Annual Progress Report (Year 2)

Research Experiences for Undergraduates in
Physics and Astronomy

NSF-REU Grant PHY-0648963

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

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Richard E. Irving
Thomas J. Kvale

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I. REU RESEARCH PARTICIPANTS, SUMMER 2008

Left to Right (Front row): Rupali Chandar**,** Al Compaan**,** Adam Lark**,** Jon Bjorkman**,** **Rosa Zartman**, **Molly Bittner**, **Dave Bergman**, **Rachell Gestrich, Michelle Labrecque, Allison Fink, Jeremy Bancroft-Brown**, **Kyle Bednar**

Left to Right (Back rows): Tom Kvale, Rick Irving**, Lesley Simanton,** J D Smith, **Kellen Mcgee**, **Dante Amoroso**, **Nathan Reaver**, *Casey Bennett*, **Adam Gray**, Adolf Witt, **Sam Spencer**

REU's, Ryan Zeller is not present in this picture.

REU participants in **boldface** type

High School Student unofficially participating as a REU in *italics* type

REU RESEARCH PARTICIPANTS, SUMMER 2008

NAME	INSTITUTION	MENTOR	RESEARCH
Dante Amoroso	Worcester Polytechnic. Inst.	Jacques Amar	Condensed Matter
Kyle Bednar	UToledo	J.D. Smith	Astronomy
C. David Bergman	Clemson	C. Theodosiou	Atomic
Molly Bittner	U. Texas at Austin	Jon Bjorkman	Astronomy
Jeremy B. Brown	Univ. of Chicago	Larry Curtis	Atomic
Allison Fink	Bryn Mawr College	Sanjay Khare	Condensed Matter
Rachell Gestrich	UToledo	Rupali Chandar	Astronomy
Adam Gray	Uiv. of Toledo	L. Anderson-Huang	Astronomy
Michelle Labrecque	UNC, Chapel Hill	Michael Dennis	Bio/Medical
Kellen McGee	Case Western Reserve	Robert Collins	Condensed Matter
Nathan Reaver	UToledo	Alvin Compaan	Condensed Matter
Lesley Simanton:	Albion College	Rupali Chandar	Astronomy
Sam Spencer	Reed College	X. Deng/ B. Ingler	Condensed Matter
Rosa Zartmann	UToledo	Sylvain Marsillac	Condensed Matter
Ryan Zeller*	UToledo	Alvin Compaan	Condensed Matter
Casey Bennett**	Northwood High School	Alvin Compaan	Condensed Matter

* Student with other funding but participated in our research program with the same expectations as the fully REU supported students.
** High school student (senior status) not funded but participated in our REU program.

II. SUMMARY OF SUMMER 2008

Introduction

The Summer 2008 NSF-REU program in Physics and Astronomy at Toledo gave enhanced research opportunities to 15 undergraduate students from 10 colleges and universities in 9 states spread from coast to coast. Of these fifteen students, one was fully funded by the department as its pledge of support to the REU grant. Student participants were chosen competitively from the 75 applications from students in 27 different states in all regions of the U.S. Besides these undergraduates, I am happy to inform NSF a highly motivated local high school senior, Casey Bennett, successfully, in an unofficial nature (unfunded), participated in our REU program. Casey discovered the REU program while attending our 2007 physics camp. He then expressed a strong interest in participating in the REU program of 2008. Al Compaan volunteered to be his mentor. His abilities were such that you could not discern any difference between him and the rest of the students. As part of his academic program at Northwood, Casey takes courses at Owens Community College too. 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://astro1.panet.utoledo.edu/~wwwreu/reusummer2008/nsf-reu2008.htm

We are pleased to report that Summer 2008 was a success from both the students' and faculty mentors' perspectives. At least two manuscripts based on research this past summer are in preparation for submission to referred journals. It is anticipated that more manuscripts are in preparation and will be submitted shortly. We also already had one poster presentation by one of our 2008 REU students based on their summer research.

Advertisement and Selection

Again this year (Summer 2008) 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 14 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, Rosa Zartman and Ryan Zeller). The students again this year formed a close-knit group. Weekly activities included movie night on Mondays, Tuesday nights at a local restaurant called Del Taco and dinner night on Wednesdays at various spots. Some of the other special events included: windsurfing, Frisbee Golf, several BBQ's, a trip to Cedar Point Amusement Park, and a Toledo Zoo visit. One thing group implemented this year was to utilize a Google calendar. The calendar was easily shared and edited by members of our REU group. This really helped keep people informed about REU activities, social or otherwise, especially in the case of last minute changes. Our calendar can be found at:

http://www.google.com/calendar/embed?src=rick5855%40gmail.com&ctz=America/New_York
(Adjust the dates to view the REU program's timetable: May 27th Thru August 1st)

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. One of the REU students could not be present for one of the bag lunches so we implemented a makeshift video conference for this REU student utilizing Skype and a web camera on both ends. The remote student even asked the speaker questions. People thought the idea worked well.

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 2008 BROWN BAG SEMINARS

TUESDAY NOON – MH 4009

May 31	Orientation & Pizza Lunch
June 03	Adolf Witt, "Big-Time Astronomy with Small Telescopes"
June 10	Scott Lee, "Dinosaur Running Speeds"
June17	Wieland, Kristopher, "The UT CdTe Solar Cell Advantage"
June 24	REU students midterm reports
July 01	Thomas Megeath, "The Search for New Worlds with Space Telescopes: A Legacy of Lyman"
July 08	Nancy Morrison, "The Brightest Stars: Spectroscopy at Ritter Observatory"
July 15	Reva-Kay Williams, "Extracting Energy from Rotating Black Holes"
July 22	Dave Ellis, "Theoretical topics in atomic spectroscopy."
July 29	Student Final Reports.
July 30	Student Final Reports
July 31	Student Final Reports

University-Wide Events

We also required the students to attend a second, university-wide seminar series that formed the basis of the course, ARS2980: 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 2008 is reproduced below. Each bag lunch presentation lasted about an hour and there was ample time for Questions/Answers for each speaker. And third, in 2007 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 2008

May 29:	**Welcome Reception**	Rosemary Haggett, Provost Penney Poplin Gosetti, Vice Provost
June 05:	**Good Presentation Practices**	Bernard Bopp, Director, CTL
June 12:	**Technology Transfer & Intellectual Property Issues**	Daniel Kory, Office of Research
June 19:	**Ethical Issues in Research/ Scholarship/Publication I**	Thomas Barden, Director, Honors Program Barb Schneider, Director, Writing Center
June 26:	**Ethical Issues in Research/ Scholarship/Publication II**	Thomas Barden, Director, Honors Program Barb Schneider, Director, Writing Center
July 03:	**Laboratory Safety**	Heather Lorenz, Safety and Health
July 10:	**Diversity Issues in Research**	Samuel Hancock, Institutional Diversity
July 17:	**Research Compliance Issues**	Jeffrey Busch, Office of Research
July 24:	**Research Presentations I**	Undergraduate student researchers
July 31:	**Research Presentations II**	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 15 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 merged with the Medical University of Ohio at Toledo (MUO) in July 2006. MUO (now, HSC - Health Science Campus) has 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 on the Health Science Campus. 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). Since the merger four REU students worked in this field for their summer research. Of these students one continued into graduate school in the Medical Physics program at UT. We expect this area to grow into a very popular and rewarding area in the foreseeable future.

III. PHYSICS AND ASTRONOMY SUMMER CAMP 2008

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 2008 Pictures. As part of the REU program, the Physics and Astronomy Summer Camp outreach activity for high school students interested in science took place during July 23-24. Wednesday July 23 the camp ran from 9 AM until 3:00 PM. Thursday's activities took place from 7 pm until 12:00 am (Friday). The announcement, forms, calendar of activates as well as links to past events can be found at:

http://astro1.panet.utoledo.edu/~rirving/Summer_Camp_2008.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 25 high school students attend. Anthony Wayne, Clay, Northwood, Perrysburg, Southview, St Ursula, and Sylvania high schools were represented.

At the start of the camp, the REUs introduced themselves to the group and described their role during the camp. Their introduction included the name of their home university, the name of their summer mentor and the area of research they are conducting at UT. They explained that NSF had made it possible for them to study at UT this summer. Hopefully the REU's provided the students with additional motivation to continue their academic careers beyond high school level. At this point the high school students were then debriefed on the upcoming activities.

Day one of the camp dealt with taking a look at alternative forms of energy. This journey began with a presentation by Dr. Alvin Compaan which not only highlighted his area of expertise, photovoltaics, but also the need for alternative forms of energy in general. This led to a healthy discussion with the students concerning political, economic and environmental factors that are associated with the production of energy not only in Toledo, but around the globe. The discussion allowed the students to express what they know about the issues of the day concerning energy. This was a valuable exercise in their learning process to coop with the possible issues of the future. To help reinforce and validate the possibility of utilizing alternative forms of energy a couple of tours followed.

Al Compaan led a tour of the department's demonstrational solar panel array (http://astro1.panet.utoledo.edu/~solar/so.html). Then the group took a road trip to Al's solar hybrid house (http://www.youtube.com/watch?v=yVCSvCPvO6Y) to view solar cell technology in action for normal everyday use. He also had his electric truck on display for the students to explore. Al described how energy collected by the solar cells can charge the batteries on his truck needed to power his commute to work. He also explained that his truck could also energize several circuits on the house if there was a power outage. After a question and answer period about the technology, we headed back to the University for a barbeque. While we ate, the REU's displayed YouTube videos concerning alternative energy and environmental issues. An example of an environmentally concerned video the students found interesting dealt with the recent news of CCD, Colony Collapse Disorder, of the honey bees.

In the afternoon the REU's helped the students construct solar cells (nanocrytalline solar cells) using fruit such as blackberries, raspberries, pomegranate seeds. This activity was led by a past REU (2007) student, Lindsay Sanzenbacher. The students had a lot of fun trying to obtain the largest current of the camp from their cell. Other activities included designing blades for a wind turbine and measuring the power production from their design. Concurrently during the above exercises, the REU's sprinkled in other items for the summer campers to try or see. One such item had students use their muscle power on a homemade bicycle generator to power light bulbs. This demo helped the students appreciate the need to reduce phantom energy (e.g. turning off lights when not being used). Another item to view was a pizza box solar oven. It was cooking mini pizzas while sitting in the sun on the patio next to the lab room. The students were introduced to biodiesel too. It was made in the lab by two of REU students, Dante Amoroso and Nathan Reaver. Also just for fun while the summer camp students were working on their solar cells or wind turbine blades, corn starch with water was passed around the room. The students played with the mix and discovered its non-Newtonian properties (very popular). One of the final items the group played with during the lab session was a trebuchet built out of PVC pipe by two of the REU students, Adam Gray and Rosa Zartmann. Various physics concepts were discussed,

such as potential energy, work, forces and torques to help students understand the operation of the trebuchet. Armed with this knowledge the students made predictions for the range of the projectile (a water balloon) launched by the trebuchet. To tie in the alternative energy theme, the students were asked what kind(s) of energy was (were) utilized in the operation of the trebuchet which resulted in the balloon's motion. Then they were asked if this differs from the types of energy used to move a car or a plane. Finally the day's events culminated with a gathering of the entire REU group and the summer campers for LN_2 ice-cream preparation and consumption.

The second day of the camp dealt with students take note of the universe through the eyes of an astronomer. The hope was to provide the students with practical knowledge they could use to explore the heavens. Karen Bjorkman, Professor of Astronomy, started off the endeavor with a wonderful tour of our solar system via beautiful PowerPoint slides and demos. Her colorful dialogue kept the audience mesmerized. She would interact with the students throughout her presentation via questions or asking for volunteers to help with the various demos. One of her demos was making a comet. Karen also provided the students with handouts that listed among other things websites and periodicals that could aid the student in their attempt to view planets or other astronomical objects. Next Karen gave the students a tour of the one meter telescope in Ritter Observatory (http://www.utoledo.edu/as/rpbo/telescope.html). The night's fun continued after this tour with a trip down the stairs to Ritter Planetarium (http://www.utoledo.edu/as/rpbo/index.html) for a planetarium show. Alex Mak, Associate Director of the planetarium, not only gave a nice over view of the night sky, but supplied information on how to select a telescope. He explained what was necessary to have fun as an amateur astronomer.

For the final leg of the camp's journey as an astronomer, the group reinforced the knowledge it had acquired with public observing on the roof of McMaster Hall at Brooks Observatory (http://www.utoledo.edu/as/rpbo/brooks.html). With the help of the REU students and department graduate students (Jimmy Davidson, Erica Hesselbach, Dave Nero, and Josh Thomas), the campers were able to get hands on experience using telescopes. Along with star gazing the students could visit the department patio two floors below for a camp fire of charcoal and wood in a fire pit. They could roast marshmallows, make smores, and have refreshment before heading back up to the roof for more observing. Additionally the patio led into the colloquium room where people could use computer software or online info to help aid in their quest for acquiring new objects to view in the night sky. One of the many notable targets acquired was Jupiter and three of its moons. The REUs and graduate students were an invaluable resource that helped made this part of the camp experience a hit.

IV. DEMOGRAPHICS

NSF-REU SUMMER 2008 APPLICATIONS

Geographical distribution by undergraduate institution

(Applications Received - 75 / REU Offers Made - 23 / REU Accepted - 15)

ARIZONA

Univ. of Arizona…… (1/0/0)

CALIFORNIA

Harvey Mudd College…… (1/0/0)

Loyola Marymount Univ……... (1/0/0)

UCLA…….…… (1/1/0)

U. Calif., San Diego…..……. (1/0/0)

DISTRICT OF COLUMBIA

George Washington Univ……... (1/0/0)

GEORGIA
Morehouse College…… (1/0/0)

ILLINOIS
Bradley Univ……..…. (1/0/0)
U. Chicago……. (2/2/1)

INDIANA
Indiana Univ…….….. (1/0/0)

IOWA
Univ. of Iowa……..... (1/0/0)

KANSAS
Kansas State Univ…….…. (1/0/0)
Southwestern College…… (1/0/0)

KENTUCKY
U. of the Cumberlands……... (1/0/0)

LOUISIANA
Louisianna State Univ……..... (1/0/0)
McNeese State Univ……... (1/1/0)

MARYLAND
U.Maryland,Baltimore County…….. (1/1/0)

MASSACHUSETTS
Worcester Polytechnic Inst……..... (1/1/1)

MICHIGAN
Albion College……... (1/1/1)
Univ. of Michigan……. (3/0/0)

MINNESOTA
Macalester College…… (1/0/0)

MISSOURI
Truman State Univ…… (1/0/0)

NEW YORK
Cornell Univ…….. (1/0/0)
Rochester Inst. of Technology…….. (1/0/0)
Siena College……. (1/1/0)
St. John Fisher College…….. (1/0/0)
SUNY, Stony Brook……. (1/0/0)
Univ. of Buffalo…… (1/0/0)

NORTH CAROLINA
U.North Carolina@Chapel Hill……. (1/1/1)

OHIO
Case Western Reserve Univ……... (1/1/1)
John Carroll Univ……..... (1/0/0)
Kent State Univ…….. (2/1/0)
Ohio Northern Univ……... (2/1/0)
Ohio Wesleyan……... (2/0/0)
Owens Community College……... (1/0/0)
U.Cincinnati……... (1/0/0)
Univ. of Toledo…….. (7/6/6)

OREGON
Reed College……. (2/1/1)

PENNSYLVANIA
Bryn Mawr College…… (1/1/1)
Carnegie Mellon Univ……... (2/0/0)
Grove City College…… (1/0/0)
Lycoming College…….. (1/0/0)
Swarthmore College……... (1/0/0)
Indiana Univ. of Pennsylvania…….... (1/0/0)
Univ. of Pittsburgh……. (1/0/0)
Westminster College…….. (1/0/0)

SOUTH CAROLINA
Clemson……. (1/1/1)

TENNESSEE
Union University…… (1/0/0)

TEXAS
Southwestern College…… (1/0/0)
Univ. of Texas at Austin…… (1/1/1)

UTAH
Brigham Young Univ……. (1/0/0)

VIRGINIA
Eastern Mennonite Univ…… (1/0/0)

Mary Baldwin Coll.&Wash.& Lee Univ…… (1/0/0)

WASHINGTON
Pacific Lutheran Univ…… (1/0/0)
Walla Walla Univ…….. (1/0/0)
Washington State Univ…….. (1/1/0)
Whitman College……... (1/0/0)

WISCONSIN
U.Wisc., Madison…….. (1/0/0)
U.Wisc., Platteville…… (1/0/0)
U.Wisc., Stevens Point……..…….. (1/0/0)

INDIA
IIT Delhi, India ……. (1/0/0)

NSF-REU Participant Demographics**
Summer 2008

Gender	
Female:	8
Male:	8

Class Rank	
Freshman:	4
Sophomore:	6
Junior:	5
Senior:	0
High School Junior:	1

Ethnicity	
International Student*:	0
American Indian:	0
Alaskan Native:	0
Asian American: (or Pacific Islands)	0
African American:	0
Hispanic American:	0
Caucasian/White:	16
Other:	

Home State	
Illinois	1
Massachusetts	1
Michigan	1
North Carolina	1
Ohio	8
Oregon	1
Pennsylvania	1
South Carolina	1
Texas	1

Home Institution:	
Albion College	1
Bryn Mawr College	1
Case Western Reserve Univ.	1
Clemson Univ.	1
Univ. of Chicago	1
Univ. of NC – Chapel Hill	1
Univ. of Texas – Austin	1
Reed College	1
Univ. of Toledo	7
Worcester Polytechnic Inst.	1

REU Students Grade Point Average: 3.73

* 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 2008 Final Presentations

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

Tuesday, July 29

12:00 Molly Bittner: "Spectropolarimetry and the Study of Exoplanets"

12:15 Rosa Zartman: "MgF_2 Anti-reflective Coating "

12:30 Kyle Bednar: "PAH Emission"

12:45 Rachel Gestrich: "Star Formation: The Search for Stellar Clusters"

1:00 Lesley Simanton: "Star Formation: The Search for Stellar Clusters"

Wednesday, July 30

12:00 Sam Spencer: "Sputter Deposition of In_2O_3-Fe_2O_3 as a Protective Layer for Photoelectrochemical a-Si Solar Cells"

12:15 Allison Fink: "Structural, Mechanical and Electronic Properties of WS_xSe_{1-x} (x = 0,0.25, 0.5, 0.75, 1), Using Ab Initio Computations. Chemical names can be spoken as just "tungsten sulfide selenide systems"

12:30 Casey Bennett: "Study of Ultra Thin CdTe Pv Cells"

12:45 Jeremy Bancroft Brown: "Intermediate coupling and configuration interaction in P II"

1:00 Ryan Zeller: "Modeling and simulation of the p-n Junction" and "Optimized Design of Front Contact Grids for CIGS Solar Cells"

Thursday, July 31

12:00 Dante Amoroso: "Motion by Mean Curvature: The Phase-Field Method"

12:15 David Bergman: "Longitudinal and Transverse Diffusion of Xe+ and Ne+ Ions In the Xe/Ne Gas Mixture"

12:30 Nathan Reaver: "Accelerated Degradation of CdTe Solar Cells on Flexible Substrates"

12:45 Adam Gray: "Parallelization of a Microturbulence Code"

1:00 Michelle Labrecque: "The Effect of Fluoride Varnish on the Caries of Pediatric Patients:Quantifying the Results"

1:15 Kellen McGee: “Guidelines for Improving the Reflectivity of Silver [Ag] Back-reflectors through the Use of a Zinc Oxide [ZnO] Thin Film”

ABSTRACTS OF REU FINAL REPORTS
The University of Toledo, Department of Physics & Astronomy
SUMMER 2008
(Faculty Mentor on parenthesis)

Astrophysics/Astronomy

Kyle Bednar, *PAH Emission, (*J.D.Smith)

Polycyclic Aromatic Hydrocarbons (PAHs) are ringed molecules responsible for up to 20% of the total infrared luminosity in galaxies, making them powerful diagnostics for probing star-formation, metal enrichment, and the presence of organic compounds at early epochs in the universe. PAH vibrational transitions produce broad emission bands in the mid-infrared (MIR) between 3-20 μm. However, the presence and behavior of PAHs in the distant universe is poorly understood. The goal of our research is to quantify both the relative PAH strength and band-to-band ratios over a large range of metallicity, radiation field intensity, and local gas density. For this, a sample of nearby galaxies with steeply varying radial gradients in gas phase oxygen abundance were mapped in the infrared using Spitzer's IRS spectrograph. These data are reduced using Cubism, an IDL-based software which constructs 3D spectral data cubes. The extracted spectra from the two instrument modules are then blended to produce a spectrum from 5-40 μm. Once completed, the data is resolved spatially; spectra extracted with Cubism are labeled by galactocentric radius. Finally, PAHFIT is used to decompose the data spectrally, determining the strength and form of PAH emission at a given radius. Future research will entail correlating these strengths and distances with radiation field intensity, gas density, and metallicity, in hopes of determining the extent to which PAH emission can be used to trace star formation and galaxy evolution at high redshift.

Molly Bittner, *Spectropolarimetry and the Study of Exoplanets*, (J. Bjorkman)

Spectropolarimetry can provide a powerful process through which the properties of planetary atmospheres may be determined. Careful calculations in radiative transfer, involving the simplest model of an isotropic star and a Lambert surface upon the planet, reveals comparisons for more realistic planetary systems. Both the ratio of the flux through the planet to that of the star and fractional polarization viewed from Earth can be shown to have phase angle dependence. This phase angle between the line of sight and the star, centered at the planet, allows the changes in brightness and polarization to be visualized. Specifically, the four Stokes' parameters measure intensity and linear and circular polarization, which may be dissected to reveal wavelength-dependent properties of planetary atmospheres. Because current technology cannot detect most magnitudes, studies tend to concentrate on systems involving hot Jupiters. These reflect more light back to Earth than do smaller planets, and have much hope for future research. Through modeling the theory behind spectropolarimetry and the motions of exoplanets, important properties of worlds beyond ours can be discovered.

Rachell Gestrich, The *Search For Stellar Clusters In NGC 4449 Position B*, (R. Chandar)

Little is known about starburst galaxies concerning how they form, how they die, and why they exhibit sudden, rapid star forming periods. Studying the stellar clusters within these galaxies can help us to understand why and how these events unfold. NGC 4449 is a starburst galaxy that has had little information published on it. Using images from the Hubble Legacy Archive my goal was to detect all of the clusters in position B of NGC 4449 and determine their properties such as age, velocity, and metallicity. Using procedures from a pre established

pipeline from NGC 1291 I was able to detect over 183,000 sources in position B of NGC 4449 and eventually narrowed down the number to a little more than 33,000 possible clusters.

Adam Gray, *Parallelization of a Microturbulence Code*, (L. Anderson-Huang)

Running a large code designed to calculate microturbulence in stellar atmospheres for multiple time steps and iterations can be a time consuming process when run on only one computer. However, if the code is run on multiple machines through the use of a Beowulf computer cluster, it has the advantage of allowing for the code to run much faster than if it were to be run only on one machine. Solving the code faster will leave less time wasted and more time to run the code again with new settings, thusly allowing for more work to be accomplished.

Lesley Simaton, *Extragalactic Star Formation*, (R. Chandar)

Photometry is used to determine many properties of astronomical objects such as brightness, age, metallicity, and mass. Finding these properties for star clusters in other galaxies can tell us about the formation and evolution not only of the star clusters, but also of the galaxies. This study focuses on establishing a procedure, or pipeline, for finding and taking photometric measurements on stellar clusters in galaxies outside of our local group. I worked on applying this method to the spiral galaxy NGC 1291's position 2 and to the starburst galaxy NGC 4449's position A

Atomic/Molecular/Optical Physics

C.David Bergman, *Longitudinal and transverse diffusion of Xe+ and Ne+ ions in the Xe/Ne Gas Mixture*, (C. Theodosiou, V. P.)

Ion swarm parameters such as longitudinal and transverse diffusion are found by Monte Carlo simulation of ion motion in the mixture of Xe/Ne gases with different concentrations of Xe over E/N range (where E is the electric field and N is the total gas density) from 10 to1000 Td. First we consider a simple model in which we vary ion and background gas masses and calculate the effect of the mass ratio on longitudinal and transverse diffusion coefficients. We also find the range of electric field where the atom temperature significantly affects the ion motion. The obtained results are applied to explain trends in the simulation data for Xe+ and Ne+ ions moving in gas mixture.

Jeremy Bancroft Brown, *Experimental and Semi-Empirical Branching Fractions of the $3s^23p^2 - 3s3p^3$ J=2 Transition Array in P II*, (L. Curtis and D. Ellis)

A semi-empirical method is used to characterize the $3s^23p^2 - 3s3p^3$ J=2 transition array in P II. In this method, Slater, spin-orbit, and radial parameters are fitted to experimental energy levels in order to obtain a description of the array in terms of LS-coupling basis vectors. The various IC and CI amplitudes resulting from this model are then used to predict the branching fractions of transitions within the array. Results close to LS-coupling values are presented, and these are compared to branching rations measured using beam-foil spectroscopy at the THIA laboratory. The work provides support for the hypothesis of Dr. Curtis that transition arrays with little upper state IC but significant upper state CI in atoms of low Z exhibit branching fractions close to LS-coupled values, although the data are inconclusive in this respect.

Biological, Health, and Medical Physics

Michelle Labrecque, *The Effect of Fluoride Varnish on the Caries of Pediatric Patients:Quantifying the Results*, (M. Dennis)

Currently, the most effective and commonly used treatment of dental caries is surgical intervention, which Involves drilling out the affected area of the tooth and replacing it with a filling. While no patient enjoys the operation, it is especially difficult and painful for children to endure the procedure. Several dentists at the University of Toledo Medical Center are interested in the effects of a fluoride varnish applied to the caries of pediatric patients. The subjects' radiographic films will be analyzed to find density changes in the teeth over time, indicating remineralization of the dental enamel or slower progression of the caries when compared to non-treated subjects. Typically, clinical dental research is reported using qualitative visual analysis of the x-ray films. However, this project will be focused on producing comparable images so that density changes can be evaluated quantitatively. This includes increased emphasis on the importance of the consistency of experimental set-up, film development and film digitization. To quantify density changes, the radiographic films will be shot with a constant reference object, digitized using the PACS system and then specific regions of interest of the tooth can be quantified and compared numerically as well as scaled to a common unit.

Condensed Matter Physics

Dante Amoroso , Motion *by Mean Curvature: The Phase-field Method, (J. Amar)*

The phase-field method is applied to the problem of motion by mean curvature. Simulations are performed doing motion by mean curvature explicitly on an initial sine wave, and analytical calculations are done for the effect of mean curvature governed evolution on an initial circle. The phase-field method is then used to solve the same situations and excellent agreement is found. The computation time of the phase-field method is then investigated, and a method involving Fourier transforms is implemented to speed up this computation. Error is introduced by this procedure, but two possible solutions are proposed. Due to time constraints, unfortunately, neither solution could be investigated. Lastly, the Fourier transform phase-field method is applied to a random initial condition and is seen to reliably produce domains which become more homogeneous with time, a result expected for any interface governed by mean curvature.

Casey Bennett, *Study of Ultra Thin CdTe Pv Cells*, (A. Compaan)

The decreasing avaiability of semiconductors grade silicon along with its high demand across multiple industries has caused silicon based solar cells to rise in cost. This gives other semiconductor materials a chance to advance. One of the most promising candidates is CdTe based collectors, unfortunately the scarcity of tellurium and toxicity of cadmium could present some problems for mass production. Additionally, CdTe hasn't yet attained the price/performance ratio of silicon based cells. One solution to these problems is to use less material per cell. However, this requires reoptimization of cell production and characterizations specific to ultra thin cells. Research on these new conditions was broken into three subprojects. The first involved determining the dependence of photovoltaic parameters on the thickness of the CdS and CdTe layers. This was done by measuring how varying thicknesses of cell layers and cadmium chloride treatment times effect the quantum efficiency and j-v measurements of the cell. The second was modeling the quantum efficiency of ultra thin cells by modifying a modeling spreadsheet to calculate the cells performance across the spectrum. The third involved

the optimization of $CdCl_2$ treatment times for ultra thin devices by calculating new treatment times and temperatures that exhibit similar chlorine diffusion profiles to circumvent uncertainties involved in shorter treatments.

Allison Fink, *Structural, Mechanical and Electronic Properties of WS_xSe_{1-x} (x = 0, 0.25, 0.5, 0.75, 1), Using Ab Initio Computations*, (S. Khare)

My objective was to use the *ab initio* method to theoretically calculate properties of the tungsten sulfide selenide systems W_2S_3Se, $W_2S_2Se_2$, and W_2SSe_3, of hexagonal 6-atom crystal structure. The properties of WS_2 and WSe_2 (composed of two atoms of tungsten and four respectively of S and Se) were already calculated and used to compare the results of mixtures of sulfur and selenium. I ran a computer program that calculates the ground state energy of one unit cell in a crystal from first principles by approximating the solutions to the many body Schrödinger equation given the specific atoms and their positions for a unit cell in a crystal lattice. I used output data from this program to calculate structural, electronic, and mechanical properties for the three materials: lattice constants, density of states, band structure, and elastic constants, from which the coefficient of friction could be determined. My advisor and the graduate student that I worked with aim to publish my results in a scientific journal, on which I may later collaborate.

Kellen McGee, *Guidelines for Improving the Reflectivity of Silver [Ag] Back-reflectors through the Use of a Zinc Oxide [ZnO] Thin Film*, (R. Collins)

This paper seeks to calculate the extent to which the absorption of an Ag back reflector, (using a pure Drude model) may be minimized by a thin film of ZnO (using a pure Cauchy model with k = 0). Starting with the basic Fresnel Equation, in which theta = 0, expressions for the reflectivity of an Ag-ZnO-Air stack are developed, as are expressions describing the periodicity of the maxima and minima of reflectivity as a function of thickness. All models are then plotted to demonstrate the change of optical properties of the stack as thickness of the ZnO layer and the incident light wavelength varies. Suggestions are then made for the direction of future research in this area, based on this report's findings.

Nathan Reaver, *Accelerated Degradation of CdTe Solar Cells on Flexible Substrates*, (A. Compaan)

CdTe solar cells are second-generation thin film cells and have typically been fabricated on glass substrates/superstrates. Researchers at the University of Toledo have been fabricating CdTe cells on flexible polymer substrates. One such polymer used in cell fabrication is DuPont™ Kapton® polyimide film. This project focuses on the degradation of CdTe solar cells on Kapton® substrates vs. similar cells on glass substrates. Cells fabricated on both glass and Kapton® were soaked in continuous one-sun conditions to accelerate the degradation of the cells' performance. The degradation of the cells' performance was determined through the measurement of each cell's open circuit voltage, short circuit current, efficiency, and fill factor over time on a logarithmic timescale. Degradation of each of the cell's attributes over time was studied to determine correlations between type of substrate and degradation of the cell's performance.

Sam Spencer, *RF Sputter Deposition of In_2O_3-Fe_2O_3 as a TCCR Layer for Immersion-type Solar Cells*, (B. Ingler)

This experiment attempted to identify the conditions under which the transparency, conductivity, and corrosion resistance of a thin film of In_2O_3-Fe_2O_3 may be maximized, for use as a protective outer layer of an immersion-type solar cell. The best sample was produced at 275 °C, 100W Fe_2O_3 and 30W In sputter powers, 6% oxygen gas, 11 sccm total gas flow, at 6.0 mTorr for two hours of deposition, and had an increasing current density at 1.6V of 4.32 mA/cm2 after 28 cycles of cyclic voltammetry from -1V to 3V.

Rosa Zartman, *Anti-reflective Coating for Photovoltaics*, (S. Marsillac)

This research focuses on using magnesium fluoride (MgF_2) to make an anti-reflective film for copper indium gallium diselenide (CIGS) photovoltaic solar cells. To accomplish this feat, the employment of a thermal evaporator with a baffled boat is the method of application. The baffled boat is essential to insure that no spitting of magnesium fluoride happens on the substrate. The test substrates of soda lime glass, indium tin oxide (ITO), and CIGS showed great improvement from before the application of MgF_2 to after that application. On the soda lime glass, the percent reflection went from 9% to 1.7%, which is a decrease of 18% in reflection. The results for ITO were even better with a decrease of at least 35% in reflection. After applying magnesium fluoride to copper indium gallium diselenide solar cells, the tests were done mainly on reflection and quantum efficiency. The reflection decreased up to 40% and quantum efficiency complemented this decrease by increasing at the same wavelength no matter the thickness of the MgF_2. The complementation has sparked an ongoing process to understand this relationship and find a way to predict the optimal thickness for each individual cell to obtain the peak performance. Magnesium fluoride is heavily used in the manufacture industry today, so it will be easy to make this research application work well in that industry.

Ryan M Zeller, *A Simple Precise Optical Thickness and Temperature Monitor*, (A. Compaan, K. Wieland)

In order to achieve maximum efficiency and performance in a photovoltaic solar cell module, optimal thickness of semiconductor layers must be controlled. Thickness of thin film layers determines key properties of cell performance. In order to optimize the performance of a RF magnetron sputtering chamber, an Optical Thickness Monitor (OTM) was built to better understand and to monitor the deposition process in real time. The OTM utilizes laser light reflected off the growing sample, which is detected with a photodiode. With LabVIEW software, the monitor outputs real-time film thickness and material growth rate. It also allows determination of substrate temperature.

NSF-REU External Publications and Presentations*
(Calendar Year 2008)

REFEREED PUBLICATIONS - Submitted/accepted/published.

1. Y. Sheffer, **M. Rogers*** **(2005)**, S. R. Federman, N. P. Abel, R. Gredel, D. L. Lambert, and G.Shaw, "Ultraviolet Survey of CO and H_2 in Diffuse Molecular Clouds: the Reflection of Two Photochemistry Regimes in Abundance Relationships," ApJ, 687, 1075 (2008).
2. **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 77,015301:1-11 (2008).
3. Wisniewski, J.P., **Kowalski, A.F.* (2004)**, Bjorkman, K.S., Bjorkman, J.E., & Carciofi, A.C., "Toward Mapping the Detailed Density Structure of Classical Be Circumstellar Disks," ApJ Letters, 656, L21 (2007).

REFEREED PUBLICATIONS - in preparation.

1. **R. Zeller* (2008),** K. A. Wieland, and A.D. Compaan, "A Simple Precise Optical Thickness and Temperature Monitor," manuscript in preparation (2008).
2. **J. B. Brown* (2008)**, D. G. Ellis, and L. J. Curtis, "Experimental and Semi-empirical Branching Fractions of the $3s^2 3p^2 - 3s3p^3$ J=2 Transition Array in P II," manuscript in preparation (2008).

PRESENTATIONS.

1. **L. Simanton*** **(2008)**, R. Chandar, A. Lark, and N. Zellner, "Photometry of Star Clusters for Extragalactic Star Formation and Telescope System Analysis," Michigan Space Grant Consortium meeting (2008).

PRESENTATIONS WITH PUBLISHED ABSTRACTS.

1. Wisniewski, J.P., **Kowalski**, **A.F.*** **(2004)**, Clampin, M., Grady, C.A., Sitko, M.L., Bjorkman, K.S., Hines, D.C., & Whitney, B.A., "First Science Results from the UKIRT UIST Coronagraphic Imaging Polarimeter," Bulletin of the American Astronomical Society, 39, 813 (2007).

2. M. Brown, S. R. Federman, L. J. Curtis, S. Cheng, R. E. Irving, **S. Torok* (2006)**, and R. M. Schectman, "Oscillator Strengths for Ultraviolet Transitions in P II and Cu II for Interstellar Studies," B.A.A.S., 40, 184, (2008).

3. **R. Hupe* (2007)**, S. Federman, and Y. Sheffer, "Electronic Transitions of C_2 in the Ultraviolet: A Survey with the Hubble Space Telescope," B.A.A.S., 40, 188, (2008).

4. Y. Sheffer, **M. Rodgers*** **(2005)**, S. R. Federman, D. L. Lambert, R. Gredel, N. P. Abel, and G. Shaw, "Ultraviolet Survey of $^{12}C^{16}O/^{13}C^{16}O$ and $^{12}C^{16}O/H_2$ in Diffuse Molecular Clouds," B.A.A.S., 40, 195, (2008).

CONFERENCE PRESENTATIONS WITH PROCEEDINGS PAPERS.

1 Wisniewski, J.P., **Kowalski, A.F.*** (2004), Bjorkman, K.S., & Bjorkman, J.E., "Toward Mapping the Detailed Density Structure of Classical Be Circumstellar Disks," in Active OB-Stars: Laboratories for Stellar and Circumstellar Physics, 361, 524 (2007).

2 **Kowalski, A.F.*** (2004), Wisniewski, J.P., Clampin, M., Grady, C.A., Sitko, M.L., Bjorkman, K.S., Fukagawa, M., Hines, D.C., Katoh, E., & Whitney, B.A. "Diagnosing the Structure of the HD 163296 Protoplanetary Disk via Coronagraphic Imaging Polarimetry", 2009, in AIP Conf. Proc.: Cool Stars 15, in press

* 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
2008 (Total Population: 15, Responses: 6)

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

2008 mean (pop. 6): 2.5

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

2008 mean (pop. 6): 2.5

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

2008 mean (pop. 6): 2.5

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

2008 mean (pop. 6): 3.0

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

2008 mean (pop. 6): 3.3

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

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

2008 mean (pop. 6): 2.0

How do you rate your summer experience personally?

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

2008 mean (pop. 6): 2.2

How do you rate your summer experience educationally?

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

2008 mean (pop. 6): 2.7

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

2008 mean (pop. 6): 4.3

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

2008 mean (pop. 6): 2.5

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

2008 mean (pop. 6): 3.5

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

2008 mean (pop. 6): 4.2

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

2008 mean (pop. 6): 2.2

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

2008 mean (pop. 6): 1.3

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

"Best

Learning to figure out things myself.

Doing the presentation and preparing it made me feel responsible for my work.

I got to learn more about quantum mechanics and a little about solid state.

My advisor was a positive person who expected a lot.

The graduate students were approachable and willing to help me.

Being with a group of nice and intelligent students who were interested in physics.

Worst

Lots of drudgery running computer program.

Not expected to understand the theory behind what I was doing.

Graduate student I worked with was not always helpful for explaining the theory and was not even a physics major. I tried to understand but since I was on my own it took a lot longer to make progress and sometimes wasted a lot of time b/c I was pursuing mistaken leads or did not know what to pursue to answer my questions officially.
My advisor did not give me the impression that taking time to answer my questions in detail was important to him. He expected the grad students to do most of that but they weren't physicists; they were engineering students and when I wanted an exact physical and mathematical explanation they gave me vague non-explanatory answers.

I worked all the time and missed out on social activities.

The Issues in Research seminars (2980) were almost always a complete waste of time. They were mostly irrelevant, or a lecture at us like we were immature or irresponsible."

"Best: everything
really good mentor
really liked other REU students, REU staff

Worst: the REU program ending ☹"

"Pretty much everything was fantastic.
My only complaint was in how far away the kitchen was."

"Personally, I found the research portion very un-educational because the material I was working with was quite beyond me, but no effort was made to bring me to the level that I needed to do the tasks assigned me. I largely felt like I was dependent on the graduate students for everything, because I had not the tools to figure out my research on my own.
I simply copied everything everyone else gave me."

"best:
-REU staff
-I really liked my advisor and I learned a lot.
-I had a lot of fun with the other REU participants
Worst:
None"

Please list any additional comments.

"At my previous REU there were two things I found useful:

1. Every week each person talked informally for 5 minutes about their project, this usually took 2 hours at the end of the day on Friday, and I felt it made people more familiar with each other's work. This was instead of a middle presentation.

2. When we first arrived, each advisor gave a half-hour presentation on their offered projects over 2 days. Everyone wrote their top 3 choices and was assigned from there. No one received their 3rd choice."

"Please make sure professors given REU students both have appropriate projects for these REUs (that hopefully give the REU students some attractive lab experience) and have enough time to actually work with the REUs so the students can learn about the topic they're researching in a meaningful way."

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 2008 PICTURES

"Camping Out"

Summer camp group are touring Al Compaan's solar hybrid house.

A picture of the REU & summer camp students on the first day after the lab activities.

Summer campers after the planetarium show by Alex Mak

At the left Jackie Kane, a St Ursula high school science teacher, getting ready to chow down.

Fun with corn starch

Fun in the Sun

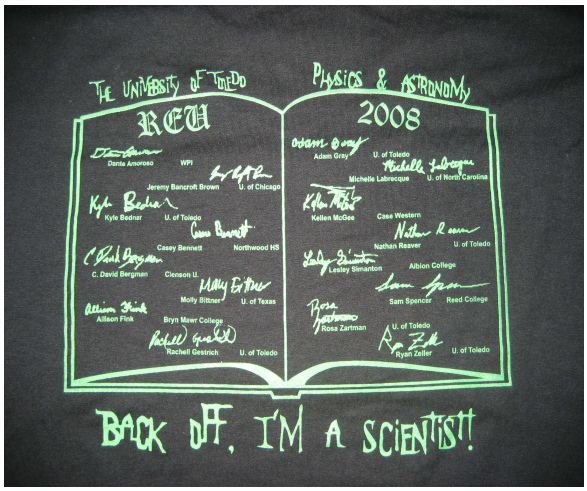
Wind Surfing @ Al Compaan's House

Nathan & Michelle get a workout @ Maumee Bay.

A Keepsake for the NSF Experience

The T-shirt REU's designed @ UT, Home of the Rockets.

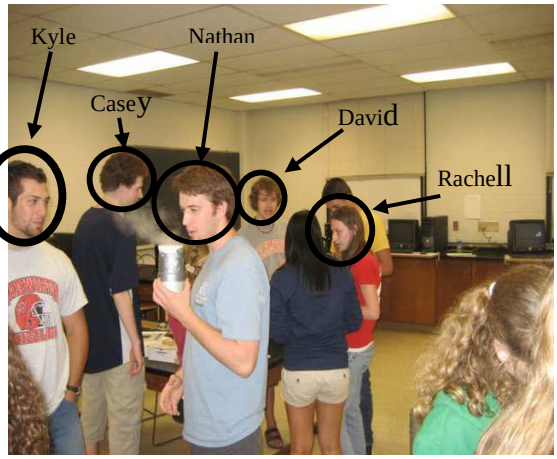
Front of Shirt



Back of Shirt

We all scream for LN_2 ice cream!

Rosa and her new friends



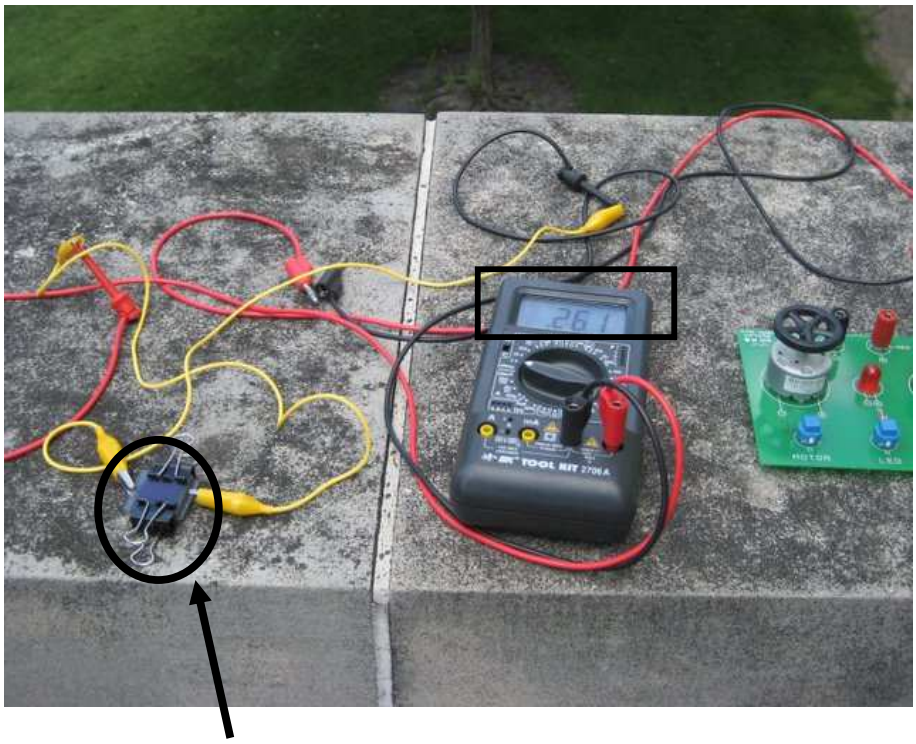
Nathan is playing with the ice cream supplies again!

People at Work

Video conferencing during a bag lunch via laptop and webcam setup by Adam for Rosa who is stuck @ home.

Final REU Presentation by Rachell and Lesley

Capturing the rays



NSF helps shine the way to enlightenment!

A student’s nanocrystalline solar cell soaking up the sun.