Annual Progress Report (Year 1)

Research Experiences for Undergraduates in
Physics and Astronomy

NSF-REU Grant PHY- 1004649

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

December 2010

Richard E. Irving
Thomas J. Kvale

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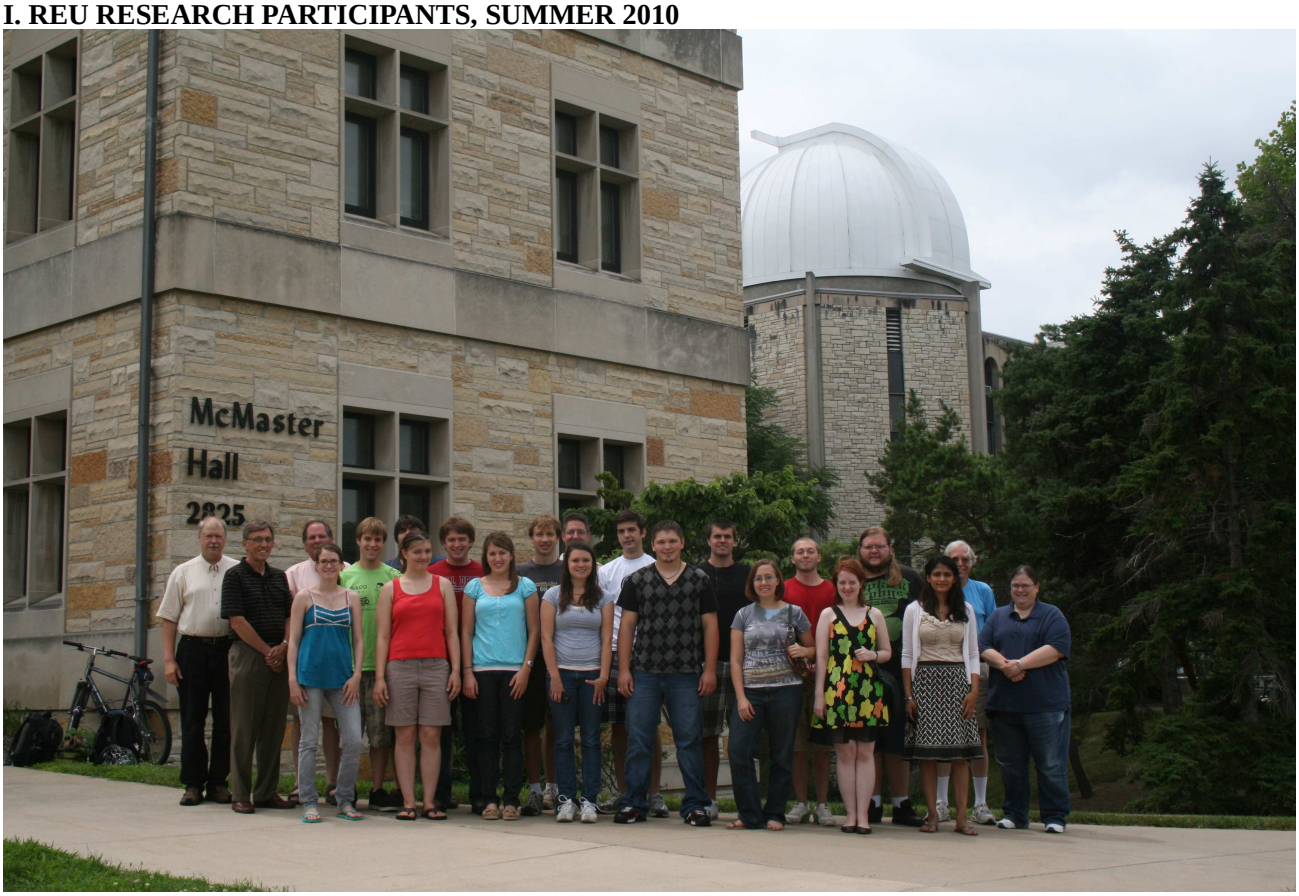

Mentors and participants (boldface) in 2010 Summer REU:
Left to Right (Front row): **Tiffany Pewett**, **Rachel Arnold**, **Katie Hoepful**, **Julia Dietz**, **Matthew Korpela**, **Mandy Kilbourn**, **Marina Kounkel**, Rupali Chandar Left to Right (Second Row) : Al Compaan, **Todd Skinner**, **Nathan Reaver**, **Tim Carleton**, **Ben Cermack**, **Devin Kelling**, **Andy Moore**, **Corbin Taylor**, Karen Bjorkman **Left to Right** (Back Row): Tom Kvale, Lawrence Anderson-Huang, Rick Irving, JD Smith, Steve Federman**.**

NAME	INSTITUTION	MENTOR	RESEARCH
Rachel Arnold*	Western Washington	Rupali Chandar	Astronomy
Tim Carleton	Univ. of Arizona	JD Smith	Astronomy
Julia Dietz*	Univ. of Toledo	Randy.Ellingson	Condensed Matter
Zachary Draper	U.Washington	K. Bjorkman	Astronomy
Caitlin Dunn	Humboldt State Univ., CA	Dave Pearson	Medical Physics
Kathryn Hoepfl*	Univ. of Toledo	A.Compaan/ A. Solocha/K.Wieland	Condensed Matter
Deven Kelling	Itasca Community College, MN	Thomas Kvale	Atomic Physics
Mandy Kilbourn	Arkansas Tech. Univ	M.Dennis	Medical Physics
Matthew Korpela	Iron Range Engr., MN	K. Bjorkman	Astronomy
Marina Kounkel*	Univ. of Toledo	Thomas Megeath	Astronomy
Rebecca Kutsko	Youngstown State	W.Fischer/T. Megeath	Astronomy
Andrew Moore	Ball State	H. Fan/B. Ingler	Condensed Matter
Todd Skinner	Kenyon College, OH	L.S.Anderson-Huang	Astronomy
Nathan Reaver**	Univ. of Toledo	Al Compaan	Condensed Matter
Corbin Taylor	Univ. of Toledo	Steve Ferman	Astronomy
Tiffany Pewett***	Univ. of Toledo	K. Bjorkman	Astronomy
Benjamin Cermack***		Kris Wieland	Condensed Matter

* Supported by external grants, but fully participated in the REU program.
** Received support from the UT USRCAP and the NSF-REU program, but fully participated in the REU program.
*** Volunteered to participate in our REU program.

II. SUMMARY OF SUMMER 2010

Introduction

The Summer 2010 NSF-REU program in Physics and Astronomy, directed by Dr. Richard Irving and Professor Thomas Kvale, gave enhanced research opportunities to 17 undergraduate students from 11 colleges and universities in 8 states spread from coast to coast. Student participants were chosen competitively out of 116 applications from students in 34 different states in all regions of the U.S. The strong support of our faculty for the REU research program is evidenced by four students receiving support from faculty members' external grants and two students volunteering to participate in our REU program. One student received funding from the internal UT USRCAP (Undergraduate Summer Research and Creative Activity Program) and from the NSF-REU grant (at the level of support of fully NSF-REU funded participants). Deven Kelling and Matthew Korpela were the first participants in our program from the newly-forged UT-Itasca Community College collaboration. 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 their results.

We are pleased to report that Summer 2010 was a success from both the students' and faculty mentors' perspectives. At least three abstracts by this year's undergraduate researchers have been accepted for presentations at national professional conferences based on research this past summer. It is anticipated that manuscripts are in preparation and will be submitted shortly to refereed journals.

Advertisement and Selection

Again this year (Summer 2010) 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 not sent, however individualized email messages were sent to approximately 30 targeted institutions. The emailing included a cover letter alerting the prospective students to our website. The selection committee was composed of Richard Irving (PI), Thomas Kvale (Co-PI), David Ellis, Rupali Chandar, and Adolf Witt. We 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. The initial web announcement (with secondary links to additional material) can be found at: http://astro1.panet.utoledo.edu/~wwwreu/reusummer2010/nsf-reu2010.htm.

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, 10 of the 17 student participants lived in the same campus dormitory (International House) with the NSF-REU grant providing the housing costs to these students. This dorm 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 with the help of the following local participants: Marina Kounkel, Nathan Reaver, and Corbin Taylor assisted in the activities. Weekly activities included movie night, sand volley ball, ultimate Frisbee, and various ventures to local restaurants. One of the notable establishments people found fun to visit was Famouse Dave's. The perennial favorite is a windsurfing adventure, courtesy of Professor Alvin D. Compaan, at his pond. He also has a solar hybrid home and is proud to give tours to the students. Some of the other special events included: Frisbee Golf, several BBQ's, a trip to Cedar Point Amusement Park, and a Toledo Zoo visit. However, one of the more exciting social events this summer was paintball. During the REU we also had fun touring the touring the ~7 Megawatt wind turbines at Bowling Green Ohio and visiting the FirstEnergy Bay Shore coal burning power plant in Oregon Ohio. The REU calendar can be found at:
http://www.google.com/calendar/embed?src=rq0k5b7jttf4jhijo3262t75i8%40group.calendar.google.com&ctz=America/New_York&dates=20090601%2F20090630

Weekly Seminars

A weekly REU "Brown Bag" seminar series is an important part of our summer program. Faculty members and/or outside speakers are asked to present a talk over the lunch hour for their chosen day. This 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 provides an opportunity to plan social events and field trips, and discuss any topics of interest to the group.

NSF-REU SUMMER 2010 BROWN BAG SEMINARS

(Noon – MH 4009)
June 1 REU Orientation MH 4009
June 8 Scott Lee, "The Conformational Flexibility of DNA."
June 15 Randy Ellingson, "Alternative Energy Sources: Why, How, and How Much Power?"
June 22 Adolf Witt, "Light Scattering by Interstellar Dust"
June 29 REU Progress Reports
July 6 Scott Lee
July 13 Lawrence Anderson-Huang,"Light/Perception/Art"
Steve Federman,"The Interplay between Astrophysics and Atomic/Molecular Physics"
July 20 Adam Ritchey;"Light Element Nucleosynthesis by Cosmic Rays and Neutrinos"
July 27 Reva-Kay Williams; "Astrophysical Black Holes and How Energy Is Extracted"
Aug 2 Student Final Presentations
Aug 3 Student Final Presentations
Aug 4 Student Final Presentations

University-Wide Events

The Co-P.I. (Thomas Kvale) also served as the director of the UT Office of Undergraduate Research (OUR-UT). This office had an immediate, positive impact on our REU program. In addition to the ARS2980 course mentioned below, OUR-UT worked with the Office of Residence Life in creating a "Living/Researching" community for students living in the dorm. Additional university procedures were facilitated in the background by OUR-UT. This was the first year of the NSF-REU Chemistry program. The Physics/Astronomy REU participants interacted with the Chemistry REU participants at the ARS2980 presentations, housed in the same wing of the dorm, and holding some joint social 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 seminar format and topics concentrated on the safe and ethical practices in research as described in this past year's syllabus. Each

presentation lasted about an hour and there was ample time for Questions/Answers for each speaker. Based on this year's REU students' critical evaluations of this seminar series, we plan to actively promote the importance of this course at the REU Orientation at the beginning of summer. By contrast, students participating in the other research programs generally gave this seminar series positive evaluations, so there appears to be a disconnect between the REU students and the other research students' perceptions of the value of this course.

ARS2980 Issues in Research and Scholarship
Summer Semester III, 2010

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Class Meetings: Thursdays, 9am-10am (6/3 – 8/5)
Location: Sullivan Hall (SL), Rooms 3050-3060-3070
Contact Persons:
Thomas Kvale Office: MH4023 Phone: x2980 Email: tkvale@utnet.utoledo.edu
Larry Connin Office: SL1240 Phone: x6037 Email:lconnin@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

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Syllabus, Summer 2010

June 3	**Welcome Reception (12 noon)**	
June 10	**Laboratory Safety**	Heather Lorenz, Safety and Health
June 17	**Research Ethics and Compliance**	Jeffrey Busch, Office of Research
June 24	**Plagiarism and Academic Honesty**	Barb Schneider, Writing Center
July 1	**Ethics and Commitment in Research**	Tom Barden, Honors Program
July 8	**Doing Advanced Research in the Library**	Wade Lee, University Libraries
July 15	**Business Prospects and Patents**	Mark Fox, Patent-Technology, Off. of Res.
July 22	Cancelled	
July 29	**Summer Recap & Miscellaneous**	Tom Kvale & Larry Connin, OUR-UT
August 5	**Research Presentations**	Student Researchers [10am-3pm]

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.

Concluding Remarks

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.

Over the lifetime of this grant 44 students participated in our REU program from 2007 to present. We were able to track 27 of these students, of which 13 of this group are from this past summer's REU program. Twelve are continuing their undergraduate education as mentioned above and one just matriculated at Case Western Reserve Univ. majoring in physics and possibly philosophy. Five of the 11 other 14 students have since graduated and are continuing their professional development in graduate schools. Most of the graduates have gone into graduate programs in physics or astronomy, but others have diversified into graduate programs in medical physics, planetarium education, civil engineering, mechanical engineering, chemical physics, atmospheric science, and materials science in prestigious universities.

Our former REU students have been very successful in publishing their work. The research of the 44 undergraduate students under this grant (2007-present) resulted in 8 publications. Several more papers are currently in manuscript form and are expected to be submitted or resubmitted to professional journals shortly. Thirteen presentations were made at regional, national, or international conferences from 2007 to present.

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. This collaboration has been extended to provide enhanced opportunities for our REU students to select projects in the medical physics fields (radiation oncology and diagnostic radiology). Two REU students worked in this field for their research this summer. Several former REU students have 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. Very recently, the UT medical physics graduate program gained CAMPEP accreditation. This attests to the excellent medical physics research experiences for our REU students.

Many thanks to all the people who helped out during our NSF- REU, especially the office staff, Willie Brown, Sue Hickey, and Stephany Mikols. A final thanks goes to the National Science Foundation. NSF's grant to the University of Toledo for the Research Experiences for Undergraduates made this summer program possible.

III. PHYSICS AND ASTRONOMY SUMMER CAMP 2010

As part of the this NSF program our REU students host the Physics and Astronomy Summer Camp. This is an outreach activity for high school students which took place July 21-20. The summer camp activities were developed and supervised with the help of our REU team. Again this year Jackie Kane, a St. Ursula high school science teacher, was extremely helpful in promoting the We had in attendance 19 high school students representing the following five local area high schools: St. Ursula, Toledo Christian, St. Francis, Rodgers, St. John, Notre Dame.

The first day of the Summer Camp dealt with alternatives for energy generation other than that produced from coal To start this journey the group did a tour of UT's own Scott Park Campus of Energy and Innovation: led by Chuck Lehnert, Interim Director for Scott Park Campus for Energy & Innovation & Vice President of Facilities & Construction. The student were able to visit a 1.2-megawatt (MW) solar and wind system at this campus. The project utilizes thin-film-on-glass photovoltaic solar technology and a 132-foot wind turbine manufactured by Wind Energy . Both the wind and solar system are expected to generate power equal to the amount of electricity used by 140 homes annually. Next the students experienced similar technology at the home owner level This consisted of a tour and discussion by Professor Alvin Compaan concerning his 4.3 kW CdTe rooftop PV system and his homemade electric truck. After a barbeque the afternoon provided the students with hands-on activities to explore the concepts of the day. One activity involved building mini generators to power an led(s). The students also really enjoyed testing their endurance to power up to 4 incandescent light bulbs (60 Watts each) with a homemade bicycle generator. I believe the students got a sense of how precious electric power while

there were laughing & grunting to keep the bulbs lit.

The second day featured night time activities related to astronomy including presentations in Ritter Planetarium, by Alex Mak. Another of which was given by Dr. JD Smith on infrared spectroscopy. The students enjoyed the interactive demos involving an infrared camera. Brad Rush did a tour of the One-meter telescope and a student activity on the scale of the solar system using the student campers as planet.

IV. DEMOGRAPHICS

NSF-REU SUMMER 2010 APPLICATIONS
Geographical distribution by undergraduate institution
(Applications Received:114 / REU Offers Made:17 / REU Accepted:15)

ARIZONA
Arizona State Univ. ..... (1/0/0)
Univ. of Arizona ..... (2/1/1)

ARKANSAS
Arkansas Tech. Univ. ..... (1/1/1)

CALIFORNIA
Cal. State Northridge ..... (1/0/0)
DeAnza College ..... (1/0/0)
Humboldt State Univ. ..... (1/1/1)
UC Davis ..... (1/0/0)
UCLA ..... (1/0/0)
UC San Diego .... (1/0/0)

COLORADO
Colorado State Univ. ..... (1/0/0)

FLORIDA
Florida International Univ. ..... (3/0/0)
Florida State Coll.,@ Jacksonville ..... (1/0/0)
Univ. of Northern Florida ..... (1/0/0)

GEORGIA
Valdosta State Univ. ..... (1/0/0)

ILLINOIS
Monmouth College ..... (1/0/0)
North Park Univ. ..... (1/0/0)
Univ. of Illinois ..... (1/0/0)

INDIANA
Ball State Univ. .... (1/1/1)
Earlham College ..... (1/0/0)
Notre Dame .... (3/0/0)
Rose-Hulman Inst. of Tech ..... (1/0/0)

IOWA
Drake Univ. .... (1/0/0)
Grinnell College .... (1/0/0)
Univ. of Iowa .... (1/0/0)

KANSAS
Benedictine College ..... (1/0/0)
Wichita State Univ. ..... (1/0/0)

KENTUCKY
Univ. of Louisville ..... (2/1/0)

LOUISIANA
Centenary Coll. Of Louisiana ..... (2/0/0)

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

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

MASSACHUSETTS
Boston Univ. .... (1/0/0)
Harvard Univ. .... (1/0/0)
Mt. Holyoke College ..... (1/0/0)
Wheaton College ..... (1/0/0)
Worcester Polytechnic Inst. ..... (1/0/0)

MICHIGAN
U.Mich.-Ann Arbor ..... (1/0/0)

MINNESOTA
Concordia College ..... (1/0/0)
Hamline Univ. ..... (1/0/0)
Iron Range Engr. ..... (1/1/1)
Itasca Community College ..... (1/1/1)

MISSISSIPPI
Millsaps College ..... (1/0/0)
U.Southern Mississippi ..... (1/0/0)

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

NEBRASKA
Hastings College ..... (1/1/0)

NEW JERSEY
Stevens Inst. of Tech. ..... (1/0/0)
The College of New Jersey ..... (1/0/0)

NEW YORK
Cooper Union ..... (1/0/0)
LeMoyne College ..... (1/0/0)
Rensselaer Polytechnic Inst. ..... (2/0/0)
SUNY at Binghamton ..... (1/0/0)
SUNY at Buffalo ..... (1/0/0)
Univ. of Rochester ..... (2/0/0)

NORTH CAROLINA
Duke University ..... (1/0/0)
Meredith College ..... (1/0/0)
U.North Carolina, Chapel Hill ..... (1/0/0)

OHIO
Baldwin-Wallace College ..... (1/0/0)
Grove City College ..... (1/0/0)
Kent State Univ. ..... (1/0/0)
Kenyon College ..... (2/1/1)
Miami Univ. ..... (1/0/0)
Ohio Weslayan Univ. ..... (2/0/0)
The Univ. of Toledo ..... (9/5/5)*
Univ. of Dayton ..... (1/0/0)
Youngstown State Univ. ..... (2/1/1)

OREGON
Reed College ..... (1/0/0)

PENNSYLVANIA
Carnegie Mellon ..... (1/0/0)
Concordia College ..... (1/0/0)
Drexel Univ. ..... (1/1/0)
Moravian College ..... (1/0/0)
Swarthmore College ..... (1/0/0)
Westminster College ..... (1/0/0)

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

SOUTH CAROLINA
Clemson University ..... (1/0/0)

TENNESSEE
Austin Peay State Univ. ..... (1/1/0)
Southern Adventist Univ. ..... (1/0/0)
U. Tenn. At Chattanooga ..... (1/0/0)

TEXAS
U.Texas at Austin ..... (1/1/0)
U. Texas at Dallas ..... (2/0/0)

UTAH
Univ. of Utah ..... (1/0/0)

VIRGINIA
Hampton Univ. ..... (1/0/0)
Lynchburg College ..... (1/0/0)

WASHINGTON
Seattle Univ. ..... (1/0/0)
Univ. of Washington ..... (2/1/1)
Western Washington University ..... (1/1/1)
Whitman College ..... (1/0/0)

WISCONSIN
Beloit College ..... (1/0/0)
Lawrence University ..... (1/0/0)
U. Wisc., LaCrosse ..... (1/0/0)
U. Wisc., Madison ..... (1/0/0)
U. Wisc., Parkside ..... (1/0/0)

PUERTO RICO
U. Puerto Rico Mayaguez Campus ..... (1/0/0)

UKRAINE
Taras Shevchenko Natl. Univ. of Kyiv ..... (1/0/0)

*Three UT students supported on external funding and one additional UT student had split funding between UT and NSF-REU. All four students fully participated in the summer research program along with the NSF-REU funded students.

NSF-REU Participant* Demographics
Summer 2010

Gender
Female**: 7
Male**: 6

Class Rank
Freshman: 2
Sophomore: 6
Junior: 8
Senior: 1

Ethnicity
American Indian: 1
Alaskan Native: 0
Asian American: 0
(or Pacific Islands)
African American: 0
Hispanic American: 0
Caucasian/White**: 16
Other:

Home State
Arkansas …… 1
Arizona ……. 1
California 1
Indiana ……. 1
Minnesota 2
Ohio** 9
Washington …… 2

Home Institution:

Arkansas Tech. Univ. ……1
Ball State ……...1
Humboldt State Univ., CA. ……...1
Iron Range Engr., MN ……..1
Itasca Community College, MN …...1
Kenyon College, OH ……1
Univ. of Arizona ……1
Univ. of Toledo** …… 7
Univ. of Washington ……..1
Western Washington Univ……..1
Youngstown State ……..1

REU Students Grade Point Average: 3.57
* Includes all students participating in our program regardless of their source of support
** 2 Students were not supported by NSF funds, but fully participated in the summer research program.

V. RESEARCH

REU 2010 Final Presentations
Each talk is scheduled for 12 minutes allowing 3 additional minutes for questions.

Monday, August 2
12:00 Rachel Arnold: “MASSCLEAN: Massive Cluster Evolution and Analysis Package”
12:15 Matthew Korpela: "TBA"
12:30 Todd Skinner:"Microturbulence in Stellar Atmospheres"
12:45 Tim Carleton:"Analysis of Dust Features in the Mid-Infrared Spectrum"
1:00 Katie Hoepfl: "TBA"

Tuesday, August 3
12:00 Corbin Taylor: "TBA"
12:15 Marnia Kounkel:”Search for Binary Protostars in the Orion Molcular Clouds”
12:30 Tiffany Pewett: "Theta CrB: From Be star to B star and Back"
12:45 Andy Moore:"Anodic Porous Alumina"
1:00 Deven Kelling:"Inside the deflection chamber"
1:15 Mandy Kilbourn:"Functional MRI"

Wednesday, August 4
12:00 Nathan Reaver: "TBA"
12:15 Julia Deitz:"Cadmium Selenide Solar Cells"
12:30 Rebecca Kutsko:"Analyzing the Hydrogen Lines of Protostars in the Orion Molecular Cloud using Near-Infrared Spectra"
12:45 Zack Draper: "TBA"
1:00 Caitlin Dunn: "Improving the Model Used for Intensity Modulated Radiation Therapy"

ABSTRACTS OF REU FINAL REPORTS

The University of Toledo, Department of Physics & Astronomy
SUMMER 2010
(Faculty Mentor on parenthesis)

Astrophysics/Astronomy

Rachel L. Arnold, *Extragalactic Globular Clusters:A Study Of Structure Through Simulation*, (Rupali Chandar)

Star clusters have three basic properties: age, mass, and size. There have been manystudies of the ages and masses of star clusters in nearby galaxies, but much less time has been devoted to understanding the structures of these clusters, despite the fact that stellar density plays a large role in their evolution. Even with high resolution images taken with the Hubble Space Telescope, the profiles measured for star clusters can have a number of biases, particularly for young clusters which form in crowded regions of galaxies. Weare using MASSCLEAN (Massive Cluster Evolution and Analysis package), a new,publicly available stellar cluster simulation program, to quantify biases in size measurements of extragalactic star clusters at different distances. We also reproduce wellknown Galactic clusters, e.g. the Orion OB1 cluster, and simulate what these would look like in more distant galaxies.

Timothy Carleton, *The Study of PAH Emission in Post-Starburst Galaxies and The Discovery of C60 in NGC 7023 and NGC 2023*, (J.D. Smith)

Emission from PAHs represent important features in the infrared spectra of galaxies. I am studying the PAH emission in post-starburst galaxies. To do this I construct and analyze spectral cubes of 15 post starburst galaxies. This can not only tell us about the role PAHs play in galaxy evolution, but also the properties of post-starburst galaxies.C60 is a spherical molecule of pure carbon that has been theorized to exist in space, but has yet to be detected. We detected C60 in thereection nebula NGC 7023 and NGC 2023.

Zachary Draper, *Modeling and Observations of Classical Be Stars π Aquari and 60 Cygnii*, (Karen Bjorkman)

Classical "Be" stars are massive main sequence stars that are rapidly rotating and have a circumstellar disk. The central question into their research is too answer how they form and control their circumstellar disk. To this end, studying their disks during phases of growth and loss and then modeling their behavior is crucial to understanding their underlying mechanism controlling the disk. Two stars of focus are π Aquari and 60 Cygnii both of which experienced a disk loss phase in the 1990's and are in the process of regrowing. Presented here is the efforts to reduce π Aquari H-alpha spectra from the Ritter observatory from 1996 to 2007 during a disk growth phase, model polarization angle deviations from the mean, and model the polarization across the Balmer Jump vs continuum Vband polarization of both stars using published previously in Wisniewski et al. 2010.

Rebecca Kutsko, *Analyzing the Hydrogen Lines of Protostars in the Orion Molecular Cloud using Near-Infrared Spectra*,(Will Fischer and Tom Megeath)

The study of the accretion luminosities of protostars is an essential step to understanding their evolution. These young stellar objects (YSOs) are completely surrounded by envelopes of dust and gas, so they are unable to be seen in any optical wavelength. Instead, infrared wavelengths are used to observe past the dust and study the objects within. By measuring the spectra of protostars (class I YSOs) within the Orion Molecular Clouds, we were able to obtain their accretion luminosities and

compare them to a study of class II YSOs, which are more evolved objects whose envelopes have dispersed. With 1-2.4 micron spectra obtained using the SpeX instrument at NASA's Infrared Telescope Facility, we analyzed 8 class I protostars and 4 class II sources. We measured the equivalent widths of the atomic hydrogen emission lines Paβ (1.28 μm) and Brγ (2.17 μm) and wrote an IDL program to convert the equivalent widths to line luminosities and then to accretion luminosities using the relationships found by Muzerolle et al. (1998) for class II YSOs in Taurus. Our results suggest that the younger protostars have a higher median accretion luminosity than the class II YSOs by almost a factor of 50. We thus conclude that it is possible to estimate protostellar accretion luminosities using infrared hydrogen emission lines; this is the most direct method available to study the disk-to-star accretion flow in embedded protostars.

Marina Kounkel, *Search for Binary Protostars in the Orion Molecular Clouds*, (S. Thomas Megeath)

The Orion molecular clouds contain the largest sample of protostars within 500 pc of the Sun. As part of a coordinated, multi-observatory program to study protostars in Orion, we observed 36 fields around protostars using IRTF with NSFCAM2 at L' band wavelength. In addition to mapping the scattered light from the individual protostars (the primary goal of the program), these data allow us to detect companions at separations as small as 300 AU at the distance of Orion. We present a search for close companions to the protostars using the IRTF data. By combining the IRTF imaging with a Spitzer space telescope survey of the Orion clouds, and NICMOS imaging we determine the density of candidate YSOs as a function of distance from each of the targeted protostars. With this analysis, we find a clear enhancement in the density of sources near the protostars, indicating that the apparent nearby companions are not due to chance alignments. We compare the incidence of multiplicity with that found in other star forming regions and in the field. This project is the continuation of previous summer research using NICMOS imaging used for finding binary protostars

Tiffany D. Pewett,*Theta Corona Borealis: From Be star to B star and Back*,(Karen Bjorkman)

B-emission class stars are stars that hold disks around them resulting in hydrogen and helium emission lines in their spectra. Little is known about how and why these disks form. One known contributing factor is the fact that they are rapidly rotating. There have to be other factors though, considering not all rapidly rotating stars have disks and the disks tend to disappear and reform randomly. Theta Corona Borealis is such a star, however it has been highly understudied. It is believed that its disk faded away in 1970 when the star's apparent magnitude decreased by about fifty percent of its normal brightness. Then, in 2006, the disk started reforming slowly, then began fading again. My goal was to analyze the available data collected at Ritter Observatory to determine when, and possibly why, the disk disappeared and is now trying to reform. No pattern has yet been discovered but I will continue my research beyond the program in the hopes of better understanding the processes behind the formation of Be stars.

Todd Skinner,*Modeling Microturbulence in Stellar Atmospheres*,(Lawrence Anderson-Huang)

We can develop our understanding of microturbulence in hot stellar atmospheres by modeling the radiation in a section of the stellar atmosphere. The code used to run this simulation, however, is complex and needs to do many computations over a large three-dimensional grid over multiple iterations. This code needs to be parallelized in order to efficiently study the microturbulence. The aim of this project was to attempt a parallelization of a subroutine of the code that solves for the radiative transfer across a three-dimensional grid and improve upon the numerical methods used in calculating the radiation field.

Corbin Taylor, *Lithium In Ic 443: A Study In Light Element Synthesis*,(Steve Federman)

Cosmic ray and neutrino-induced spallation processes are thought to be production pathways for the

light element Li, making supernova remnants possible sites for the element's synthesis. Observations toward the OB stars HD 43582, HD 254477, HD 254577, and HD 254755 in the vicinity of the supernova remnant IC 443 were made at the 9.2 m Hobby-Eberly Telescope ($R\sim10^5$). We analyzed the Li I doublet at 6707 Å to obtain the $^7Li/^6Li$ abundance ratio for two of these sight lines, as well as absorption lines for K I, Ca I, CH, and CH^+ to aid in the line fitting. The goal of this research is to further our knowledge about the synthesis of Li and the light elements in general.

Atomic/Molecular/Optical Physics

Deven Kelling, *Current use of The Toledo Heavy Ion Accelerator*, (Thomas Kvale/Richard Irving)

The Toledo Heavy Ion Accelerator, THIA, has issues with beam instability. The research used for this paper studied the Electrostatic deflection chamber, and it's inherent sources of beam instability. It was found that damage to the deflection plates within the chamber was a prime factor in the resulting beam instability the is seen at the end of the line. This damage is the result of impact ionization of the beam incident on residual gas particles in the vacuum.

Biological, Health, and Medical Physics

Caitlin Dunn, *Improving the Model used for Intensity Modulated Radiation Therapy*, **(**Dave Pearson**)**

Radiation therapy is a common treatment for cancer despite the danger of radiation to noncancerous cells. The scientific community has been continuously working on a process to make radiation therapy treatments more successful. The rate of success is correlated with how much healthy tissue is spared while still irradiating the entire target. Recently intensity modulated radiation therapy (IMRT) has become the best way to administer complicated plans to patients. IMRT has many advantages, but one major barrier is that the IMRT planning process is too complicated to compute manually. This barrier can be overcome with a good modeling program. Pinnacle is the program currently used at the University of Toledo Health and Science Campus and it performs well under most circumstances. However it has been noticed that when doing quality analysis (QA) for IMRT plans that use many small heavily blocked fields the error is higher. By using different ion chambers to obtain more consistent data we were able to create a new model that was more accurate.

Mandy Kilbourn, *VBM: Voxel based morphometry for the study of brain differences between lower-limb amputees and control subjects*, (Micheal Dennis)

Voxel based morphometry, or VBM, is a technique used to compare brains on a voxel-by-voxel basis. VBM uses MR images that have been spatially normalized, which can then be compared to find differences between gray matter concentration between two groups of subjects. This study consisted of eleven male lower-limb amputees and seven male control subjects. The VBM analysis was carried out in MATLAB 7.10.0 using SPM8, a program from the Functional Imaging Laboratory (FIL) in The Wellcome Trust Centre for NeuroImaging, in the Institute of Neurology at University College London (UCL), UK. Differences were reported for $p=0.005$, with $2.58<Z<3.83$. Using these parameters, statistical parametric mapping (SPM) led to the identification of 15 areas of average lower concentration and 13 areas of average higher concentration in the amputee brains. In the future, the preliminary results from this study will be compared to the results of the Freesurfer analysis for cortical thickness, as well as to results from longitudinal studies from individual subjects.

Condensed Matter Physics

Ben Cermack,

Julia Deitz, *Exploring Possibilities of Cadmium Selenide Nanocrystal Solar Cells*,(Randall Ellingson)

With limited past success with Cadmium Selenide nanocrystals for solar cells, it was hoped that more efficient versions could be made. In attempts to make the solar cells, many problems were faced with the CdSe nanocrystals attaching to the substrate. This was caused from the unknown surface chemistry of the nanocrystals that were worked with. Many techniques were used in attempts to understand the surface chemistry and successfully attach the nanocrystals to a substrate, but the surface chemistry remains unresolved.

Katie Hoepfl, *Comparison of Solar and Wind Power Output and a look at Real-Time Pricing, (*Alvin Compaan, Andrew Solocha, Kristopher Weiland)

This paper presents a method that can be used to determine the least volatile power output of a wind and solar hybrid energy system. Hourly data for a wind and PV system in Toledo, OH is used to show that a combination of both types of sustainable energy produces a much more stable power output and would be more easily tied to the grid than either individually. This method could be used to determine the ideal ratio in any part of the country and should be used to convince energy companies to bring more renewable online. This paper also looks at real-time market pricing and how each system (solar, wind, and hybrid) correlates with the 2009 hourly pricing.

Andrew Moore, *Texture Characteristics of Aluminum Back Reflectors*, (Qi Hua Fan, Dr. Bill Ingler)

This report seeks to characterize the texture of thin aluminum films for solar cell application. Aluminum was deposited on glass slides, controlling various deposition parameters such as temperature, power, power type, pressure, and time. The samples were scanned by an atomic force microscope (AFM). The AFM produces a 3-dimensional image of the surface in the nanoscale. A program was developed to analyze the AFM data and calculate a texture angle and height for each surface peak. The average angle and height for a given sample is its characteristic texture. Systematic tests in controlling the texture by altering deposition parameters were also analyzed.

Nathan Reaver, *Effects of Back Contact Materials on Substrate Configuration CdTe Solar Cells*, (Kristopher Wieland, Alvin. Compaan)

Substrate configuration CdTe photovoltaics has the potential to provide both a reduction in the production costs and improved power to mass ratio. In this study the effect of copper placement in the cells, sequence of CdCl2 treatment, and the effect of back contact material on cell performance was examined. Cells were deposited on a Mo coated conductive substrate, on stainless steel or on TCO coated glass, using RF magnetron sputtering. Three different back contacts were used, copper-gold as used in superstrate configuration cells, Sb2Te3, and ZnTe:N. Cells were measured using a solar simulator at one sun to obtain current density vs. voltage curves and cell efficiencies. The structure that gave the best performance was stainless steel/Mo/Sb2Te3/CdTe/CdS/ZnO/ZnO:Al, with the best cell having an efficiency of 5.34%.

NSF-REU External Publications and Presentations*

I'll bet that you never had an REU student who testified at an NRC-related event related to relicensing of a nuclear power plant!

Katie will probably speak/testify at the event Saturday.

(Update from Annual Report 2009)

REFEREED PUBLICATIONS - Submitted/accepted/published.

Yunsic Shim, **Mary E. Mills* (2007)**, Valery Borovikov, and Jacques G. Amar, "Effects of substrate rotation in oblique-incidence metal(100) epitaxial growth," Physical Review E 79, 051604 (2009)

Ingler Jr, W. B.; **Ong, G**.* **(2007)**; Deng, X. "RF Sputter Deposition of Indium Oxide – Iron Oxide Films for Photoelectrochemical Hydrogen Production" *ECS Trans.* Vol. 16, No. 7. (State-of-the-Art Program on Compound Semiconductors 49 (SOTAPOCS 49), **2008**, 49.

REFEREED PUBLICATIONS - in preparation.

PRESENTATIONS.

Ingler Jr, W. B.; **Ong, G.* (2007)**; Deng, X. "RF Sputter Deposition of Indium Oxide – Iron Oxide Films for Photoelectrochemical Hydrogen Production" *ECS Trans.* Vol. 16, No. 7. (State-of-the-Art Program on Compound Semiconductors 49 (SOTAPOCS 49), **2008**, 49. *210th Meeting of the Electrochemical Society, Inc.*, Honolulu, HI, October 12-17 (Oral Presentation)

PRESENTATIONS WITH PUBLISHED ABSTRACTS.

CONFERENCE PRESENTATIONS WITH PROCEEDINGS PAPERS.

R. M. Zeller (2008), J. D. Walker, K. A. Wieland, and A. D. Compaan, "R*eal-time Optical Thickness monitor for Thin Film Growth,"* 34th IEEE Photovoltaic Specialists Conference Philadelphia, PA, June 7-12, (2009)

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

NSF-REU Physics and Astronomy
RESEARCH PROGRAM EVALUATION - STUDENT
2010

To help us improve our summer research program in future years, please give us your confidential opinion on the following questions. Indicate your selection by **CIRCLING** the number. You may use the backs of these pages and/or additional pages if extra space is needed for comments.

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

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

2. How much do you think that your research experience has helped you educationally?

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

3. How do you rate your summer research experience personally?

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

4. 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

5. How do you rate the <u>level of your research</u> project this summer in regards to your educational level?

Far above my level			**About Right**			**Far below my level**
1	2	3	4	5	6	7

6. How skilled in the tools/techniques/methods of inquiry in the profession of the research project did you start with at the <u>beginning of the summer</u>?

Very skilled/knowledgeable			**Neutral**			**Not very skilled/knowledgeable**
1	2	3	4	5	6	7

7. How skilled in the tools/techniques/methods of inquiry in the profession of the research project did you acquire by the <u>end of the summer</u>?

Very skilled/knowledgeable			**Neutral**			**Not very skilled/knowledgeable**
1	2	3	4	5	6	7

8. How much time did your faculty mentor spend per week personally mentoring you on your research project?

1	2	3	4	5	6	7
0-1hrs/wk	1-2 hrs/wk	2-3 hrs/wk	3-4 hrs/wk	4-5 hrs/wk	5-6 hrs/wk	>6 hrs/wk

9. How do you rate your faculty mentor/supervisor's interactions in helping you in your research experience?

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

10. 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

11. How do you rate the Physics/Astronomy Bag Lunches and the ARS2980 seminar presentations?

Very informative			**Neutral**			**Not very informative**
1	2	3	4	5	6	7

12. How do you rate the REU social activities this summer?

Very fun			**Neutral**			**Boring: waste of time**
1	2	3	4	5	6	7

13. 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

14. Were you made to feel welcome by the department and REU staff this summer?

Very welcome			**Neutral**			**Not welcome**
1	2	3	4	5	6	7

15. 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

Critical Reflection Questions (Use additional pages and/or backs of these pages if desired.)

1. Why did you choose to become involved in a research project this summer?

2. What prior knowledge did you find useful in your research project (e.g., courses, experiences, etc.)?

3. What knowledge was missing that would have helped you in your research project (e.g., courses, experiences, etc.)?

4. What new knowledge central to your project did you discover in your research?

5. What new knowledge tangential or incidental to your project did you discover in your research (e.g., new methods, connections, resources, etc.)?

6. How might your research project impact the greater community (professional and/or societal)?

Please list any additional comments.

VIII. SUMMER 2010 PICTURES