Annual Progress Report (Year 1)

REU Site: Research Experiences for Undergraduates in Physics and Astronomy

NSF-REU Grant PHY−0353899

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

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I. REU RESEARCH PARTICIPANTS, SUMMER 2004

Left to Right (Standing): **Adam Kowalski**, B. Gao, **Paul Sell**, K. Bjorkman, **Erin Allgaier**, T. Kvale, L. Curtis, **Nicholas Sperling**, **James Steiner**, R. Collins, N. Morrison, J. Amar

Left to Right (Kneeling): **Victoria Winbow**, **Jennifer Hawk**, **Levi Gorrell**, A. Lukaszew, **Arow Hieronymus**, **Joshua Inks**

NAME	COLLEGE	MENTOR	RESEARCH
Erin Allgaier	American University, DC	Nancy Morrison	Astronomy
Levi Gorrell	University of Toledo	Al Compaan	Condensed Matter
Jennifer Hawk	Hillsdale College, MI	Thomas Kvale	Atomic Physics
Arow Hieronymus	King College, TN	Jacques Amar	Condensed Matter
Joshua Inks	Grove City College, PA	Robert Collins	Condensed Matter
Adam Kowalski	University of Chicago	Karen Bjorkman	Astronomy
Paul Sell	University of Toledo	Adolf Witt	Astronomy
Nick Sperling	University of Toledo	Ale Lukaszew	Condensed Matter
James Steiner	Ohio University	Larry Curtis	Atomic Physics
Victoria Winbow	Trinity University, TX	Bo Gao	Atomic Physics

II. SUMMARY OF SUMMER 2004

Introduction

The Summer 2004 NSF-REU program in Physics and Astronomy at Toledo gave enhanced research opportunities to 10 undergraduate students from 8 colleges and universities in 7 states spread from DC to Texas. We also provided partial support from the NSF-REU grant to two additional UT students that were primarily funded through their advisors' grants. This supplement brought up their level of support to be commensurate with the students fully supported by the REU grant. This policy of supplementing external grant support allows us to involve more students (and faculty members as mentors) in the program than we could do with just the REU grant alone. Student participants were chosen competitively from the 114 applications from students in 33 different states in all parts 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 gender distribution (including the two additional male UT students) of the participants this year were 7 men (70%) and 3 women (30%). The initial web announcement (with secondary links to additional material) can be found at:

http://www.physics.utoledo.edu/~wwwreu/reusummer2004/nsf-reu2004a.html

We are pleased to report that Summer 2004 was a success from both the students' and faculty mentors' perspectives. Three refereed publications involving REU student co-authors were published (and/or accepted for publication) in 2004; at least one additional conference proceedings manuscript will be submitted; and five papers in three different conferences were presented and/or submitted in 2004.

Advertisement and Selection

Again this year (Summer 2004) we utilized a web-based advertisement and application system. We believe that the internet is the main search vehicle for students because most of the applications we received came from students not associated with institutions to which we mailed posters. The only paper announcement sent to institutions (about 130 institutions) was a very brief letter alerting the prospective students to our website and a paper copy of our Application form in case the students didn't have readily available access to the internet. The selection committee was composed of Thomas Kvale (PI) and R. Alejandra Lukaszew (Co-PI). 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. Although we were successful in these areas, we will again try harder to attract more persons of under-represented groups in our program. For instance, we made contact with faculty at Central State University and plan to personally visit their campus this Spring.

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 the student participants lived in the same campus dormitory, with the NSF-REU grant providing the housing costs. 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. The director of Student Housing on the campus of the University of Toledo has cooperated with us fully in this respect for the past 13 summers of NSF-REU support. The students stayed in the Academic (Honors) House, which is organized into suites adjoining a common area that encouraged social interactions among the REU students. We will continue to work with the Housing office in order to better secure kitchen facilities for the students.

Social Activities

Social activities were coordinated by the three UT participants (Levi Gorrell, Paul Sell, and Nick Sperling) who are officers in the UT chapter of SPS. This worked out very well and the students formed a close-knit group. Some of the special events included:

1) Trip to Toledo Art Museum twice
2) Trip to Toledo Zoo
3) Attended a Toledo Mud Hens game
4) Every Thursday night was game night. We played card games (mostly Eucher) and board games. A couple of times we went out a played Volleyball.
5) Wednesdays were all you can eat panckakes at Uncle John's (went about every other week)
6) We went windsurfing twice. The first time was at Olander park and the second time was at Maumee Bay State Park. Both times included a Barbeque as well.
7) Went to Murphy's Jazz cafe
8) Trip to Cedar Point Amusement Park
9) We went to the Arts Festival at the Toledo Botanical Gardens.

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" seminar series played an important part of our summer program. Faculty members and/or outside speakers presented a talk over the lunch hour for the 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. The whole department was invited to attend the Bag Lunches, and the participation was very 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 2004 BROWN BAG SEMINARS

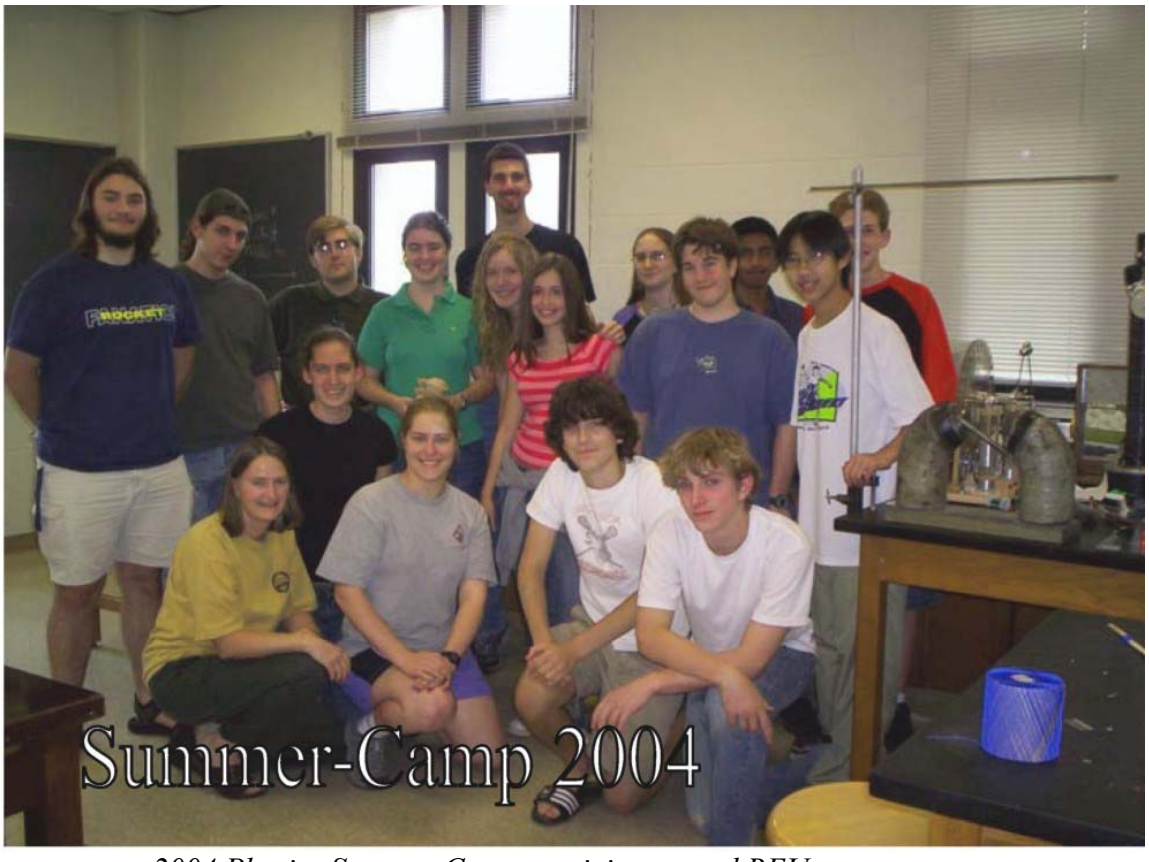
TUESDAY NOON - MH 4009

June 01	T. Kvale + Staff	*REU Orientation and Welcome Lunch*
June 08	P.B. James	*Martian Climate Research*
June 15	N. D. Morrison	*Spectroscopy of Hot, Luminous Stars at Ritter Observatory*
June 21-25 -- Physics Summer Camp		
June 29	REU Students	Progress Reports
July 06	A.D. Compaan	*Solar Electricity in Toledo*
July 13	R. W. Collins	*Ellipsometry for Study of the Optical Properties and Structure of Solids and Thin Films*
July 20	I. Parsai (MCO)	*Medical Physics, Not an Oxymoron!*
July 27	S. V. Khare	*Theory and Computation in Nano-science*
July 29, Aug. 3-5	REU Students	*What I Did This Summer -- Final Presentations*

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 REU students were coauthors on three refereed publications in 2004. All three of the manuscripts had REU students as first authors! At least one additional manuscript is in preparation. Five presentations were made or submitted this year at conferences. One poster presentation won in the Physical Sciences and Engineering division at the regional 2004 Sigma Xi Student Research Symposium held at UT.

II. PHYSICS SUMMER CAMP 2004



2004 Physics Summer Camp participants and REU team.

List of participants and their local high-school name:

1. Mr. Jeff Eisenstadt, Ottawa Hills HS
2. Mr. Sean T. George, Bedford HS
3. Aakrit Prasad, Southview HS
4. Ms. Marissa Rokicki, St. Ursula Academy
5. Ms. Anne Slama, Southview HS
6. Mr. Daniel Kane, Ottawa Hills HS
7. Ms. Samantha Kronk, St. Ursula Academy
8. Ms. Jennifer Brubaker, Maumee Valley Country Day School
9. Mr. Mike Deng, North View HS
10. Mr. Casey Bennett, North Wood MS
11. Ms. Anne M. Slama, South View HS
12. Andre Copenhaver, Maumee Valley Country Day School

During one of the brown-bag lunches R. A. Lukaszew (Co-PI) introduced to the REU team the concept of Physics Summer Camp for high-school students interested in science. She explained that the idea was 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 the concept and all wanted to share experiences that they had at one time or another and that inspired them to study Physics. The schedule of activities was sketched and perfected in a second short meeting after another brown-bag lunch.

Schedule of Physics Summer Camp Activities

Monday, June 21

9:00am	**Light Breakfast**	Introducing yourselves and each other
10:00am	**REU Members**	How does an elevator work?, Question of the day, Introductory survey
11:30am - 3:00pm	Lunch, Building bridges with pop-sickle sticks to test their mechanical resistance	

Tuesday, June 22

9:00am	**Light Breakfast**	
10:00am	**Philip James**	Prof. James' involvement in the exploration of Mars.
11:30am - 3:00pm	Lunch, Testing bridges, Demo on Chain Reaction	

Wednesday, June 23

9:00am	**Light Breakfast**	
10:00am	**Larry Curtis**	Larry Curtis talks about the Universe that we live in.
11:30am - 3:00pm	Lunch, Building a DC motor, How does it work?, E&M demos	

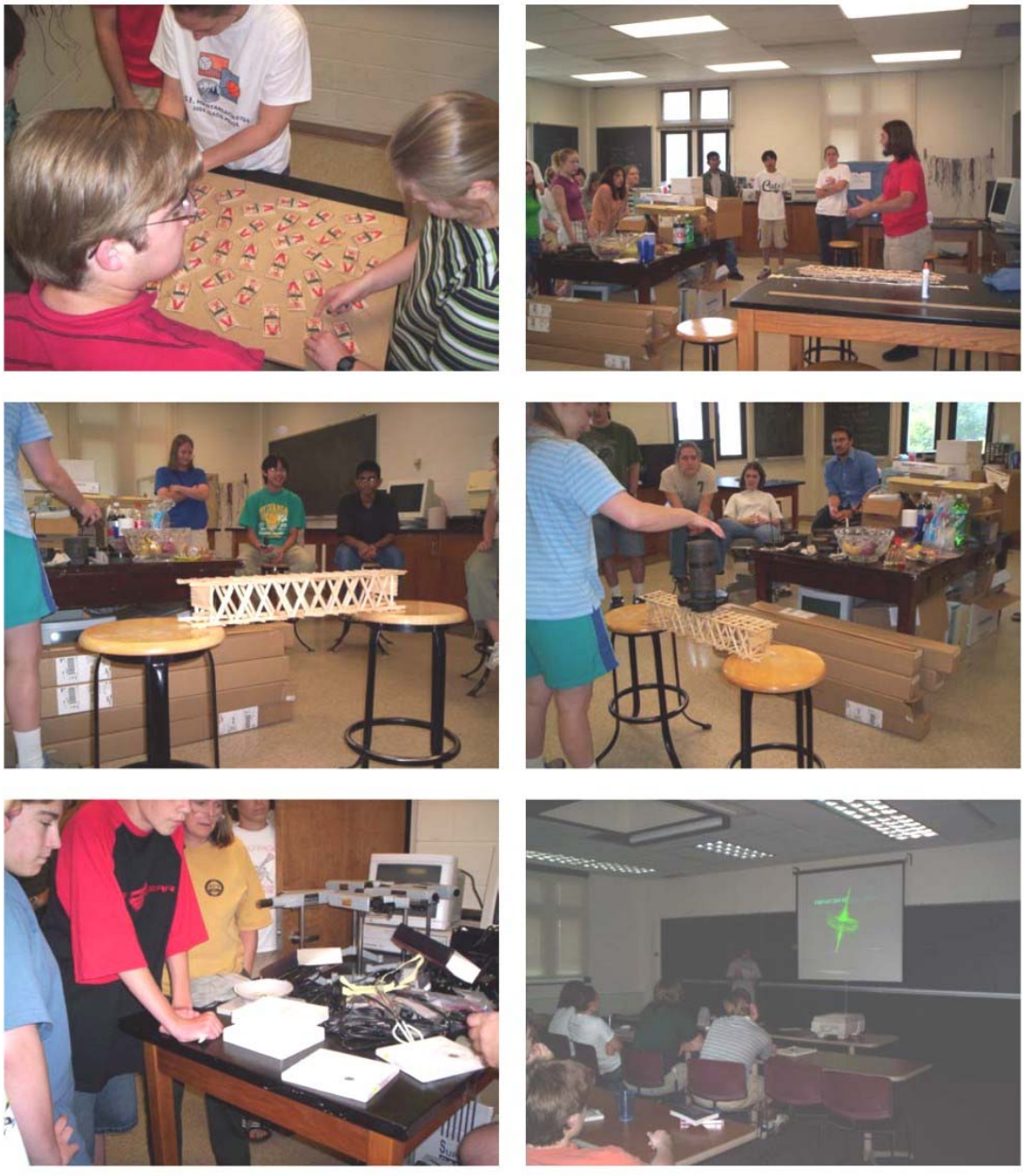
Thursday, June 24

9:00am	**Light Breakfast**	
10:00am	**REU Members**	Building a catapult to study Projectile motion. Take the catapults outside to test them.
11:30am - 3:00pm	Lunch, Visit research labs: Profs. X. Deng, N. Morrison, L. Curtis.	

Friday, June 25

9:00am	**Light Breakfast**	
10:00am	**S. Lee, C. Theodosiou**	Career choices in Physics
11:30am - 3:00pm	Lunch: BBQ, Fun with LN2: ice-cream, The Meissner effect, Farewell survey	

The schedule of activities was fully designed by the REU team under the supervision of R. A. Lukaszew. The activities ran daily for one week from 9 a.m. till 3 p.m. The activities comprised informal talks about how things work, with presentations by the REU-team, formal talks by faculty from the department, and hands-on activities. We asked two anonymous surveys at the beginning and end of the camp in order to find out the expectations of the campers as well as their satisfaction with the activities. The results from the surveys were shared and discussed with the REU team. The general outcome of the event was that there was considerable interaction between the two groups and several of the campers were quite impressed by the performance and involvement in research of the REU-team and left the camp with a renewed interest in science.



Picture captions

top left: assembling the chain-reaction chamber*; top right:* explanation on the chain-reaction by REU team members.
middle left: bridge built with pop-sickle sticks; *middle-right:* testing bridges for mechanical strength by adding weights.
bottom left: observing the Meissner effect; *bottom-right:* a talk on black-holes by one of the campers.

IV. DEMOGRAPHICS

NSF-REU SUMMER 2004 APPLICATIONS

Geographical distribution by undergraduate institution
(Applications Received / REU Offers Made /REU Accepted)

Alabama
U. of Alabama ..... (1/1/0)

Alaska
U. of Alaska Fairbanks ..... (1/0/0)

California
Harvy Mudd College ..... (4/1/0)
Humboldt State Univ. ..... (1/0/0)
San Diego State Univ. ..... (1/1/0)
UC Berkeley ..... (1/1/0)

Colorado
Colorado School of Mines ..... (1/0/0)

Connecticut
U. Connecticut ..... (1/0/0)

District of Columbia
American University ..... (2/2/1)

Florida
Florida Institute of Technology ..... (1/0/0)
Florida State Univ. ..... (2/0/0)
Jacksonville Univ. ..... (1/1/0)
St. Peter College ..... (1/0/0)

Georgia
Weslyan College ..... (1/0/0)

Illinois
Loyola Univ., Chicago ..... (2/0/0)
Monmouth College ..... (1/1/0)
U. of Chicago ..... (1/1/1)
U. Ill., Urbana-Champaign ..... (1/1/0)

Indiana
Ball State Univ. ..... (1/0/0)
Depauw Univ. ..... (1/1/0)
Earlham College ..... (1/0/0)
Purdue University ..... (1/0/0)
Rose-Hullman Inst. of Tech ..... (1/0/0)
U. of Notre Dame ..... (1/0/0)

Iowa
U. of Iowa ..... (1/0/0)

Kansas
Emporia State Univ. ..... (1/1/0)
Southwestern College ..... (1/0/0)

Kentucky
U. of Kentucky ..... (1/0/0)
Western Kentucky Univ. ..... (1/0/0)

Maryland
McDaniel College ..... (1/0/0)

Massachusetts
Amherst College ..... (1/0/0)
Harvard College ..... (2/0/0)
Worcester Polytechnic Inst. ..... (1/0/0)

Michigan
Albion College ..... (1/0/0)
Hillsdale College ..... (1/1/1)
Michigan State Univ. ..... (1/1/0)

Minnesota
Concordia College ..... (1/0/0)
U. of Minnesota ..... (2/0/0)

Missouri
Northwest MO State Univ. ..... (1/0/0)
U. of Missouri-Columbia ..... (1/0/0)

Nebraska
U. Nebraska at Kearney ..... (1/0/0)

New Jersey
Ramapo College of New Jersey ..... (1/0/0)

New York
Clarkson Univ. ..... (1/0/0)
Columbia Univ. ..... (3/1/0)
Cornell University ..... (1/0/0)
Dutchess Community College ..... (1/0/0)
Skidmore College ..... (1/0/0)
U. of Rochester ..... (1/1/0)

North Carolina
Duke University ..... (1/0/0)
North Carolina State Univ. ..... (1/0/0)

Ohio
Case Wester Reserve Univ. ..... (1/0/0)
College of Wooster ..... (1/0/0)
Heidelberg College ..... (1/0/0)
Kenyon College ..... (1/0/0)
Marietta College ..... (1/0/0)
Muskingum College ..... (2/0/0)
Ohio Northern Univ. ..... (2/0/0)
Ohio University ..... (2/2/1)
Univ. of Toledo ..... (6/3/3)*

Oregon
Linfield College ..... (1/0/0)
Reed College ..... (1/1/0)

Pennsylvania
Bucknell Univ. ..... (3/0/0)
Carnegie Mellon Univ. ..... (2/0/0)
Duquesne University ..... (1/1/0)
Grove City College ..... (1/1/1)
Slippery Rock Univ. ..... (1/1/0)

South Carolina
Clemson Univ. ..... (2/0/0)

Tennessee
King College ..... (1/1/1)
Middle Tennessee State Univ. ..... (1/0/0)

Texas
Angelo State Univ. ..... (1/0/0)
Rice University ..... (1/0/0)
Texas A&M Univ. ..... (1/0/0)
Trinity College ..... (1/1/1)
U. of Dallas ..... (1/0/0)
U. of Texas at Arlington ..... (2/1/0)
U. of Texas at Austin ..... (1/0/0)
U. of Texas at Dallas ..... (1/0/0)
U. of Texas at El Paso ..... (3/1/0)
West Texas A&M ..... (1/0/0)

Vermont
Univ. of Vermont ..... (1/0/0)

Virginia
College of William & Mary ..... (2/0/0)
James Madison University ..... (1/0/0)
Radford University ..... (1/0/0)

Washington
U. of Washington ..... (2/0/0)
Whitworth College ..... (1/0/0)

West Virginia
Marshall University ..... (1/0/0)
West Virginia University ..... (1/0/0)

Wisconsin
Lawrence University ..... (1/0/0)
U. of Wisconsin-Madison ..... (1/0/0)

* includes two UT students with only partial REU support.

SUMMARY
114 Applications received
29 Offers made
10 Offers accepted

NSF-REU Participant Demographics
Summer 2004

Gender	
Female:	3
Male:	7*

Entering Fall Class Rank (after Summer)	
Freshman:	0
Sophomore:	4
Junior:	3
Senior:	3
Higher:	0

Ethnicity	
International Student:	0
American Indian:	0
Alaskan Native:	0
Asian American: (or Pacific Islands)	0
African American:	0
Hispanic American:	0
Caucasian/White:	10*
Other:	0

Home State	
Tennessee	1
Michigan	2
Texas	1
Ohio	6

Home Institution:	
American University, DC	1
Grove City College, PA	1
Hillsdale College, MI	1
King College, TN	1
Trinity University	1
University of Chicago	1
University of Toledo	3*

REU Students Grade Point Average: 3.53

* Includes two UT students with partial REU support.

V. RESEARCH

2004 REU Final Presentations

Thursday, July 29

2:00pm - 2:20pm **Erin Allgaier**, *Stellar Wind Variability of alpha Cygni* (N.Morrison)

Tuesday, Aug 03

12:00pm - 12:20pm **Jack Steiner**, *Isoelectronic Modeling of Energy Levels and Emission Intensities in the Mg sequence* (L. Curtis)

12:20pm - 12:40pm **Adam Kowalski**, *Infrared Spectra of Be Stars* (K. Bjorkman)

12:40pm - 1:00pm **Nick Sperling**, *Simulations for Experiments on Nano-Magnetic Materials* (A. Lukaszew)

Wednesday, Aug 04

12:00pm - 12:20pm **Paul Sell**, *Exploring the Excitation of Extended Red Emission* (A. Witt)

12:20pm - 12:40pm **Arow Hieronymus**, *Effects of Shadowing and Diffusion on Surface Morphology in Thin-film Growth* (J. Amar)

12:40pm - 1:00pm **Victoria Winbow**, *Applications of Semi-Classical Methods to Molecular Spectra* (B. Gao)

Thursday, Aug 05

12:00pm - 12:20pm **Joshua Inks**, *Analysis of the Optical Properties of the Component Layers of the CdTe Solar Cell* (R. Collins)

12:20pm - 12:40pm **Levi Gorrell**, *Temperature Dependent Photoluminescence of Ion Implanted Crystalline CdTe* (A. Compaan)

12:40pm - 1:00pm **Jennifer Hawk**, *Measurements of Kinetic Energies Using Hemispherical Energy Analyzers* (T. Kvale)

ABSTRACTS OF REU FINAL REPORTS
The University of Toledo, Department of Physics & Astronomy
SUMMER 2004
(Faculty Mentor on parenthesis)

Astrophysics/Astronomy

Erin Allgaier, *"Stellar Wind Variability of alpha Cygni,"* (N.Morrison)

We take a look at the star a Cygni and observations taken of the star over three seasons at Ritter Observatory at the University of Toledo. Alpha Cygni is a class A2Iae star that is losing mass creating a P Cygni profile. Using a 1-meter reflecting telescope, an échelle spectrograph and a CCD, data are taken of the star. The 1998, 1999, and 2000 observing seasons are examined for a total of 151 spectra. For each spectrum, telluric lines are removed, cosmic rays and electronic defects are removed, the Doppler shift is corrected, and continuum is normalized. The accumulation of the analysis is represented in three dynamical spectra. From the dynamical spectra, periodic behavior is attempted to be found, verifying or opposing the theory of periodic wind behavior due to increased mass loss at specific locations on the star.

Adam Kowalski, *"Infrared Spectra of Be Stars,"* (K. Bjorkman)

Using the Spex spectrograph mounted on the Infrared Telescope Facility (IRTF), Dr. K. Bjorkman, Dr. J. Bjorkman, and John Wisniewski took infrared spectra (0.85 microns to 2.5 microns) of about 30 Be stars, which are stars that are known to have circumstellar gaseous discs around them. I have used an IDL program called SpexTool to reduce the raw data from the observing run and produce finalized spectra of each of the stars on the second observing night. From the equivalent width and full-width-at-half-max of the emission features in the spectra, we are in the process of deducing each disc's orientation, elemental composition, rotational motion, and behavior of its density waves. We found that 48 Libra's V/R variation is similar between the Hydrogen alpha emission taken at Ritter and the Hydrogen Brackett series taken in the infrared, which tells us that the density clump is generally uniform at different radii of the disc. The results will give insight into the physics of many disc systems ranging from the rings of Saturn to the spiral arms of galaxies.

Paul Sell, *"Exploring the Excitation of Extended Red Emission,"* (A. Witt)

Extended Red Emission (ERE) is a photoluminescence process that was first detected in the Red Rectangle at wavelengths between approximately 600 and 800 nanometers. Many properties of the nature of ERE have remained a puzzle for decades. Theorists have suggested models for numerous carriers of this complicated emission, but none of the models have thoroughly accounted for the emission. Our data consists of observations with the Hubble Space Telescope (HST) of the dust filaments in a photodissociation region in NGC 7023. We use the known exciting radiation value of 1104 Å for H_2 fluorescence and infrared (I) band observations to find the exciting radiation for the ERE. We used ratios of the relative penetration depths of the H_2 and I bands to the ERE and found the spectral region for the exciting radiation for the ERE to be in the far UV (ultraviolet).

Atomic/Molecular/Optical Physics

Jennifer Hawk, *"Measurements of Kinetic Energies Using Hemispherical Energy Analyzers,"* (T. Kvale)

Two electrostatic energy analyzers are employed on the UT-P/NIELS accelerator facility at UT in order to measure the kinetic energies of ejected electrons and scattered energetic ion projectiles following ion-atom and ion-surface collisions. This project involved accurate modeling of the ion and electron trajectories entering and exiting the analyzers in order to achieve the high energy resolution necessary for the current atomic scattering experiments.

Jack Steiner, *"Isoelectronic Modeling of Energy Levels and Emission Intensities in the Mg sequence,"* (L. Curtis)

A new model has been developed for calculating branching fractions along the Mg-like isoelectronic sequence. By adjusting the $^1D_2$ energy level in the $3p^2$ and 3s3d configurations in order to minimize differences between Slater off-diagonal and diagonal spin-orbit energies, close agreement is obtained with MCHF calculations. The results of this investigation show little configuration interaction (except for the singlet D) and nearly pure LS coupling between energy levels. Use of this model has led to interesting questions of what it means to have imaginary mixing angles and investigations of modeling imaginary parameters. Further investigation is being done into semi-empirical modeling of Slater parameters in order to accurately model energy levels along the Mg-like sequence. Subsequently, this technique may be useful for modeling Zn-like and possibly Ca-like sequences.

Victoria Winbow, *"Applications of Semi-Classical Methods to Molecular Spectra,"* (B. Gao)

The usual WKB method does not perform well for highly excited states of molecular spectra. Our method is a modified WKB in which a local scaling transformation is made, and then the traditional WKB method is applied to the transformed problem. This method was tested on a class of Lennard-Jones potential.

Condensed Matter Physics

Levi Gorrell, *"Temperature Dependent Photoluminescence of Ion Implanted Crystalline CdTe,"* (A. Compaan)

We have used ion-implanted CdTe crystals to study the photoluminescence (PL) signature of specific dopant atoms in this semiconductor. The crystals were prepared by graduate student, Xiangxin Liu, using ion implantation to introduce controlled densities of dopants and then annealed to remove the implantation-induced damage. I measured the temperature dependence of the PL from room temperature to 10 K using argon-ion laser excitation and the intensity and spectral shifts were studied to help identify the origin of the PL lines and bands including the energies of the impurity-bound excitons and the donor-acceptor pair luminescence.

Arow Hieronymus, *"Effects of Shadowing and Diffusion on Surface Morphology in Thin-film Growth,"* (J. Amar)

Recent experiments on vapor deposited CF_2 thin-films have shown a power-law distribution $P(\Delta h)$ for nearest neighbor sites height-differences (Δh) where $P(\Delta h) \sim (\Delta h)^{-\eta}$, and $\eta \approx 4.6$. In order to understand this we have studied the effects of shadowing and diffusion on thin-film growth by sputter deposition using four distinct models in two and three dimensions. Our simulations indicate that both shadowing and sideways growth (overhangs) are necessary to observe a power-law distribution of the height-difference. For the case of "cosine" distribution we found that in two dimensions $\eta \approx 2.6$ and in three dimensions $\eta \approx 3.1$. We also observed shadowing and sideways growth lead to a porous film and anomalous scaling of the height difference correlation function.

Joshua Inks, *"Analysis of the Optical Properties of the Component Layers of the CdTe Solar Cell,"* (R. Collins)

With the application of rotating compensator ellipsometry and powerful data analysis software, a detailed interpretation of the optical properties of the component materials used in thin film solar cells has become possible. To this end, I have adopted this methodology to begin the characterization of the optical properties of the component layers of a CdTe solar cell. The CdTe solar cell consists of a substrate of soda-lime glass with layers of a transparent conducting oxide (TCO), SnO_2, along with CdS and CdTe, deposited onto it. My task was to parameterize the optical characteristics of the glass substrate and the TCO. In general, this was accomplished by fitting the data to a simple Cauchy function for the spectral range over which absorption could be considered negligible, in order to determine the thickness of the layer, and then fixing the thickness and fitting the data to a more sophisticated model consisting of a sum of Lorentz oscillators to determine the optical properties over the full range. The parameterization of the optical properties of each component of the cell will be useful in on-line analysis of completed solar cells measured at the solar cell factory.

Nicholas Sperling, *"Simulations for Experiments on Nano-Magnetic Materials,"* (A. Lukaszew)

The analysis of nanometer sized structures is a difficult proposition, particularly analyzing the internal magnetization of structures made on magnetic materials. Using the Object Oriented Micro Magnetic Framework (OOMMF) released by NIST, it is possible to simulate structures on the nanometer scale to aid in understanding results from indirect analysis methods, such as Magneto-Optical Kerr Effect (MOKE) measurements, which cannot directly analyze surface morphology. This technique was used to create simulations of nanometer sized bridges on Nickel in multiple crystallographic directions in an attempt to offer support to domain wall trapping at the nano-contact. Simulations were also run using "The Stopping and Range of Ions in Matter" (SRIM), to determine the energy and current required to inject Chromium ions into a Zinc Telluride sample, in an attempt to create a room temperature ferromagnetic semiconductor.

NSF-REU External Publications and Presentations
(Calendar Year 2004)

REFEREED PUBLICATIONS.

1. **Thomas Crenny*** (2001) and S.R. Federman, *"Reanalysis of* Copernicus *Measurements on Interstellar Carbon Monoxide,"* Astrophysical Journal, 605, 278-284 (2004).

2. **James Steiner*** (2004) and L.J. Curtis, "Branching fractions for the Mg-like 3s3p-3s3d and 3s3p-$3p^2$ transition arrays," J.Phys. B: At. Mol. Opt. Phys. 37, 3771-3779 (2004)

3. **Joshua Thomas*** (2001, 2003), G.S, Hodges, D.G. Seely, N. Moroz, and T.J. Kvale *"Performance Enhancement Study of an Electrostatic Faraday Cup Detector,"* Nucl. Instrum. Meth. A (2004) accepted.

PRESENTATIONS.

1. **Joshua Thomas*** (2001, 2003), "*Performance Enhancement Study of an Ion Detector in Atomic Collisions*," 25th Annual Sigma Xi Student Research Symposium, University of Toledo, Poster Division, PR-11, April 24, 2004. **(winner -- Physical Sciences & Engineering Poster Division)**

2. **Jacquelyn Must*** (2002, 2003), "*Dust in Galaxies,*" 25th Annual Sigma Xi Student Research Symposium, University of Toledo, Undergraduate Student Research Division, UDG08, April 24, 2004.

3. **Nicholas Sperling*** (2003, 2004), "*Low Cost Scanning Tunneling Microscope and OOMF Simulations,*" 25th Annual Sigma Xi Student Research Symposium, University of Toledo, Undergraduate Student Research Division, UDG07, April 24, 2004.

4. T.J. Kvale, **Joshua Thomas*** (2001, 2003), G.S Hodges, D.G. Seely, "*Secondary Electron Emission from Copper Surfaces Due to keV Proton Impact*," Abstracts for the Eighteenth International Conference on the Application of Accelerators in Research and Industry (CAARI-2004), J.L Duggan and I.L. Morgan, ed., University of North Texas, Denton, Texas, (2004).

5. J. A. Zapien, Jie Chen, Jian Li, **Joshua Inks*** (2004), N. J. Podraza, Chi Chen, J. Drayton, A. Vasko, A. Gupta, S. L. Wang, R. W. Collins, and A.D. Compaan, *"Real Time Spectroscopic Ellipsometry of Thin Film CdTe Deposition by Magnetron Sputtering for Photovoltaic Applications,"* 31st IEEE Photovoltaic Specialist's Conference, Orlando, FL January 3 - 7, 2005. (submitted)

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

VI. PROGRAM EVALUATION

NSF-REU 2004 Summer Research Program
Department of Physics & Astronomy
The University of Toledo
(Total REU Participants: 10, Responses Received: 7)

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

2004 mean (pop. 7): 1.8

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

2004 mean (pop. 7): 1.6

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

2004 mean (pop. 7): 1.1

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

2004 mean (pop. 7): 2.1

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

2004 mean (pop. 7): 3.7

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

Very Enjoyable			**Neutral**			**Not Enjoyable**
☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

2004 mean (pop. 7): 2.4

How do you rate your summer experience personally?

Great Fun						**A Real Drag**
☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

2004 mean (pop. 7): 2.3

How do you rate your summer experience educationally?

Learned a Lot						**Not Worth Much**
☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

2004 mean (pop. 7): 1.4

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

More general learning						**More research time**
☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

2004 mean (pop. 7): 4.0

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 only the traditional scientific talks such as we had this summer?

A great idea						**A waste of time**
☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

2004 mean (pop. 7): 2.8

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

Much Too Advanced						**Much Too Elementary**
☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

2004 mean (pop. 7): 2.6

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						**Too much: I got lost**
☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

2004 mean (pop. 7): 3.8

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

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

2004 mean (pop. 7): 3.6

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

Yes, very much so						**No, definitely not**
☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

2004 mean (pop. 7): 2.3

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

1. Windsurfing & Dr. Compaan's cookout were great!
2. Awesome advisors -- very patient
3. Seminars a bit too advanced
4. Grad students/faculty very friendly
5. The proposed seminar topics would be nice

Best - The trip to the [Toledo] zoo was a lot of fun., gatherings that happened every Wed. at Uncle John's, the windsurfing, the high quality of the professor (very knowledgeable and helpful), the liquid nitrogen ice cream for summer camp was cool

Worst - losing hot water for two weeks, organization of the physics summer camp could have been better –> suggestion: instead of using up the research time for all of the REU students every day during the summer camp, assign only a couple of REU students per day so that each student only has to show up 1-2 days of the week and not sacrifice an entire week of research time.

Best: - learned a lot
- got good research experience
- got to use new (to me) equipment
- Pancake nights were fun
- Windsurfing was great!

Worst: - sometimes difficult to find things to do evenings
- lack of accessibility to a kitchen in dorm made dinners hard

Best thing - The grad student I worked with - Imran Khan, the most patient and interesting supervisor one could hope for.
Worst thing - life here is pretty isolated and if you don't have a car, it sucks. Living on microwave food for 10 weeks is NOT FUN.

- my project was not well defined and this made it difficult to do the final project + paper .
- sometimes my grad student and advisor would leave and not give me things to do while they were gone.

This program has been a great help to me in furthering my knowledge of physics and research in general. The best parts of my experience:

1) Working with my advisor and learning a great deal from him.
2) Working with the grad students and getting an idea of what life is like as a grad student.
1) The challenge of rising to a new level in my understanding of physics.

Please list any additional comments.

It is really helpful and interesting to do meaningful research as an undergraduate. I am now more motivated in physics than before the 10-week program started.

I'm really glad I came - I learned a lot. It was really helpful to be able to learn how to use/analyze/reduce data in a real research environment. Everyone here was very nice + extremely helpful. Thanks for a great summer!

Dr. Gao rocks!

- overall, I did learn alot. However I was a little disappointed with the amount of work compared to some of the other projects.

An excellent program which I will strongly recommend.