Annual Progress Report (Year 3)

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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Thomas J. Kvale
R. Alejandra Lukaszew

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Left to Right (Front row): C. Theodosiou, A. Lukaszew, **Kimberly Morton***, **Ahmed Giwa***, **Aaronica Bivins***, **Daniel Moomey**, **Shellie Huether**, **Amber Ferguson**, **Mary Lin**, **Anna Dupay**, **Brian Bismack**

Left to Right (Back rows): T. Kvale, **Paul Sell**, **Jason Owens**, **Christopher Galyean**, **Kristen Jones**, **William Booth**, **Robert (Chip) Davidson**, **Marian Axente**

REU participants in **boldface** type.
* Glenn-Stokes Research Internship Program participants

REU RESEARCH PARTICIPANTS, SUMMER 2006

NAME	INSTITUTION	MENTOR	RESEARCH
Marian Axente*	Univ. of TN - Chattanooga	Ishmael Parsai	Bio/Medical
Brian Bismack	Michigan State Univ.	Michael Dennis	Bio/Medical
William Booth	SUNY - Fredonia	Sylvain Marsillac	Condensed Matter
Robert Davidson	Univ. of Louisville	Jon Bjorkman	Astronomy
Anna Dupay	Macalester College	R. Alejandra Lukaszew	Condensed Matter
Amber Ferguson*	Mount Union College	Nancy Morrison	Astronomy
Christopher Galyean	Lousiana Tech	Thomas Kvale	Atomic
Shellie Huether	Univ. of MO - Rolla	Karren Bjorkman	Astronomy
Kristen Jones	Univ. of WI - Madison	Thomas Megeath	Astronomy
Mary Lin*	Northwestern Univ.	Alvin Compaan	Condensed Matter
Dainel Moomey*	Univ. of Toledo	Steven Federman	Astronomy
Jason Owens	Univ. of Toledo	Alvin Compaan	Condensed Matter
Paul Sell	Univ. of Toledo	Adolf Witt/Steven Federman	Astronomy

* Students with partial REU support and/or with other funding but participated in our research program with same expectations as the fully REU supported students.

II. SUMMARY OF SUMMER 2006

Introduction

The Summer 2006 NSF-REU program in Physics and Astronomy at Toledo gave enhanced research opportunities to 13 undergraduate students from 11 colleges and universities in 10 states spread from New York to Louisiana and Minnesota. Of these thirteen students, nine were fully funded by the REU grant, one was fully funded by the department as its pledge of support to the REU grant and three were partially funded by external grants. The NSF-REU grant supplemented the other funding sources for these three students so that their level of support was 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 109 applications from students in 30 different states in all regions of the U.S. All the participants were serious and talented young scientists, who tackled substantial problems, participating in all stages of a project, from formulation to conclusion, including oral and written presentations of results. The initial web announcement (with secondary links to additional material) can be found at:

http://www.physics.utoledo.edu/~wwwreu/reusummer2006/nsf-reu2006a.htm

We are pleased to report that Summer 2006 was a success from both the students' and faculty mentors' perspectives. Five manuscripts have been published in archival, refereed journals involving REU student co-authors in 2006 of which REU coauthors were first author on two; one conference proceedings manuscript is currently in press; one manuscript is currently in preparation and is expected to be submitted to the Journal of Solid State Chemistry shortly, and at least four presentations were made in regional or national conferences in 2006.

Advertisement and Selection

Again this year (Summer 2006) 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 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.

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 11 of the thirteen 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 Ottawa House-East, which is among the newest dorms on campus. 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 Paul Sell (UT & REU participant). The students again this year formed a close-knit group. Weekly activities included Wednesday nights at a local, family restaurant (Uncle John's Pancake House) and Thursday lunches at the Phoenicia restaurant. Some of the other special events included: windsurfing, several BBQ's, and trips to Cedar Point Amusement Park, Toledo Zoo, and COSI. Many of the evaluation comments mentioned these activities favorably. The calendar can be found at:

http://www.physics.utoledo.edu/~wwwreu/reusummer2006/reu2006calendar1.htm

Weekly Seminars

During the first week, the students attended an orientation seminar to cover the basic items such as ID cards, parking, health services, food services, stipend checks, etc. After that, a weekly "Brown Bag Lunch" seminar series played an important part of our summer program. Faculty members and/or outside speakers presented a talk over their research during the lunch hour for their chosen day. This bag lunch format fosters more of an informal atmosphere, which the students appreciate when it is their turn to give a presentation at the close of the summer session. This weekly meeting of the entire REU

group also provided an opportunity to plan social events and field trips, and discuss any topics of interest to the group. The three 2006 Glenn-Stokes Research Internship Program participants also attended our Bag Lunches. In addition, the whole department was invited to attend the Bag Lunches, and the participation was good with many graduate students and faculty members also attending each week. The Bag lunches provided a useful departmental weekly gathering, otherwise absent in the summer. The talks at these weekly meetings were for the most part similar to standard physics research talks, but chosen to be appropriate for the REU audience, and with all the speakers being careful to give undergraduate-level introductions. We also required the students to give a 5 minute presentation of their research about midway into their summer period. These midway progress talks went well and kept the students focused on their projects. We plan to repeat the mid-term Progress talks for this coming summer.

NSF-REU SUMMER 2006 BROWN BAG SEMINARS

TUESDAY NOON - MH 4009

May 30	Orientation & Pizza Lunch
June 06	Natalia Dushkina (Millersville University), "*True Physical Colors*"
June 13	Thomas Megeath, "*Observing Formation of Star Clusters with the Spitzer Space Telescope*"
June 20	R. Ale Lukaszew, "*Issues in Nanomagnetism*" and coordinating the upcoming Phys. Summer Camp activities.
June 22 - 23	The Physics Summer Camp
June 27	REU students midterm reports
July 04	Independence Day -- no Bag Lunch scheduled
July 11	Sylvain Marsillac, "*Renewable Energies & Photovoltaics*"
July 18	Bruno Ullrich (BGSU), "*Roosbroeck-Shockley Analysis of GaAs Photoluminescence*"
July 25	Final REU presentations and dept BBQ lunch
Aug. 01	"*Ethics in Research*" university-wide seminar (2 hours)

This summer we experimented with a variation on the past Bag Lunch series. The Office of Undergraduate Research coordinated a seminar on ethical practices in research as described in the following section. To allow for it, the Final Presentations were moved up to the ninth week of the program and scheduled for only one day (morning/afternoon with BBQ lunch) instead of the customary three days over the lunch hour. The other motivation for holding the presentations in the ninth week was to give the students extra time to complete their final reports. From their evaluation comments, we will modify this practice in still holding the Final presentations on one day, but that it occur in the tenth week instead of the ninth week.

University-Wide Events

The P.I. (Thomas Kvale) assumed the position of the director of the newly-created UT Office of Undergraduate Research (OUR-UT) in May 2006. The creation of 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.

A reception for all undergraduates conducting research on campus was held in June. This event brought together students from the main campus as well as the Health Science campus (formerly, the

Medical University of Ohio). Over 110 students were identified in conducting research this past summer; many of which attended this reception. The second university-wide event was an extended "Ethics in Research" seminar on the tenth week, the final week of the university's Summer Session IV as well as the final week of the REU program. This seminar was coordinated through the Office of Undergraduate Research and featured speakers Dr. Jeffrey Busch (Compliance Officer, UT Office of Research) and Prof. Thomas Barden (Director, UT Honors Program). Dr. Busch discussed ethical practices in research and federal/state compliance issues. Prof. Barden discussed plagiarism and related issues in publications. This seminar was for all undergraduates conducting research this summer. As such, the REU students attended along with students participating in other research programs on campus. We plan to expand this seminar series to throughout the summer for next summer and include more in-depth discussions on ethics issues and safe research practices.

Reports and Conclusion

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

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

III. PHYSICS SUMMER CAMP 2006

The activities that were developed and performed this year with the help of our REU team are shown in the table on the following page. A sampling of summer pictures from REU activities (including the Summer Camp) are included in section VII: Summer 2006 Pictures. As part of the REU program, the Physics Summer Camp outreach activity for high school students interested in science was developed during June 22-23, 2006 from 9 AM till 3 PM. This event was entirely funded by an internal Academic Excellence Award from the University of Toledo. The announcement, forms, calendar of activates as well as links to past events can be found at:

http://www.physics.utoledo.edu/~alukasz/Summer_Camp_2006.html

The REU group was informed about this event during the first "brown bag lunch seminar" and they were

asked to participate mentoring the high school participants. In addition they were asked to offer possible activities to perform with the participants. We had a total of 10 participants from local schools, and also one visiting faculty member from Millersville University, PA, Dr. Natalia Dushkina.

The organizer asked that the REU students selected in which of the two days they wanted to participate, to minimize distraction regarding their own research projects. They were asked to mentor one-to-one a high school student of their choice during that particular day of their choice. The activities for the Summer Camp were divided in two days: "Optics Day" and "Electromagnetism and Cold Temperature Day". All participants performed "hands-on" activities and demonstrations. Lectures were given by the organizer (Professor R. A. Lukaszew) and the visiting faculty fellow (Professor Natalia Dushkina). Dr. Dushkina gave a talk and performed a presentation during "Optics Day" while Dr. Lukaszew was in charge of the electromagnetism and cold temperature presentations during the following day.

Each day started with a presentation followed by a questions and answer period. After lunch, the hands-on activities and demonstrations took place during the afternoon. The event culminated with a gathering of the entire REU group and the summer campers on Friday June 23 afternoon, with LN2 ice-cream preparation and consumption. The campers had ample opportunity during breakfast, snack-breaks and lunch (all funded with the UT internal grant) for informal conversations with the REU group and learn about their individual research projects as well as their motivation to pursue a career in science. The outcome of the event was evaluated with an anonymous survey. The overall information on the survey was shared with the REU group, so that they could also learn about their effect on the campers.

IV. DEMOGRAPHICS

NSF-REU SUMMER 2006 APPLICATIONS

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

ALABAMA
Univ. of W. Alabama ..... (1/0/0)

CALIFORNIA
Calif. Polytechnic State ..... (1/0/0)
CSU Sacramento ..... (1/0/0)
Harvey Mudd College ..... (1/0/0)
Santa Clara Univ ..... (1/0/0)
UC Berkeley ..... (2/0/0)
UC Davis ..... (1/0/0)
UCLA ..... (1/1/0)

COLORADO
The Colorado College ..... (1/0/0)
Colorado School of Mines ..... (1/0/0)

CONNECTICUT
Connecticut College ..... (1/1/0)

ILLINOIS
Northwestern Univ ..... (1/1/1)

INDIANA
Goshen College ..... (1/0/0)
Purdue Univ ..... (1/0/0)
Taylor University ..... (1/1/0)
U.Evansville ..... (1/0/0)

IOWA
Cornell College ..... (1/0/0)

KANSAS
Fort Hays State Univ ..... (1/0/0)

KENTUCKY
Morehead State Univ ..... (2/0/0)
Univ. of Louisville ..... (3/2/1)

LOUISIANA
Centenary College of Louisiana ..... (1/0/0)
Louisiana Tech Univ ..... (1/1/1)

MAINE
Univ. of Maine ..... (1/0/0)

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

MICHIGAN
Eastern Michigan Univ ..... (1/0/0)
Hope College ..... (1/0/0)
Michigan State Univ ..... (1/1/1)
Kalamazoo College ..... (2/0/0)
Monroe County Comm. College .... (1/0/0)
U. Michigan ..... (2/0/0)

MINNESOTA
Macalester College ..... (1/1/1)

MISSOURI
U.Missouri, Columbia ..... (1/0/0)
U.Missouri, Rolla ..... (1/1/1)

NEW JERSEY
Drew University ..... (1/0/0)

NEW YORK
Columbia Univ ..... (1/0/0)
Cornell Univ ..... (2/0/0)
New York University ..... (1/0/0)
St. John's Univ ..... (1/0/0)
SUNY Fredonia ..... (1/1/1)
U.Rochester ..... (3/0/0)

NORTH CAROLINA
Guilford University ..... (1/0/0)

OHIO
Agnes Scott College ..... (1/0/0)
Case Western Reserve ..... (4/1/0)
College of Wooster ..... (1/0/0)
Kent State Univ ..... (1/0/0)
Marietta College ..... (2/1/0)
Mount Union College ..... (2/1/1)
Ohio Northern Univ ..... (2/1/0)
U.Dayton ..... (1/0/0)
U.Toledo ..... (7/2/2)
Wittenberg Univ ..... (1/1/0)

OKLAHOMA
Oklahoma State Univ ..... (1/0/0)

PENNSYLVANIA
Bloomsburg Univ ..... (2/0/0)
Bucknell Univ ..... (2/0/0)
Carnegie Mellon ..... (2/0/0)
Lycoming College ..... (1/0/0)
Slippery Rock University ..... (2/0/0)
St. Vincent College ..... (1/0/0)
Swarthmore College ..... (1/0/0)
Temple University ..... (1/0/0)
Wilkes University ..... (1/0/0)

RHODE ISLAND
U. Rhode Island ..... (1/0/0)

SOUTH CAROLINA
Bob Jones Univ. ..... (1/0/0)

TENNESSEE
U.Tenn@Chattanooga ..... (1/1/1)

TEXAS
Austin Peay State Univ ..... (1/1/0)
Rice University ..... (3/0/0)

VERMONT
Bennington College ..... (1/0/0)

VIRGINIA
U. Virginia ..... (1/0/0)

WASHINGTON
U.Washington ..... (1/0/0)

WEST VIRGINIA
Marshall Univ ..... (1/1/0)

WISCONSIN
Lawrence Univ ..... (1/0/0)
U.Wisc.,-Madison ..... (1/1/1)
U.Wisc., River-Falls ..... (2/0/0)

SUMMARY
102 **Applications received**
22 **Offers made**
13 **Offers accepted***

*Including those with partial REU and/or other funding sources.

NSF-REU Participant** Demographics

Summer 2006

Gender	
Female:	5
Male:	8

Class Rank	
Freshman:	1
Sophomore:	4
Junior:	7
Senior:	1
Higher:	0

Ethnicity	
International Student*:	1
American Indian:	0
Alaskan Native:	0
Asian American: (or Pacific Islands)	1
African American:	1
Hispanic American:	0
Caucasian/White:	10
Other:	0

Home State	
Kentucky	1
Louisiana	1
Michigan	1
Minnesota	2
Missouri	1
New York	1
Ohio	5
Tennessee	1

Home Institution:	
Univ. of TN - Chattanooga	1
Michigan State University	1
SUNY - Fredonia	1
Univ. of Louisville	1
Macalester College	1
Mount Union College	1
Lousiana Tech	1
Univ. of MO - Rolla	1
Univ. of WI - Madison	1
Northwestern University	1
Univ. of Toledo	3

REU Students Grade Point Average: 3.54

* 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 2006 Final Presentations

Tuesday, July 25

Each talk is scheduled for 15 minutes allowing 5 additional minutes to set-up and for questions.

9:00 am	Kristen M. Jones: "High Mass Star Formation in NGC 6334 I and I(N)"
9:20 am	Shellie Huether: "Periodic Variations in the Emission Lines of Zeta Tau"
9:40 am	Jason Owens: "PV Research Database Implementation Proposal"
10:00 am	Marian Axente: "Dosimetric Analysis of Scattered Dose in IMRT Plans Using .decimal Compensators"
10:20 am	Brian Bismack: "Brain Perfusion Study: A Summer Long Headache"
10:40 am	Chris Galyean: "Modeling an Energy Analyzer for Secondary Electron Emission Measurements."
11:00 am	Anna Dupay: "Magnetic nanostructures"
11:20 am	William Booth: "Design of the Substrate Heater for Vacuum Evaporation"

LUNCH BREAK/BBQ 11:40 AM - 12:55PM

1:00 pm	Robert Davidson: "An Investigation of Cooling Times in Protoplanetary Disks".
1:20 pm	Amber Ferguson: "Finding the Radial Velocity of Beta Trianguli using Cross-Correlation."
1:40 pm	Paul Sell: "Visible Wavelength Emission from High Galactic Latitude Clouds"
2:00 pm	Daniel Moomey: "Chlorine in Interstellar Gas Clouds"

Scheduled for a later date,

Mary Lin: "Plasma Spectroscopy: Making Light of Solar Cells."

ABSTRACTS OF REU FINAL REPORTS
The University of Toledo, Department of Physics & Astronomy
SUMMER 2006
(Faculty Mentor on parenthesis)

Astrophysics/Astronomy

Robert Davidson, *Developing a Hydrodynamics Code for Modeling Gravitational Instabilities in Protoplanetary Disks,* (J. Bjorkman)

Stars form from very cold, gaseous clouds that collapse under their own self-gravity, but the clouds from which they form also create another interesting astronomical feature: protoplanetary disks. Researchers are divided as to the mechanism for planet formation, but regardless of the method, the disk cooling time is an important factor. Using a computer program, my goal for this project was to develop a subroutine that would calculate the geometrical thickness of a disk of material using an input array of temperatures versus surface density. We found that the subroutine was in agreement with analytical calculations for simple cases such as isothermal disks. The computational model was also in close agreement for more complex cases like a disk with changing temperature. Using this subroutine with real temperatures and surface densities will allow for a working computer model to be tested for success or failure. Regardless of the outcome, we are confident that such a model will only aid in the development of more accurate and realistic planet formation simulations in future research.

Amber Ferguson, *Finding the radial velocity of the double-lined spectroscopic binary, beta Trianguli, using Cross-Correlation,* (N. Morrison)

Cross-correlation is a task in the program IRAF (Image Reduction and Analysis Facility). Although it is not a new method for finding velocities of astronomical objects; it hasn't yet been used in determining the radial velocities of the double-lined spectroscopic binary, beta Trianguli. I used cross-correlation to solve for the radial velocities of the primary component of the binary. When the secondary component was present I had to use a task called deblend to find its radial velocity. This star has been studied before, but we utilized this new approach to try and obtain more accurate results.

Shellie L. Huether, *Periodic Variations in the Emission Lines of Zeta Tau,* (K. Bjorkman)

The emission lines of Be stars are usually double peaked due to the rotation of the circumstellar disk. Zeta Tauri exhibits this feature in both the Hα and the Fe II, with the V/R ratio of the peaks varying periodically due to different density regions in the disk. At certain times the Hα emission becomes triple peaked, a phenomenon yet to be completely explained. A spiral shaped disk has been proposed as a model that can explain the triple peak in the Hα emission. To attain a better picture of the disk's structure, we investigate the behavior of the Hα, Fe II, and the He I lines of Zeta Tau. The observations span from 1997 to 2006, and were taken at the Ritter Observatory at the University of Toledo.

Kristen Jones, *High Mass Star Formation in NGC 6334 I and I(N),* (S. T. Megeath)

The presence of massive stars drives the evolution of molecular clouds. Despite their importance, however, little is known as to how high mass stars form. We seek to investigate low and high mass protostars within the ideal star formation area that is NGC 6334. Observations from the 8-m Gemini South telescope at 1.2 ìm, 1.6 ìm, and 2.2 ìm and the 85-cm Spitzer Space telescope at 3.6 ìm, 4.5 ìm, 5.8 ìm, and 8.0 ìm are reduced and analyzed for low mass star formation as a function of distance from high mass protostars.

Daniel Moomey, *The Abundance of Cl I and Cl II in Interstellar Gas Clouds,* (S. Federman)

Observations from the Copernicus satellite were used to determine the abundances of Cl I and Cl II along 22 sight lines. Observations at lambda = 1071, 1088, 1097, 1347 Å were analyzed to measure the equivalent width of the lines along each direction. A computer simulation was run to determine the chlorine abundances from each absorption line. The lines of the same species were then weighted to create an average as the final column density for that species toward that line of sight. This has successfully been done for 19 of the 22 stars so far. The Cl abundances will be compared with H abundances for studies on its chemistry and the amount of chlorine tied to solid interstellar grains.

Paul Sell, *Visible Wavelength Emission from High Galactic Latitude Clouds,* (A. Witt & S. Federman)

The study of high galactic latitude interstellar clouds is still in its infancy. Thus far, mainly radio and far-infrared observations have been used to map these clouds, while, at optical wavelengths, they have largely remained unexplored. This is primarily the result of the low optical surface brightness of these clouds as their emissions are at most about 5-10% above the background light of the night sky at even the darkest observing sites. Therefore, mapping these clouds at optical wavelengths requires weeks of observing time, far more than would normally be granted at a large telescope capable of adequately imaging these clouds. As a result, we are using small but fast amateur-sized telescopes that can be used exclusively for our purposes and that have much larger fields-of-view than larger telescopes. We rely on the optical principle that detection of extended sources of diffuse light does not depend on the aperture of the telescope but is exclusively dependent on the focal ratio of the telescope, independent of its aperture. We carried out optical broadband photometry on a set of three high galactic latitude clouds with a f/5.0, 100 mm refractor to search for Extended Red Emission (ERE), Hα emission, and to image the large-scale structure of these clouds. We confirm the detection of the ERE in these clouds and provide evidence of a shifting peak and varying intensity of this emission from cloud to cloud. Our observations are in very good agreement with the long-slit spectroscopic observations made with a much larger telescope of one of these three clouds at optical wavelengths as well as with the results of a large-scale search for ERE based on observations obtained with Pioneer 10 and 11.

Atomic/Molecular/Optical Physics

Christopher Galyean, "*Electron Optics Simulation for the Design of a Secondary Electron Energy Analyzer*," (T. Kvale)

The work performed this summer focused on the creation of an electrostatic lens for use with a hemispherical energy analyzer. The lens is to be used to focus electrons emitted from a solid target due to collisions from an energetic (5 - 50 keV) proton beam upon the target surface. Modeling of the electrostatic lens was done using Simion 7.0. For simplicity, the sheath of the electrostatic lens was considered to be at ground voltage. This can be corrected when the mean voltage of the hemispheres of the energy analyzer is determined by adding the mean voltage to the voltages of the electrodes. It should also be noted that, when considering a grounded sheath, it is possible to scale the initial electron energy to any value as long as the same ratio is kept with the voltages on the electrodes. The final design of the electrostatic lens is a two electrode step-down configuration. The sheath of the lens will extend past the faceplate of the energy analyzer and end exactly at the depth of the hemispheres to ensure that no stray electric field may interfere with the electron trajectory. Through the modeling process, a difference of only 0.01 mm between the focal point of the emitted electrons and the hemisphere entrance was achieved. Also, the diameter of the disk of least confusion was found to be

0.025 mm, and the fill ratio of the electron trajectories compared to the difference in hemisphere radii was found to be 0.296. These values suggest that the design for the lens is plausible for construction and use for the hemispherical energy analyzer.

Biological, Health, and Medical Physics

Marian Axente, *Dosimetric Analysis of Absorbed Dose from Scattered Radiation in IMRT Delivery Using Tungsten Leafs as Compared to Compensating Filters,* (E. I. Parsai)

Inverse planning with Intensity Modulation Radiation Therapy (IMRT) using multi leaf collimation system has revolutionized the radiation delivery in terms of delivering dose to target organ while sparing the surrounding normal tissues. However, very large monitor units (MUs) and small fields has always been a concern for physicists in terms scattered dose to shallow regions in the field, and quality of beam delivered specially in out-of-field areas. This project involved a comparison between two methods of delivering intensity-modulated beams – compensator (milled brass beam filters) and conventional multi-leaf collimators (tungsten leaves), with a special attention to out-of-field dose analysis. No base line methodology for this study is described in the recent research literature, so several methods were used. Acquired data showed that in-target conformity (volumetric), and dose uniformity (planar) in central-axis and off-axis at different depths, compensators do a similar if not better job at delivering IMRT plans. Regarding dose from scattered radiation, initial measurements reveals that compensators do deliver less to the area surrounding the target volume.

Brian J. Bismack, *Brain Perfusion Study*, (M. Dennis)

The cause of migraines has been somewhat of an enigma that this study hopes to shed some light on. The study involved a comparison of vascular reserve and blood flow through tissues of the brain between different groups of people. Of particular interest is of course the comparison between people with migraines and people without migraines, but the study also involved a group of people with migraines who also had a skin condition called livedo reticularis. The overall goal of the study is to see how migraines and livedo reticularis affect a blood flow to the brain and vascular reserve. Direct data collection involved a series of Echo Planar Images (EPI) from a MRI system while a contrast agent was injected into the blood stream and entered the brain. This gave data on how blood flows through the brain. Two data runs were performed on each subject, the second data run involved a vasodilator called Diamox. This gave data on the subject's physical capacity to increase blood flow.

Condensed Matter Physics

William Booth, *Solar Cells and the Design of A Substrate Heater,* (S. Marsillac)

Solar cells are slowly becoming an important part of our quest for alternative sources of energy. More productive and more efficient processes need to be designed in order to create better power efficiencies for the solar cells while keeping them cheap. Using the method of vacuum evaporation one uses a substrate heater, which the elements are deposited on, in order to change the properties of the solar cell. These properties include the mobility of the carriers, the morphology, and the composition of the cell. Much of the technical information about the vacuum evaporation system was taken from Vacuum Technology Products by the Kurt J. Lesker Company. Much of the information about the

various solar cell materials was taken from Fundamentals of Photovoltaic Materials by the National Solar Power Research Institute. Most of the basic cell theory was taken from Solar Electric Systems by George Warfield.

Anna Dupay, *Micro-Magnetic Simulations on Cobalt Nanostructures,* (R. A. Lukaszew)

It remains a challenge to model magnetization dynamics at the nano-scale. The purpose of this research project is to simulate arrays of nanomagnets that can be fabricated using a novel nano-patterning method based on the use of micro-spheres. By using Object-Oriented Micro-Magnetic Framework (OOMMF) to simulate the magnetic behavior of arrays of nanomagnets produced with this method we can predict how the magnets will behave in real life and also predict how this nano-patterning process can be used for research in nano-scale magnetism, for data storage, and other industrial and scientific applications. Preliminary work indicated that some of the methodology and parameters used ought to be adjusted to produce clearer and more consistent results.

Mary Lin, *Plasma Spectroscopy of rf sputtering for CdS,* (A. Compaan)

During the development of the thin film used in photovoltaic cells, the quality and efficiency of the solar cells can often be determined using a method known as spectroscopy, which can aid in identifying the elements present during the sputtering process of making the thin films. In the process of solar cell sputtering, the atoms of the elements present gain energy and briefly become excited, giving off light in a spectrum of wavelengths characteristic to that element. Using spectroscopy, the individual spectra of light produced by different elements can be analyzed and their peaks identified, giving us valuable insight about the types of elements present during the sputtering process. While ideally only the target elements and the noble gas should be present during sputtering, it is possible for even minor contaminants and impurities to affect the ultimate efficiency of the solar cell being produced.

In this experiment, the spectrometer was used to analyze the sputtering of cadmium sulfide onto a glass substrate in the AJA sputtering chamber, using argon as the sputtering gas. The expected impurities that we were looking for in the spectroscopic data were calcium, copper, magnesium, iron, and chromium. After calibrating the spectrometer by accounting for the shift in wavelength it produced during data collection according to the pixel number assigned to each peak, however, the majority of the peaks were identified as argon. Many of the major non-argon peaks were then identified as produced by cadmium and sulfur, though the data suggests the presence of copper during the sputtering as well.

NSF-REU External Publications and Presentations*
(Calendar Year 2006)

REFEREED PUBLICATIONS - Submitted/accepted/published.

1. Witt, Adolf N.; Gordon, Karl D.; Vijh, Uma P.; **Sell, Paul H.* (2004, 2006)**; Smith, Tracy L.; Xie, Rui-Hua, "*The Excitation of Extended Red Emission: New Constraints on Its Carrier from Hubble Space Telescope Observations of NGC 7023*," Astrophys. Jour., 636, 303-315 (2006).

2. **J. A. Warner* (2005)**, S. K. R. Patil, S. V. Khare, K. C. Masiulaniec, "*Ab Initio Calculations for Properties of MAX Phases Ti_2TlC, Zr_2TlC, and Hf_2TlC*," App. Phys. Lett. 88, 101911 (2006).

3. **A.J. Larkoski* (2005)**, D. G. Ellis, and L. J. Curtis, "*Numerical implementation of the Einstein-Brillouin-Keller quantization for arbitrary potentials*," Am. J. Phys. 74, 572-577 (2006).

4. Jie Chen, Jian Li, D. Sainju, **K. D. Wells (2005)**, N. J. Podraza, and R. W. Collins, "*Multilayer analysis of the CdTe solar cell structure by spectroscopic ellipsometry*", Proceedings of the 2006 IEEE 4th World Conference on Photovoltaic Energy Conversion, (IEEE, Piscataway NJ, 2006) pp. 475-478.

5. A. Ritchey, **M. Martinez* (2002)**, K. Pan, S.R. Federman, and D. L. Lambert, "*The Nature of Interstellar Gas toward the Pleiades Revealed in Absorption Lines*," Astrophys. Jour., 649, 788-806 (2006).

6. S.R. Federman, M. Brown, **S. Torok* (2005)**, S. Cheng, R.E. Irving, R.M. Schectman, and L.J. Curtis, "*Oscillator Strengths for Ultraviolet Transitions in P II*," (Astrophysical Journal, submitted).

7. Wisniewski, J.P., **Kowalski, A.F. (2004),** Bjorkman, K.S., Bjorkman, J.E., and Carciofi, A.C., 2006, "*Toward Mapping the Detailed Density Structure of Classical Be Circumstellar Disks*," (Astrophysical Journal, submitted).

REFEREED PUBLICATIONS - in preparation.

1. J. A. Colin, S. D. Gates, **D. V. Camper (2005)**, M. D. Simon, C. Lind, "Zirconium Tungstate Hydroxide Hydrate Revisited: The Role of Halides in the Formation of Crystalline Particles" (probably J. Solid State Chem.)

PRESENTATIONS.

1. Wisniewski, J.P., **Kowalski, A.F. (2004),** Bjorkman, K.S., and Bjorkman, J.E., 2006, "Towards Mapping the Detailed Density Structure of Classical Be Circumstellar Disks", in *Active OB Stars as Laboratories for Stellar and Circumstellar Astrophysics*, ASP Conf. Ser., in press.

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

2. **Stephanie Torok* (2005)**, Mike Brown, Richard Irving, Steven Federman, Lorenzo Curtis, Lifetime and Branching Fraction Measurements for P II, DAMOP Meeting of The American Physical Society, Knoxville, TN, May 16 - 20, 2006.

3. **Huether, Shellie, L.* (2006)**, and Bjorkman, Karen, S., 2006, "Periodic Variations In The Emission Lines Of Zeta Tauri", presentation at the Symposium for Undergraduates in Science, Engineering and Mathematics, held at Argonne National Laboratory, Nov 3-4 2006.

4. **Huether, S. L.* (2006)**, and Bjorkman, K. S., 2006, "Periodic Variations In The Emission Lines Of Zeta Tauri", poster presentation for the meeting of the American Astronomical Society, held in Seattle, WA, Jan 6-10 2007. (published in the Bulletin of the American Astronomical Society, Dec 2006)

* 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
2006 (Total Population: 13, Responses: 10)

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

2006 mean (pop. 10): 2.8

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

2006 mean (pop. 10): 2.4

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

2006 mean (pop. 10): 3.1

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

2006 mean (pop. 10): 2.8

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

2006 mean (pop. 10): 3.9

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

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

2006 mean (pop. 10): 1.4

How do you rate your summer experience personally?

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

2006 mean (pop. 10): 1.7

How do you rate your summer experience educationally?

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

2006 mean (pop. 10): 2.8

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

2006 mean (pop. 10): 4.1

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

2006 mean (pop. 10): 2.1

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

2006 mean (pop. 9): 3.8 + one answer: "varied greatly", with no numerical selection.

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

2006 mean (pop. 9): 4.3 + one answer: "N/A", with no numerical selection.

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

2006 mean (pop. 10): 3.7

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

2006 mean (pop. 10): 1.9

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

"This summer was a great experience for me. Though I was not left to 'sink or swim', I was plunged deep into my new research project very quickly. I learned a great deal about myself + my field.
Best things: having a mentor interested in their REU student, working on an actually significant project, pancake house Wednesdays, movie Tuesdays, all living in the same dorm area, Cedar Point + other outings.
Worst things: ethics seminar = long, boring, repetitive; Also the weekly seminars were simply not that interesting."

"This was a very socially active group. We spent a lot of our free time together as one. Personally, I did not live in the dorms because I'm from Toledo, but I spent almost every night there with the group. It was that much fun. The research I was doing is continuing through this school year. I made a lot of progress over the summer, and I can't wait to see how it turns out and what I'm going to learn."

"(+) I feel that I worked on a great project with a wonderful advisor. I generally had a lot of fun at the social events.
(–) Never do the final presentations all in one day! In addition, never do the final presentations before the next to last Thursday at the very earliest. They should optimally be held in the beginning of the final week."

"I enjoyed the research and the overall experience. I learned a lot from my advisor and the other REU students. Watching MS thesis defenses was much more educational than the bag lunch series. So maybe next year more REU students should be encouraged to attend defense presentations. The social activities were fun, but I think there should be more events where the students can get to know the professors. The dorms were quite a distance from work, which was a bit of a hassle. They also housed us with football players who were loud and stoke our food on multiple occasions. When I mentioned this to one of the residence hall employees, I was told there was nothing they could do because this campus treats the football players like gods! Next year I would recommend that you request not to put them REU students on the same floor as the football team. I don't blame the REU program for any of the dorm issues. But I'm sure you want to be aware of them. Overall, my experience here has been one of the most valuable I have ever had. Thanks again for this opportunity."

"Research: My advisor had next to no time for me for the majority of the summer. I never really received what I would consider a 'research project'. I spent some time reading, looking through scientific papers, and drawing some images during the final weeks. It almost seems as if my advisor was forced into this program as he is a new professor and did not have his lab set up yet. This does not seem like a reasonable for me to get so little to do. I was quite disappointed. Social: I was quite satisfied with the social atmosphere due to the other REU participants. We had a good fun summer."

"Best: Being able to speak one-on-one with my advisor.
-- There was no shortage of events.
-- My advisor and all faculty were very helpful and courteous.
-- Good housing, office.
-- Wind surfing.
-- All accommodations were met (summer-log REC pass, refrigerator, dishes, etc.).
-- Getting great experience as a student/researcher.
Worst: Brown bag lunches sometimes didn't seem relevant to us.
-- I wish REU information had been sent out a little earlier than a week before we were to arrive."

"Best: The students I met. Worst: No clear direction in my research."

"BEST:
・It showed what kind of requirements a future career in the particular field are needed.
・It introduced me to the terminology and apparel that a physicist works with in the field.
・Meet some really friendly people that are examples for future decisions.
WORST:
・The program can be a lot more strict about goals of the different researches. Even though the researches are very different, a certain algorithm can be established with different advisors in order that the student exploits the time during the program at maximum. That implies mostly a definite clearing of what the goals of the advisors a lot better. They should know what they expect from the students before the program begins. If that would happen, a drastic change will move the whole program to better efficiency."

"BEST:
・Social activities;
・working with graduate students;
・meeting other physics students from around the US;
・living with everyone.
WORST:
・no real guidance from my advisor;
・no research progress was really made in the time frame given;
・I didn't get paired with a program that fit with my real major (magnetics vs. astronomy)."

"I enjoyed my research experience; I feel that I learned a lot. I made a lot of friends and although we worked this summer, we still had a lot of fun. The living situation was good except for the others living in the building. There were also theft issues with our stuff in the fridge. I don't really have any suggestions to change this though. I think the presentations might have been pushed back at least a week. That's all..Thank you for everything!"

Please list any additional comments.

" ・The fridge/utensils were vital + wonderful
・would like to see a GRE prep as one of the seminars"

"I wish some of the activities we did could have been paid for us instead of paying out of our stipends."

"Are midterm reports necessary? It is quite repetitious to have both them and the final presentations in a short period of time. Upon move-in, see to it that the REU students receive UT lanyards from the Office of Residence Life as everyone else does when they first come to UT to stay in the dorms."

"Overall I would like to say I thoroughly enjoyed my time at The Univ. of Toledo, and I learned a great deal. I thank you for all the experience and the insight you have given me as a researcher and a student. I must also admit that it was pretty cool to have my own office! Thanks again!"

"I felt that my advisor didn't' really help me or care to help me too much. She was too busy with two grad students and two visiting professors plus outside collaborators, to help me or guide me in my research. I didn't know what I supposed to accomplish or what my goal was. I don't think I added to my knowledge of physics, other than some terms. I also felt she wasn't really interested in what I was researching."

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

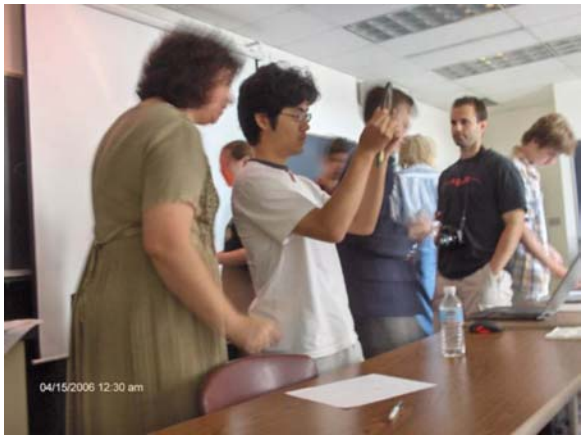
VII. SUMMER 2006 PICTURES

Dept/REU BBQ Lunch

Final Talk - Brian Bismack

Final Talk - Kristen Jones

Summer Camp 2006



Summer Camp 2006

LN2 ice cream at Summer Camp 2006