film thicknesses and the decay of the efficiency, Voc, Jsc, and Fill Factor. I found that modules with thinner layers of CdS (0.045 µm and below) had Voc degradation much greater than those with thicker layers of CdS. The addition of a layer of HRT promoted cell stability in cells with relatively thin layers of CdS that were not subjected to light soaking, yet did not seem to keep light soaked cells any more stable. Modules with thicker layers of both CdTe and CdS were more uniform and more stable. CdS thickness is very important in the stability of efficiency of a CdTe solar cell.

Mary Mills, *Simulating Thin Films: The Effects of a Rotating Substrate on Surface Morphology in Oblique-Incidence Epitaxial Growth*, (J. Amar)

The effects of substrate rotation during deposition on the surface morphology and roughness in oblique-incidence epitaxial growth are studied via kinetic Monte Carlo simulations, and compared with previous results obtained without rotation. In general, two main effects are observed. At high deposition angles rotation leads to a drastic change in the surface morphology. In particular, it leads to isotropic mounds and pyramids rather than the strongly anisotropic structures observed in the absence of rotation. At large angles, very regular pyramids are observed. Rotation also leads to a reduced surface roughness, although the surface roughness tends to increase with rotation rate. An explanation for these effects is given in terms of the effects of rotation rate on shadowing and coalescence. Some interesting effects at low rotation rate (less than 1 rev/ML) are also discussed. Our results are also compared with the case of deposition with fixed deposition angle but random azimuthal angle.

Grace Ong, *Sputter Deposition of Indium Iron Oxide Films for Photoelectrochemical Hydrogen Production*, (X. Deng, B. Ingler)

This project focuses on using indium and iron oxide to make a protective thin film for amorphous silicon based solar cells. From the work completed, the results indicate that samples should be made at 228°C, with 30W of indium and 100W of iron oxide, and a sputter deposition time of two hours. At 0.6V, the best sample displays a maximum photocurrent density of 50μA/cm2. Subsequently, an X-ray diffraction scan confirmed that it is indeed indium iron oxide that is being produced.

Randy Patton, *Modeling and Simulation of the p-n Junction And Optimized Design of Front Contact Grids for CIGS type Solar Cells*, (S. Marsillac)

. An understanding of the solar cell requires an understanding of the p-n Junction. Animations of various aspects of semiconductor phenomena (including the p-n junction) were created to aid in comprehension of semiconductor processes, and to increase information retention through the association of the mathematical description of these phenomena with a visual interpretation of the physical and chemical behavior of these devices. The front contact grid of a solar cell serves to reduce conductive losses in the cell. However, the grid itself will shade the cell beneath, resulting in shadowing and a decrease in power generation. An optimization process must therefore be applied, wherein both resistive losses and shadowing losses are minimized. Also analyzed were the effects of busbar shape on performance losses.

Jennifer Schanke, Ab-*Initio Modeling of the Slippery Hexagonal Solids MoX_2 (X = O, S, Se, Te)*, (S. Khare)

This summer our group's objective was to calculate the theoretical values for various properties of materials from the MoX2 group (X = O, S, Se, Te) in the hexagonal P63/mmc space group. We wanted to discover if either material would act as a suitable lubricant for application to aerospace systems to increase the lifespan of the systems and to reduce the wear caused by friction. The first properties we calculated were the lattice constants for our materials using the ab-initio method. These were followed by the calculations of the elastic constants, whose values were extensively used to calculate the bulk modulus, shear modulus, Young's modulus, and Poisson's ratio of our materials. We are hoping to write a manuscript and publish our results in a research journal.

Ryan M Zeller, *Optical Thickness Monitoring System for High Vacuum Deposition Chamber*, (A.Compaan, J.Walker)

Groups at the University of Toledo studying CdTe/CdS based thin film photovoltaic solar cells require precise measurement and variation of film parameters to produce the most efficient cells possible. Controlling film thickness of the CdTe and CdS layers is essential to optimizing cell efficiency and desired cell characteristics. A non-destructive film thickness monitoring system for in-situ, real time chamber depositions in the AJA International Inc High Vacuum RF magnetron sputtering chamber was constructed. The monitoring system visualizes interference fringes of reflected laser light from front and back surfaces of the deposited film. Sample thickness is determined from known optical properties of the film material. Complications due to sample rotation during growth, background noise, and limitations from chamber geometry were overcome to achieve clear signal detection.

Physical Materials

Lindsay Sanzenbacher, *Two-Dimensional Crystallization of Microspheres by Drop-Drying*, (T. Bigioni)

When a drop of colloidal solution is dried on a substrate, nearly all of the particles are deposited at the drop's edge, a result of fluid flows inside the evaporating drop. The remaining particles typically form disordered deposits inside the drop's perimeter. My research studies the mechanism involved in the opposite effect, the formation of a uniform and highly-ordered monolayer array of colloidal spheres, namely, 800 nm polystyrene microspheres. For a monolayer to form, two key conditions must be achieved. First, the particles must be segregated from the bulk of the drop, and placed on the liquid-air interface. The interface must in turn be "sticky" enough to trap the particles long enough for them to crystallize into a two-dimensional array. This interfacial "stickiness" is due to favorable energetic conditions. The energetic factors that make this mechanism work are already well understood for large spheres, and thus, I have altered he kinetics of the system in various ways to bring the particles in contact with the liquid-air interface. This includes changing the rate of evaporation and drying the drop upside down. The effect that pinning has on the drop has also been studied. So far, I have succeeded in getting particles on the interface, but a highly-ordered monolayer has not yet been achieved. Further study of the methods that resulted in interfacial particles will be done to determine the best way to promote two-dimensional crystallization. Understanding these different effects will allow a more general method to be developed that can be used to form monolayers from a wide range of colloidal particles.

NSF-REU External Publications and Presentations*

(Calendar Year 2007)

Publications with participants from the previous years 2004-2006 were reported in the Final report for NSF-REU grant PHY-0353899 but are listed here for completeness.

REFEREED PUBLICATIONS - Submitted/accepted/published.

1. S. R. Federman, M. Brown, **S. Torok* (2006)**, S. Cheng, R. E. Irving, R. M. Schectman, and L. J. Curtis, "Oscillator strengths for ultraviolet transitions in P II," Astrophys. J. 660, 919-921 (2007).
2. L. J. Curtis, S. R. Federman, **S. Torok*** **(2006)**, M. Brown, S. Cheng, R. E. Irving and R. M. Schectman, "The need for branching fraction measurements in multiply-charged ions" Comments on Atomic, Molec. & Opt. Phys., Phys. Scr. 75, C1-C7 (2007).
3. **N. Reshetnikov*** **(2007)**, L. J. Curtis, M. S. Brown and R. E. Irving, ``Determination of polarizabilities and lifetimes for the Mg, Zn, Cd and Hg isoelectronic sequences," Physica Scripta (accepted 16 November 2007, tentatively scheduled for January 2008).
4. Witt, Adolf N.; Mandel, S.; **Sell, P. H*** **(2006**).; Dixon, T.; Gordon, K. D.; Vijh, U. P, Extended Red Emission in High-Galactic Latitude Interstellar Clouds, (Astrophysical Journal, submitted)

REFEREED PUBLICATIONS - in preparation.

1. Y. Shim**, M. E. Mills* (2007)**, V. Borovikov, and J.G. Amar, "Effects of Substrate Rotation in Oblique Incidence Epitaxial Growth", manuscript in preparation (2007).

PRESENTATIONS.

1. S.R. Federman, L.J. Curtis, M. Brown, S. Cheng, R.E. Irving, **S. Torok* (2006)**, and R.M.Schectman, "Oscillator Strengths for Ultraviolet Transitions in P II and Cu II," 9th International Colloquium on Atomic Spectra and Oscillator Strengths for Astrophysical and Laboratory Plasmas (2007).
2. **R.C. Hupe* (2007)**, and S.R. Federman, "Perturbation of Electronic Transitions in C2 in the Ultraviolet," Argonne National Laboratory Undergraduate Symposium (2007).
3. Witt, Adolf N.; Mandel, S.; **Sell, P. H* (2006).**; Dixon, T.; Gordon, K. D.; Vijh, U. P., "Extended Red Emission in High-Galactic-Latitude Interstellar Clouds," AAS Meeting in Honolulu , HI , in Summer of 2007.
4. **W. J. Dirienzo* (2007)** (Univ. of Wisconsin), A. N. Witt (University of Toledo), & S. Mandel (Hidden Valley Obs.), "Extended Red Emission as a Function of Optical Depth in High-Latitude Interstellar Clouds," AAS Meeting in Austin , TX , in Jan 2008.

* REU students' names in **bold face type*** with year of participation.

VI. PROGRAM EVALUATION

PROGRAM EVALUATION

NSF-REU Summer Research Program
Department of Physics & Astronomy
The University of Toledo
2007 (Total Population: 15, Responses: 11)

To help us improve our summer research program in future years, please give us your confidential opinion on the following questions. Thanks very much.

Did this summer's experience live up to your expectations in general?

Definitely Yes			Neutral			Definitely No
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 1.9

How do you rate your research experience this summer in helping you get a better idea of what a career in scientific research might be like?

Very Helpful			Neutral			Not Helpful
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 1.5

How do you rate your summer research experience in helping prepare you for graduate study?

Very Helpful			Neutral			Not Helpful
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 2.0

How do you rate your faculty advisor's interactions in helping you in your summer research experience?

Very Helpful			Neutral			Not Helpful
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 2.0

How do you rate the weekly seminar series in helping you learn more about physics and astronomy?

Very Helpful			Neutral			Not Helpful
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 2.4

How do you rate the Social Activities organized by the REU Staff?

Very Enjoyable			Neutral			Not Enjoyable
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 1.6

How do you rate your summer experience personally?

Great Fun			Neutral			A Real Drag
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 1.4

How do you rate your summer experience educationally?

Learned a Lot			Neutral			Not Worth Much
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 1.7

How would you change the division of time between general activities (seminars, visits, outings) vs. research work.

More general learning			Neutral			More research time
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 3.5

What do you think about having some of the seminar talks on subjects such as: "choosing a graduate school", "careers in physics and astronomy", "how to achieve greater diversity among physicists", etc., rather than the traditional scientific talks?

A great idea			Neutral			A waste of time
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 2.4

What do you think about the average level of the weekly Bag Lunch talks?

Much Too Advanced			About Right			Much Too Elementary
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 3.7

How do you rate your research experience in terms of the freedom you had to do things your own way?

None: I did what I was told			About Right			Too much: I got lost
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 4.0

Were you given enough advance information before coming to Toledo to begin the summer?

Yes, the mailings in May were very helpful			Neutral			No, I didn't know what to expect.
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 3.4

Were you made to feel welcome when you arrived and comfortable overall in the program?

Yes, very much so			Neutral			No, definitely not
□	□	□	□	□	□	□
1	2	3	4	5	6	7

2007 mean (pop. 11): 1.5

Please list the best and/or worst thing(s) about your summer experience (research and/or social/recreational).

"I enjoyed the research and the guidance I was given along the way. I wish I met with my actual advisor more during the summer, but I am happy that my work will be published."

"Best
Good REU Students
Work was at correct level of understanding
Fun activities
Laid-back people

Worst
A/C in the dorms didn't work for 1st month
Dorms bad in general
Too little work at beginning and to much work at the end"

"I really enjoyed interacting with the faculty and other REU students.
I thought the format of the summer was very good as well, a good blend of research and other activities. Rick was especially encouraging, and provided good info on Toledo attractions & restaurants."

"- the other students in the program were amazing! I loved everything we did and wish that we had more time together. They've become close friends."

" Best: My research advisor was awesome, and I learned a lot. I also had freedom to try a bunch of different things.
The other REU students were amazing and we had so much fun this summer.
Worst: The thusday talks"

" best - paychecks
- learned lab practices that will be crucial to future research
worst – Chipotle is not closer to campus"

"Best: the social events, making new friends and memories.
Learning what doing research is like.

Worst: none"

"Best Things:
The other REU students

The faculty members and staff were so friendly and helpful.
Learned a lot about graduate students and their responsibilities

Worst Thing:
Being misunderstood by a faculty member, very hurtful and disorienting"

"best:
Zoo
tressure hunting
cosi
worst:
None"

"Best
Research
Being Involved with research group
Classes
Dr. Marsillac's Semiconductor classes
Meeting post docs and grad students
Working with post docs and grad students

Worst
The beds in Ihouse are terrible.
Ihouse staff kept putting non REU people in our suites.
Mostly Ihouse related gripes."

Please list any additional comments.

"Maybe for these students who will be taking the GRE in the following academic year have a 1 hour a week study session or something along these lines."

"Thank you for such a great experience!"

"I had lots of trouble w/ my project and sometimes had trouble finding help that actually helped. Coming in, I was very unprepared for what I was doing. I wish I would have known my project and had time to learn specific things."

"It was an exceptional summer and I learned so much valuable information. Many of the things I learned in the lab will be critical to future research and beneficial for grad school, etc.

Field trips were always a good idea."

"Thank you for making the summer so memorable. I appreciate all your time and effort."

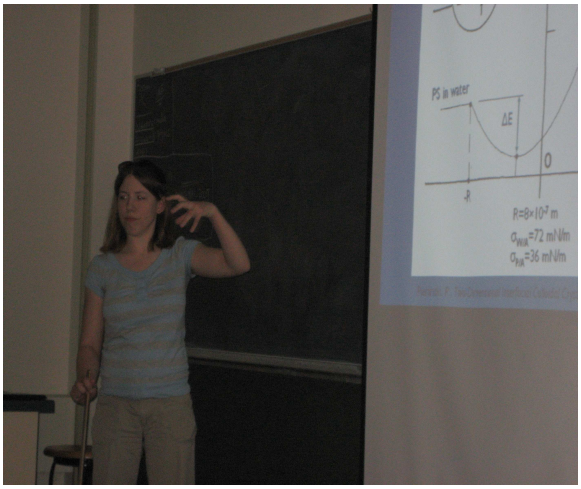
Thanks again for your time, and best wishes for continued success in everything you do. As part of the tracking we need (and want) to do, we need for you to tell us about your degrees received and your career activities (grad school, work, etc) after participating in our program. Please keep in touch with us!

Please return this questionnaire in the anonymous envelope provided to:

Sue Hickey
Department of Physics & Astronomy, M/S111
The University of Toledo
Toledo, Ohio 43606

VII. SUMMER 2007 PICTURES

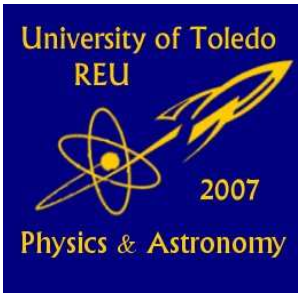
Summer Camp Field Trip to Al Compaan's Solar Hybrid House.



Lindsay Sanzenbacher's Final Presentation

REU's "Last Supper" at Red Robin

LN2 Ice Cream at the Summer Camp



REUs Wearing the T-Shirt They Designed Front of Shirt Back of Shirt
(A keepsake for their NSF experience @ Toledo)

REU's 4th of July Fun!

The Persistence of Vision made possible by the vision of NSF!