Annual Progress Report (Year 1)

Research Experiences for Undergraduates in
Physics and Astronomy

NSF-REU Grant R-110005-07

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

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Richard E. Irving
Thomas J. Kvale

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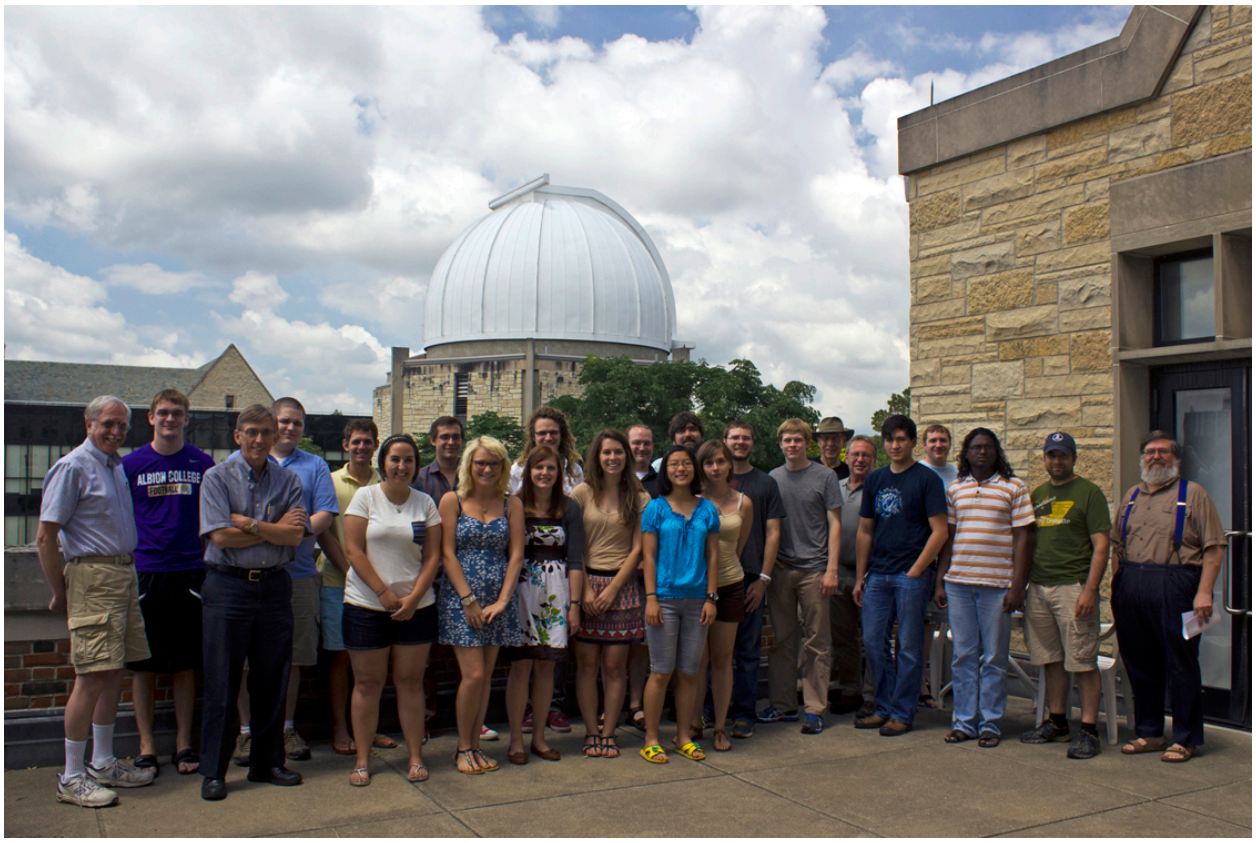
I. REU RESEARCH PARTICIPANTS, SUMMER 2013



REU students, Mentors and other research students

REU Summer 2013 Participants

NAME	INSTITUTION	MENTOR	RESEARCH
Luke Kwiatkowski	University of Toledo	Mao-Pei Tsui	Mathematical Physics
Timothy Anderson	Itasca Community College (Minnesota State Mankato)	T. Kvale/R. Irving	Plasma Physics
Jennifer Jin	Mary Baldwin College	Jacques Amar	Mathematical Physics
Andrew Yandow	Harvey Mudd College	Yanfa Yan	Condensed Matter
Brandon Schurter	Berea College	T. Kvale/R. Irving	Plasma Physics
Elise Mesenbring	Gustavus Adolphus College	Nikolas Podraza	Plasma Physics
Kody Kamunen	Itasca Community College (Minnesota State Mankato)	Jon Bjorkman	Astronomy
Kevin Kelbach	University of Toledo	A. Compaan/R. Irving	Plasma Physics
Demi St. John	Murray State University	Adolf Witt	Astronomy
Rebekah Thomas	Bowling Green State Univ.	Victor Karpov	Condensed Matter
Anna Barnes	University of Toledo	Nikolas Podraza	Plasma Physics
Nathan Ross	Albion College	D. Ellis/R. Irving	Atomic Physics

II. SUMMARY OF SUMMER 2013

Introduction

The Summer 2013 NSF-REU program in Physics and Astronomy, directed by Dr. Richard Irving and Professor Thomas Kvale, gave enhanced research opportunities to 12 undergraduate students from 9 colleges and universities in 6 states. Student participants were chosen competitively out of 146 applications from students in 32 different states and Puerto Rico in all regions of the U.S. The strong support of our faculty for the REU research program is evidenced by additional students receiving support from faculty members' external grants and/or participating through the Office Undergraduate Research programs. Six of our twelve REU students participated in our program from community colleges and/or small liberal arts colleges. 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 our students had three refereed publications and two conference presentations this year. We expect additional manuscript(s) from this summer's (2013) are in preparation and will be submitted shortly to refereed journals and/or presented at conferences.

This was the first year of collaborating with national facilities to give the students a "blended" research experience in a national research facility. This year two students conducted research in high temperature plasma physics at UT and through our collaboration with the Nevada Terawatt Facility (NTF). While at UT, they prepared for their research by electronic communications with the senior research team leader at NTF prior to their travel to Reno, NV to participate in the actual experiments. Co-PI Kvale accompanied the students to NTF so the students made the transition between Toledo and Reno as seamless as possible. Because of frequent (many times per week) interactions leading up to the travel, their time at the facility was very productive. After travelling back to Toledo, they stayed in continual contact with the NTF research team to finish analyzing the data taken at NTF. The NTF team even participated in the students' final presentations via Skype.

Advertisement and Selection

Again this year (Summer 2013) 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 mode of information transference and sufficient interest in our program, paper announcements were not sent thus saving our program significant costs of printing and postal fees. The emailing included a cover letter alerting the prospective students to our website. The selection committee was composed of Richard Irving (PI) and Thomas Kvale (Co-PI). 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://www.utoledo-pa-reu.org/ .

Registration and Housing

This year, all 12 of the REU student participants lived in the International House dormitory 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.

Networking & Social Activities

As has been the case for several years now, social activities were coordinated by the students themselves with the help of the local REU and UT participants. Activities included movie nights, ultimate Frisbee, board games, and various ventures to local restaurants. 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: a UT Planetarium show, a trip to Cedar Point Amusement Park, and visits to the Toledo Zoo and Toledo Museum of Art. The REU calendar can be found via the REU link on our department home page at: http://www.physics.utoledo.edu.

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 2013 BROWN BAG SEMINARS
(Noon – MH 4009)

May 28 **REU Orientation**
June 06 **Randy Ellingson** *"Thin Film PV Research and Education at the University of Toledo -- Innovation in Materials, Characterization, and Devices"*
June 13 **William Fischer** *"Revealing the Hunter's Secrets with HOPS, the Herschel Orion Protostar Survey"*
June 20 **David Pearson** *"The daily duties of a Medical Physicist at UTMC"*
June 26 **REU Progress Reports**
June 27 **REU Progress Reports**
July 04 **Independence Day Celebration**
July 11 **Timothy Anderson** & **Brandon Schurter** *"Recap of a visit to NTF"*
July 18 **Sanjay Khare** *"Building a Sustainable Energy Future"*
July 24 **Lawrence Anderson** *"Perception of Vision"*
July 25 **Reva Williams** *"Astrophysical Black Holes and How Energy is Extracted"*
July 29 **Student Final Presentations**

July 30 **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 UGR2980 course mentioned below, OUR-UT worked with the Office of Residence Life in creating a common "Living/Researching" community for all students conducting research in the summer and living on campus. Additional university procedures were facilitated in the background by OUR-UT.

We also required our students to attend a second, university-wide seminar series that formed the basis of the course, UGR2980: "*Issues in Research and Scholarship*". This course was coordinated by the Office of Undergraduate Research. 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 listed below. Each presentation lasted about an hour and there was ample time for Questions/Answers for each speaker. We actively promoted the importance of this course at the REU Orientation at the beginning of summer however from the evaluations, some REU students appeared not to think it was relevant to them in physics. This coming year, we plan to go a step further by providing (with discussions) the book, "Plastic Fantastic: How the Biggest Fraud in Physics Shook the Scientific World" by Eugenie Samuel Reich to the students to illustrate that, unfortunately, physics is not immune to human failings.

UGR2980 Issues in Research and Scholarship
Summer Semester III, 2013

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Class Meetings: Thursdays, 9am-10am (6/6 – 7/25)
Location: Sullivan Hall (SL), Rooms 3050-3060-3070
Contact Person:
Thomas Kvale Office: MH4023 Phone: x2980 Email: tkvale@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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UGR2980: Issues in Research and Scholarship
(Summer Semester III, 2013)
Topics and Speakers

Class Meetings: Thursdays, 9am-10am (6/3 – 8/5)
Location: Sullivan Hall (SL), Rooms 3050-3060-3070
All presentations are scheduled for Thursdays, Third Floor of Sullivan Hall.

May 30	Welcome	Lakeesha Ransom, Jesup Scott Honors College
	Summer Schedule & Procedures	Thomas Kvale, Office of Undergraduate Research
	Laboratory Safety	Heather Lorenz, Office of Safety & Health
	Pizza Lunch	

June 06	Research Ethics and Compliance	Walter Edinger, Office of Research
June 13	Adv. Research in the Library	Wade Lee, University Libraries
June 20	Math in Acad. & Ind. Research	David Corliss, Ford Motor Company
June 27	Plagiarism and Acad. Honesty	Barbara Schneider, Director, UT Writing Center
July 04	Independence Day Holiday	No presentation
July 11	Ethics in Academia & Research	Jamie Teeple, Grad Assistant, OUR-UT
July 18	Business Prospects and Patents	Mark Fox, Office of Research Lakeesha Ransom, Jesup Scott Honors College
July 25	Summer Recap & Summation	Thomas Kvale, Office of Undergraduate Research Jamie Teeple, Graduate Assistant, OUR-UT

July 31 Summer Research Presentations (Sullivan Hall):

- 9:00am - 9:30am Oral and Poster Presentation Set-up
- 9:30am - 11:30am Oral Session 1
- 11:30am - 12:00n Poster Session 1
- 12:00n - 12:15pm Welcoming Remarks
- 12:15pm - 1:00pm Pizza Lunch and Poster Session 2
- 1:00pm - 3:00pm Oral Session 2

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.

Physics and Astronomy Summer Workshop 2013

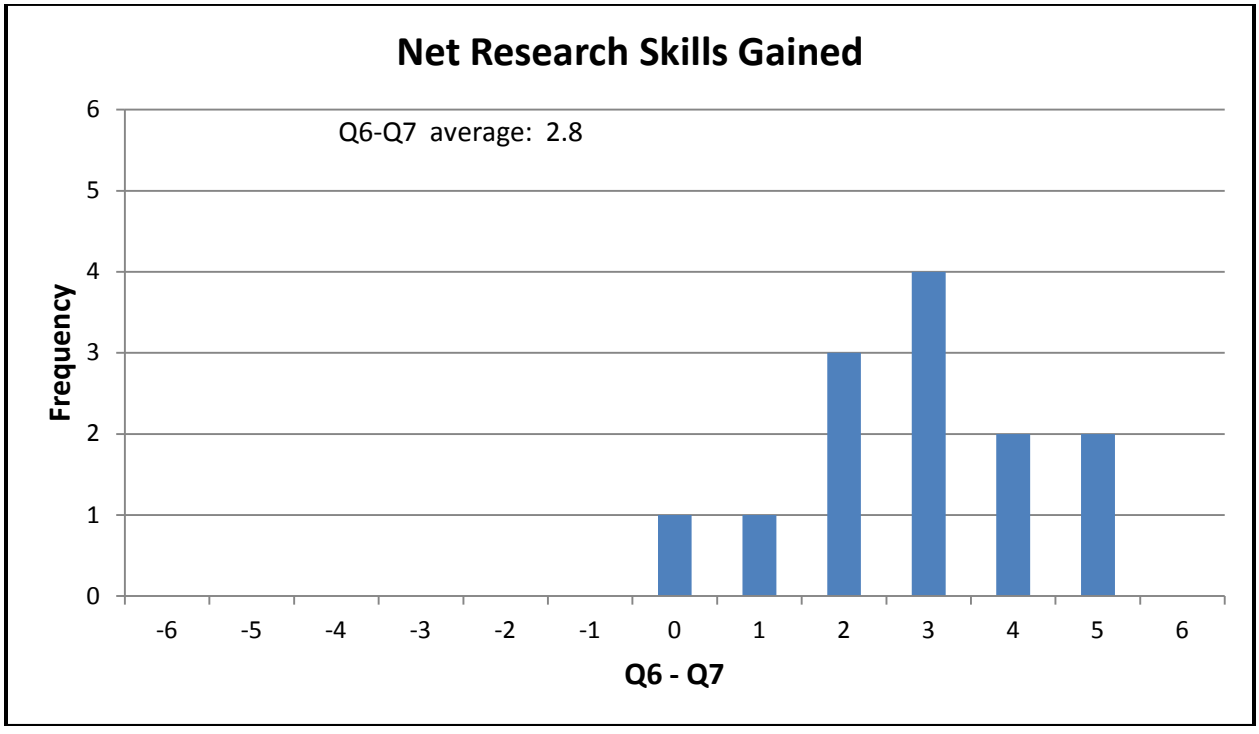
As part of our NSF program, the REU students helped host a Physics and Astronomy outreach. This year we decided to experiment with a workshop format. The outreach activity aimed to teach aspects of how to sense and control the physical world (physical computing), utilizing a Raspberry Pi while highlighting the science behind it. The idea was to should how easy, cheap and fun it is to interact with the outside world. Further, the hope is people would see the endless possibilities sparking their desire for further exploration beyond the workshop with the hope that at least some of the participants would embark in a career in experimental physics!

As in previous years, Jackie Kane (high school teacher at St. Ursula), was still instrumental in helping bring the event to fruition. Twelve of her science students participated in the workshop which took place on Saturday, July 20 from 9:00 am - 12:00 pm. One particular goal of the workshop was to setup a Raspberry Pi

and circuitry to measure and record the lab room's temperature. Several of the REU's helped setup and test the equipment for the activity. During the event REUs helped the high schools students with the hands-on lab. Students worked in pairs on their own Raspberry Pi and associated electronics, The group was exposed to many concepts on their exploration to include a little python programming on Pi to interface temperature sensor, electronics, and the physics associated with the temperature sensor. Naturally the students were offered refreshments throughout the event of which included raspberry juice, raspberries, raspberry cream cheese on bagels, and last but not least: raspberry pie!

Program Evaluation Summary

Every year we have had the students fill out a Summer Research Evaluation survey. We have two related questions to see how they view the value of the research experience. The questions are: Q6. "How skilled in the tools/techniques/methods of inquiry in the profession of the research project did you start with at the beginning of the summer?" and Q7 similar except for "... at the end of summer?". The numerical choices ranged from 1 to 7 with 1-"Very skilled/knowledgeable", 4-"Neutral", and 7-"Not Very skilled/knowledgeable". By subtracting Question 6 from Question 7, the students reported their net research skills gained from participation in our program last summer. The graph below shows their assessment that they have grown in the field. The full evaluation is included later in this report.



NSF-REU External Publications and Presentations (REU students' names in **bold face type** with year of participation.)

Refereed Publications

A.J. Porras (2012), S.R. Federman, D.E. Welty, and A.M. Ritchey, "*OH^+ in Diffuse Molecular Clouds*," The Astrophysical Journal Letters, 781:L8, (2014).

W.J. Fischer, S.T. Megeath, J.J. Tobin, L. Hartmann, A.M. Stutz, **M. Kounkel (2011, 2012)**, C.A. Poteet, B. Ali, M. Osorio, P. Manoj, I. Remming, T. Stanke, and D.M. Watson, "*HOPS 136: An Edge-On Orion Protostar Near the End of Envelope Infall,*" Astrophysical Journal, 781, 123 (2014).

Y. Shim, **N.B. Callahan (2011)**, and J.G. Amar, "*Localized saddle-point search and application to temperature-accelerated dynamics,*" Journal of Chemical Physics, 138, 094101 (2013).

Conference Presentations

S.R. Federman, **A.J. Porras (2012)**, D.E. Welty, A.M. Ritchey, "*OH^+ in Diffuse Molecular Clouds,*" 222nd Meeting A.A.S., 216.04 (2013).

Brandon Schurter (2013), Tom Kvale, Rick Irving, Erik Mckee, and Tim Darling, "*Equivalent Dosage from Neutron Radiation Produced by Deuterium-Palladium Plasma in the NTF Zebra Chamber,*" Poster 44, Kentucky Academy of Sciences Annual Meeting, Morehead State University, Morehead, KY, November 8-9, 2013.

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 10-20 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 many of our REU students are authors on manuscripts that have been published, submitted, or are in preparation.

We are very excited about this coming summer and beyond. Summer 2013 was the first year of our collaborative agreements with a national research facility where two of our students (accompanied by Co-PI Kvale) conducted their research at the Nevada Terawatt Facility (NTF) at the University of Nevada, Reno (UNR). This collaboration increases the numbers of our students conducting research in plasma physics by involving experts in high temperature plasma physics serving as the students' co-mentors (with PI Irving and Co-PI Kvale serving as the students' co-mentors at Toledo). This collaboration is made possible through the long-standing collaboration that we, individually, have had with researchers at UNR. This arrangement worked well and we plan on continuing it. Finally, the University of Toledo has a national reputation of having an excellent medical school and our department (Physics and Astronomy) has a close collaboration in medical physics with the Medical Physics department on the Health Science Campus. This collaboration has provided enhanced opportunities for our REU students to select projects in radiation detector physics and researching the physics of living systems. We expect continued research in these areas most summers.

III. DEMOGRAPHICS

NSF-REU SUMMER 2013 APPLICATIONS

Geographical distribution by undergraduate institution

(Applications REU - 146 / REU Offers Made- 20 / REU Accepted- 12)

ALABAMA

Alabama A&M University	(1/0/0)

ARIZONA

Northern Arizona University	(2/0/0)

CALIFORNIA

Azusa Pacific University	(1/0/0)
Univ. Cali, Santa Barbra	(1/0/0)
Univ of California, Merced	(1/0/0)
College of the Sequoias	(1/0/0)
Las Positas Collage	(1/0/0)
Univ. of California Santa Cruz	(1/0/0)
Wright State University	(1/0/0)
Whitworth University	(1/0/0)
University of Redlands	(2/0/0)
St. Mary's College California	(1/0/0)
Harvey Mudd College	(1/1/1)
Univ. of CA, Berkeley	(1/0/0)

COLORADO

University of Colorado	(1/0/0)

FLORIDA

Florida State University	(1/0/0)
University of North Florida	(1/0/0)
Univ. Central Florida	(1/0/0)
Duke University	(1/0/0)
Florida Institute of Tech.	(1/0/0)
University of Florida	(2/0/0)
Florida Atlantic University	(1/0/0)

HAWAII

University of Hawai'i-Hilo	(1/0/0)

ILLINOIS

University of Chicago	(2/0/0)
Northern Illinois Univ.	(1/0/0)
Illinois Valley Community College	(1/0/0)

INDIANA

Valparaiso University	(1/0/0)
Manchester University	(1/0/0)
Rose-Hulman Institute Tech	(1/0/0)
DePauw University	(1/0/0)
Wabash College	(1/0/0)
Purdue University	(1/0/0)

IOWA

University of Iowa	(1/0/0)
Drake University	(1/0/0)

KENTUCKY

Berea College	(2/1/1)
Thomas More College	(1/1/0)
Murray State University	(1/1/1)
Univ. of Kentucky	(1/0/0)

MARYLAND

Univ. of MD, College Park	(1/0/0)

MASSACHUSETTS

Colby College	(1/0/0)
Harvard University	(1/0/0)
Bates College	(1/0/0)
Williams College	(1/0/0)

MICHIGAN

Kalamazoo College	(1/0/0)
Univ. of Michigan – Flint	(1/0/0)
Grand Valley State Univ.	(1/0/0)
Hillsdale College	(1/0/0)
Albion College	(1/1/1)
Univ. of MI-Dearborn	(1/0/0)
Saginaw Valley State Univ.	(1/0/0)
Adrian College	(1/0/0)
Kalamazoo College	(1/0/0)

MINNESOTA

Hamline University	(1/0/0)
Minnesota State Mankato	(1/1/1)
St Cloud State University	(1/0/0)
New Mexico State University	(1/0/0)
Univ. of Minnesota-Twin Cities	(2/0/0)
Univ. Minnesota, Morris	(1/0/0)
Macalester College	(1/0/0)
Gustavus Adolphus College	(1/1/1)
Concordia College	(1/0/0)
Minnesota State University	(1/1/1)
St. John's University	(1/0/0)
Minnesota State Univ. Moorhead	(1/0/0)
Gustavus Adolphus College	(1/0/0)
St. Olaf College	(1/1/0)
Macalester College	(1/0/0)

MISSISSIPPI

University of Mississippi	(1/0/0)

MISSOURI

Pittsburg State University	(1/0/0)
Lincoln University of Missouri	(1/0/0)
Washington Univ. in St. Louis	(1/0/0)
Missouri State University	(1/0/0)

MONTANA

The University of Montana	(2/0/0)

NEBRASKA

University of Nebraska-Lincoln	(1/0/0)

NEW JERSEY

The College of New Jersey	(1/1/0)
Villanova University	(1/0/0)
Lehigh University	(1/0/0)
University of Pennsylvania	(1/0/0)

NEW MEXICO

St. John's College	(1/1/0)

NEW YORK

Columbia University	(1/0/0)
Clarkson University	(2/0/0)
Rensselaer Polytech. Institute	(1/0/0)
Cornell University	(1/0/0)
Binghamton University	(1/0/0)
City College of NY (CCNY)	(1/0/0)
St. John's University	(1/0/0)
New York Univ.	(1/0/0)
Univ. of the Sciences	(1/0/0)

NORTH CAROLINA

Univ. of NC, Chapel Hill	(2/0/0)

OHIO

University of Toledo	(8/5/3)
Morehead State University	(1/0/0)
Goshen College	(1/0/0)
Terra Comm. College	(1/0/0)
Case Western Reserve Univ.	(1/0/0)
University of Cincinnati	(1/0/0)
Baldwin Wallace University	(1/1/0)
Univ. of Akron	(1/0/0)
The College of Wooster	(1/0/0)
Bowling Green State Univ.	(1/1/1)
Marietta College	(1/0/0)
The Ohio State University	(1/0/0)

OREGON

Whitman College	(1/0/0)
Reed College	(1/0/0)
Linfield College	(1/0/0)

PENNSYLVANIA

Shippensburg University	(2/0/0)
Clarion University of PA	(1/0/0)
Penn. State Univ.	(2/0/0)
Villanova University	(1/0/0)
Westminster College	(1/0/0)
Clarion University of PA	(1/0/0)

PUERTO RICO

Univ. of Puerto Rico, Humacao (4//0/0)

SOUTH CAROLINA

Univ. of SC, Honors College (1/0/0)

TENNESSEE

Austin Peay State University (1/1/0)

TEXAS
Houston Baptist University (1/0/0)
University of Texas, Austin (1/0/0)

VIRGINIA
Old Dominion University (1/0/0)
Mary Baldwin College (1/1/1)
Hampden-Sydney College (1/0/0)

WASHINGTON
Whitman College (1/0/0)

WEST VIRGINIA
West Virginia Wesleyan College (1/0/0)

WISCONSIN
Bard College Simon's Rock (1/0/0)
Univ. Wisconsin Steven Point (1/0/0)
University of Wisconsin, Madison (1/0/0)
Univ. of Wisconsin, River Falls (1/0/0)
UW-Eau Claire (1/0/0)

NSF-REU Participant* Demographics

Summer 2013

Gender
Female: 5
Male: 7

Class Rank (As of Spring semester 2013)
Freshman: 0
Sophomore: 7
Junior: 5
Senior: 0

Ethnicity
American Indian: 0
Alaskan Native: 0
Asian American: 1
(or Pacific Islands)
African American: 0
Hispanic American: 0
European American: …… 11
Other:

Home State
California ….....…… 1
Kentucky…….....…… 2
Michigan 1
Minnesota 3
Ohio 4
Virginia ….....…… 1

Home Institution
Berea College ……..... 1
Minnesota State. Mankato
(Itasca Community College) 1
Univ. of Toledo…. .....… 3
Mary Baldwin College..... 1
Harvey Mudd College..... 1
Gustavus Adolphus College..... 1
Minnesota State University
(Itasca Community College) 1
Murray State Univ. 1
BGSU..... 1
Albion College..... 1

REU Students Grade Point Average: 3.7

IV. RESEARCH

REU 2013 Final Presentations
Each talk is scheduled for 12 minutes allowing 3 additional minutes for questions.

Monday, July 29th		**Room: MH 4009**
12:00	**Nathan Ross**	*Calculating transition probabilities for configurations of interest for Pb II using the new grasp2K relativistic atomic structure package* (D. Ellis/ R. Irving)
12:15	**Luke Kwiatkowski**	*A Review of Elementary Manifold Theory and Differential Geometry; Null Geodesics in Schwarzchild Spacetime* (Mao-Pei Tsui)
12:30	**Rebekah Thomas**	*Numerical Modeling the degradation of thin film photovoltaics* (V. Karpov)
12:45	**Jennifer Jin**	*Modeling and Simulating Gold Nanoparticle Interactions on a Liquid-Air Interface* (J. Amar)
1:00	**Elise Mesenbring**	*Optical Emission Spectroscopy to Study Plasma Chemistry* (N. Podraza)
1:15	**Kody Kamunen**	*Atmospheric Extinction for Ritter Observatory* (J. Bjorkman)
1:30	**Andrew Yandow**	*Development of Zinc Phosphide Films for Solar Cells* (Yanfa Yan)

Tuesday, July 30th		**Room: MH 4009**
12:00	**Brandon Schurter**	*Effective Dosage from Neutron Radiation in NTF's Zebra Bay* (T. Kvale/T. Darling)
12:15	**Timothy Anderson**	*X-Ray Film Analysis of X-pinch Plasmas* (T. Kvale/T. Darling)
12:30	**Demi St. John**	*Interstellar Dust Cloud Barnard 207* (A. Witt)
12:45	**Malinda Bender**	*Analysis of CH and CH+ in Diffuse Interstellar Clouds* (S. Federman)
1:00	**Anna Barnes**	*Optical Emission Spectroscopy to Study the Chemistry of Plasma Enhanced Chemical Vapor Deposition* (N. Podraza)
1:15	**Abril Galang**	*Characterization of Carbon Single Wall Nanotube-Hydrogenase Nanobiohybrid Films for Hydrogen Production* (M. Heben)
1:30	**Adam Wierville**	*Design, Installation, and Operation of a PV Array Atmospheric Monitoring Station* (R. Ellingson)

End-of-Summer Research Symposium Wednesday, July 31
Poster Session

Poster#21	**Brandon Schurter**	*Effective Dosage from Neutron Radiation in NTF's Zebra Bay* (T. Kvale & R. Irving)
Poster#22	**Anna Barnes**	*Optical Emission Spectroscopy for Low Temperature Plasma during Chemical Vapor Deposition* (N. Podraza)
Poster#26	**Kevin Kelbach**	*Oxygen in Spatter Plasma* (A. Compaan)

ABSTRACTS OF REU FINAL REPORTS
The University of Toledo, Department of Physics & Astronomy
SUMMER 2013 (Faculty Mentor on parenthesis)

Atomic, Molecular, Optical Physics

Nate Ross, *Theoretical Examination of the 1203 Å Transition in Pb II* (David Ellis and Richard Irving)

A fully relativistic method is implemented to examine the transition in Pb II seen at 1203 Å. This line represents the transition from the ground state, $6s^2 6p\ ^2P^0_{1/2}$, to the $6s6p^2\ ^2D_{3/2}$ excited state at 83,083 cm^{-1}. This excited state, however, is a mix of both the $6s6p^2\ ^2D_{3/2}$ configuration and the $6s^2 6d\ ^2D_{3/2}$ configuration. This configuration mixing has been highlighted in [1], [2] and [3]. The new GRASP2K [4] relativistic atomic structure program was used to make calculations for this transition of interest. GRASP2K is the most recent available version of a general-purpose multi-configuration Dirac-Hartree-Fock atomic structure program. Our first calculation included correlation effects between the 5d, 6s and 6p electrons and the 5f, 6d, 7s, 7p and 8s virtual orbitals, and gave a preliminary result for the A value of this line of 1.826 ns^{-1}. Further work remains to be done to add more configurations in order to achieve more reliable results.

Mathematical Physics

Luke Kwiatkowski, *Calculations of Null Geodesics in The Schwarzchild Metric* (Mao-Pei Tsui)

In this paper, I present what I have learned over the summer on the topic of general relativity. I begin with a review of elementary manifold theory and differential geometry, including transformations of contravariant and covariant vectors and tensors. I then reproduce the calculations carried out by Robert M. Wald [1] in _nding equations which describe the motion of light near a non-rotating black hole. Specifically, this is accomplished by solving the null geodesic equations in Schwarzchild spacetime. Although geodesics are the simplest geometric objects, we conclude from this work that they provide valuable insight into the geometry of 4-dimensional curved spacetime.

Jennifer Jin, *"Modeling and Simulating Gold Nanoparticle Interactions on a Liquid-Air Interface,"* (Jacques Amar)

Fully understanding the interaction of gold nanoparticles with each other on the surface of an evaporating toluene droplet is crucial for developing ways to self-assemble gold nanostructures and nanofilms. Unfortunately, the surface of an evaporating toluene droplet is a quasi-two-dimensional surface and is difficult to model. In addition, the reason behind gold nanoparticle island diffusion is not fully known. Running simulations is thus important for understanding more of the movement of gold nanoparticles and analyzing the results of physical experiments. Changing the parameters of the simulation aids in learning how different movement rates and detachment mechanisms affect the gold nanoparticle island size distribution. By calculating the Van der Waals attraction and dipole-dipole repulsion between nanoparticle islands and summing the two forces, we find an energy barrier for two nanoparticle islands to overcome before coalescing together. Adding the energy barrier to coalescence to simulations produces island size distributions that agree much better with experimental island size

distributions, suggesting that gold nanoparticles suspended on the surface of an evaporating toluene droplet experience both attraction and repulsion.

Plasma Physics

Kevin Kelbach, *Optical Emission Spectroscopy (OES) used in relating atomic oxygen emission and ZnO:Al conductivity in RF sputtering* (Al Compaan)

The topic of interest is the optical emission lines of oxygen found in a sputtering plasma. Oxygen emission lines are examined at different pressures, flow rates, and powers using optical emission spectroscopy (OES). The goal is to find a relationship between the intensity of the oxygen peaks and the flow rate of the argon gas used in a sputter chamber.

Elise Mesenbring, *Optical Emission Spectroscopy of RF Magnetron Sputtered Zinc Oxide Thin Films* (Yanfa Yan)

Low temperature plasma was studied using optical emission spectroscopy (OES) during the deposition of zinc oxide (ZnO) films by rf magnetron sputtering. The emission spectra was analyzed to identify the zinc and argon peaks in the plasma and to determine how the intensities of these peaks changed as a function of zinc oxide target power. The peaks in the emission spectra correspond to those found in literature. These peak intensities lowered when target power was initially lowered from normal deposition parameters, but not all peaks decreased equally. Further research will be done to identify how the intensities of these peaks relate to the concentration of chemical species in the plasma and the impact of plasma characteristics on ZnO film properties.

Anna Barnes, *Optical Emission Spectroscopy to Study the Chemistry of Plasma Enhanced Chemical Vapor Deposition* (Nikolas Podraza)

Low temperature plasma was studied using optical emission spectroscopy (OES) during the production of solar cells through plasma enhanced chemical vapor deposition (PECVD) of hydrogenated amorphous silicon. This data was analyzed in order to determine how the chemistry of the plasma reacted to different deposition parameters and whether there was a change during the deposition of a single layer (p-, i-, or n-layer). A collection of the spectral data acquired shows that the plasma chemistry changes significantly for different deposition parameters including the plasma power density and gas mixture. The plasma is also probably changing during a deposition of a single layer. Further research will determine which deposition parameters are ideal for an efficient solar cell.

Timothy Anderson, *X-Ray Film Analysis of X-Pinch Plasmas* (Thomas Kvale and Rick Irving (Toledo), and Erik Mckee and Timothy Darling (NTF))

Image J is used to analyze a series of X-Ray films from three separate Zebra shots from the Nevada terawatt facility. The shots were x pinch plasma shots and it is hoped that by analyzing the luminosity densities of the plasma x-ray certain characteristics of x pinch generated plasma can be observed. This data can also be used to experimentally determine filter values used at the different pinholes on the camera.
Collaborative research project conducted at The University of Toledo and Nevada Terawatt Facility at The University of Nevada, Reno.

Brandon Schurter, *Equivalent Dosage from Neutron Radiation Produced by Deuterium-Palladium Plasma in the NTF Zebra Chamber* (Thomas Kvale and Rick Irving (Toledo), and Erik Mckee and Timothy Darling (NTF))

In this project, the radiation shielding for the console and safety rooms in the NTF (Nevada Terawatt Facility) Zebra bay was tested against neutron radiation by computer simulation. The radiation flux through a person in the console and safety rooms was simulated using MCNP (Monte Carlo N-Particle simulation). The results were then analyzed using the flux-to-dose-rate conversion standards established by the American Nuclear Society. The calculated dosage received by the simulated person was compared to national standards for equivalent radiation dosage to determine if the console and safety rooms for the Zebra bay were safe from neutron radiation.

Collaborative research project conducted at The University of Toledo and Nevada Terawatt Facility at The University of Nevada, Reno.

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Astrophysics

Kody Kamunen, *Atmospheric Extinction for Ritter Observatory* (Jon Bjorkman)

We measured the atmospheric extinction at Ritter Observatory using the half-wave spectro-polarimeter (HPOL). We observed the flux standard Alpha 2 CVN on the nights of May 2nd, June 19th, and June 20th, 2013 at air masses ranging from 1.004 to 2.704. We determined the extinction coefficients using the standard technique of plotting the monochromatic brightness vs. air mass for each wavelength channel of HPOL. We found that the extinction in the red on the night of May 2nd was anonymously large and roughly constant with wavelength (3000-10500nm) possibly owing to the larger amount of pollen in the atmosphere that night. The extinction on the 19th and 20th of June were consistent with each other. As such, we combined the data gathered on those two nights for a finalized extinction curve. The results are consistent with typical extinction curves and slightly larger extinction values from when the HPOL unit was at the Pine Bluff Observatory (PBO) in Wisconsin.

Demi St. John, *Single Forming Star in LDN 1489, Not the Prototype You've Always Expected* (Adolf Witt)

I used optical data obtained from the Discovery Channel Telescope by Aditya Togi in February 2013 to analyze the interstellar dust cloud Barnard 207, also known as LDN1489. Barnard 207 is particularly interesting because there is currently a star forming ~10,000 AU to the west of the dense core. This research was to study Barnard 207 through 3 different methods in order to determine extinction. The methods carried out included surface brightness photometry, stellar BVRI photometry, and star counts. Extinction values of ~32 and ~38 magnitudes for V and B bands respectively were determined. Additionally, a density on the order of 10^5 cm^{-3}was determined for B207 with a mass of ~3.5$M_\odot$ for the core. We found evidence for grain growth from measurements of the dust albedo in B, V, R, I and from the detection of coreshine at 3.3 micron. Such grain growth suggests a minimum age for Barnard

207 of ~ 10^6 years. Finally we were able to show a correlation between surface brightness and optical depth.

Condensed Matter Physics

Rebekah Thomas, *Numerical Modeling of degradation of thin film solar cells* (Victor Karpov)

Thin film photovoltaics (TFPV) has evolved into a highly competitive technology. Given its simpler manufacturing processes, and growing market share, the success of TFPV will boost solar energy production. However, this will only be realized if the remaining problem of degradation under light and bias can be solved. As the unique attributes of TFPV became more evident, some degradation mechanisms related to the underlying physics have been proposed mostly at a qualitative level. That effort, however, remained peripheral to the major effort of maximizing TFPV efficiency, and hampered, in addition, by the proprietary nature of the relevant information. In many cases, TFPV efficiency and reliability have been thought of as inversely proportional: the higher efficiency, the shorter the lifetime. While true for a-Si based PV, its degradation rates can be slowed at the expense of efficiency by 'presoaking', this concept has never been proven for other types of TFPV. From a monetary standpoint, efficiency and reliability appear to be complementary. For example, integrating the temporal efficiency decay $\eta(t) = \eta_0 F(t/\tau)$ over time, where F is an arbitrary function, yields the total energy collected by device, $E \propto \eta_0 \tau$ equally dependent on initial efficiency and degradation time τ. More complex kinetics can put even stronger weight on the degradation factor. Therefore, understanding the reliability of TFPV is practically important and requires insight into its physics. For this project, we developed a numerical model of laterally uniform degradation in CdTe based thin film photovoltaics. This brand of TFPV is currently leading industry. It was developed mostly by First Solar LLC with significant contributions from NREL, University of Toledo, and several other teams.

Andrew J Yandow, *Development of Zinc Phosphide Films for Use in Solar Cells* (Yanfa Yan)

The effect of hydrogen plasma treatments on the electrical properties of zinc phosphide (Zn3P2) thin films was tested. The plasma treatments were executed with a power of 10 W, a plasma chamber pressure of 1.5 Torr, and time lengths of 5, 10, and 25 minutes. For all treatments, a significant degradation of the film carrier density and mobility were observed, along with a sharp increase in the film resistivity. SEM imaging showed that the plasma treatments destroyed the crystal structure, rendering the surface amorphous. Attempts to recrystalize the surface by annealing in a helium ambient atmosphere with a pressure of 15 Torr and a temperature of 400^{o}C for 8 hours repaired some of the damage done by the plasma treatments, but did not have significantly improved carrier density than an untreated film.

V. STUDENT PROGRAM EVALUATION

NSF-REU Physics and Astronomy
2013

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

2013 mean (pop. 13): 2.5

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

2013 mean (pop. 13): 2.5

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

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

2013 mean (pop. 13): 2.2

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

2013 mean (pop. 13): 2.1

5. How do you rate the level of your research 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

2013 mean (pop. 13): 3.7

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

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

2013 mean (pop. 13): 5.7

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

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

2013 mean (pop. 13): 2.8

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

2013 mean (pop. 13): 4.1

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

2013 mean (pop. 13): 2.2

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

2013 mean (pop. 13): 3.9

11. How do you rate the Physics/Astronomy Bag Lunches and the UGR2980 seminar presentations?

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

2013 mean (pop. 13): 2.9

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

2013 mean (pop. 13): 2.5

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

2013 mean (pop. 13): 4.1

one comment: I was not really involved in the group activities.

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

2013 mean (pop. 13): 1.5

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

2013 mean (pop. 13): 4.5

Critical Reflection Questions

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

- Needed money/resume building
- To stem the ebb of memory over the summer, and earn some extra money
- To take place in an individual research project. Before I was always an assistant
- To gain more knowledge in what it would be like to be a researcher
- To gauge my interest in research as a career and to gain more skills
- I choose to come to UToledo because the grant for research at my home institution did not make it out of review (we got it later in the summer for next year). I choose UToledo over other REU programs because it has a strong section of experimental projects.
- I know undergraduate research can be very helpful later in my career, so I wanted to get started with that experience.
- To feel like I did something useful over the summer, to learn more, to experience science research
- I wanted to pursue research for my career and I knew I needed experience in order to do it in the future
- I hope to research one day. This experience helped me
- Get experience in research
- To learn if I'm interested in research as a future
- To give research a shot

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

- None
- Knowledge of software, general physics
- Knowledge I gained from previous research experiences
- Experience-working in a lab
- All prior atomic courses, labs, etc.
- Quantum mechanics, a few past lab courses, and my science courses were useful in my projects
- The things I found most helpful were three of my previous physics courses! EM theory, modern and general physics II w/calculus.
- Material science course reading PC world magazine
- I had some helpful classes previously, but not much
- Quantum physics
- Circuits and solar classes
- Chemistry/physics, past summer experiences
- Excel

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

- A Biophysics course or electrochemistry course
- Course work- solid state would have been helpful, E&M too
- Quantum mechanics course
- I had never previously taken sand state physics, but I learned some this summer
- More knowledge of Thermodynamics would have been helpful
- Computer science classes, multivariable calculus, and differential equations (to a lower extent)
- Computer programming
- I definitely needed more courses, but I can't change how far along in school I am. I wasn't sinking from lack of knowledge, but it would have been helpful.
- Programming
- Being an astronomer

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

- Adjustment of mathematical models
- Basic electrochemistry
- More info/better understanding of semiconductors
- How to run GRASP2K
- Plasma treatments are not good for films
- What I learned about radiation was new for me, but not new in general
- Computer programming
- Our object had never been studied before so we were able to determine physical properties that no one had before.
- Plasma physics
- Programming and circuitry
- OES peaks

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

- Astronomical methods of measurement
- Atomic force microscopy
- Connections, New software
- Specifics of GRASP2k
- I learned a lot about deposing thin films. I also stumbled on a useful peak firing that I may be able to use in my research next year
- I learned quite a bit about high energy physics and about potential careers in health physics
- Supercomputing
- We were able to connect up and coming topics, such as Coreshine, to our Cloud and

reach out to fellow astronomers in other fields.

- Analysis methods
- Atmospheric data affecting solar power
- Using the new spectrometer
- Python

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

- It won't
- Hydrogen gas production
- Better understanding of CdTe systems/PVs
- Help astronomers with measurements for line strengths
- This project may be useful for the development of solar cells
- My research project may help to keep some people studying high-energy physics safe
- Probably not much society could be useful for s small number of scientist in the field
- It will impact the professional community greatly. Will kick start research as to why stars form and not in the center?
- It could help to make more efficient solar cells
- Be able to correlate weather conditions to solar power generated
- Now UT knows how to use the new machine
- N/A

Please list any additional comments.

- Rick and Dave were both awesome. I wish it was for more then 10 weeks
- For next year's program, please try your hardest to give details and descriptions of your projects and the program. I had absolutely no idea of what I would be doing before I came here, what I would expect for housing, and the area around campus. When I called the department to ask questions, I got no answer. Also, there were a lot of other students on campus doing research but we hardly ever saw them. You might want to consider housing REU students with the other research groups so we aren't alone in I-house.
- This opportunity allowed me to see how I could fit into a graduate program in the future. Also, it made me really excited about research and confirmed I 'm on the right path
- Rick Irving is an amazing human being and wonderful at everything he does for the REU program and students. He is perfect for his job and makes the entire experience so much better for all the students.

VI. PICTURE COLLAGE AND YOU-TUBE VIDEO LINK Summer 2013

A collage of the various REU activities over the summer 2013. High resolution versions of each picture are available upon request. In addition, we captured the students' REU final presentations 2013 in You-Tube movies. The link to the set of movies is: http://www.youtube.com/playlist?list=PLP3ZFN0CK6y7XRt__d8BZ1WUc6cKLaW0t. This link is private and only available directly through the link provided above. We plan to remove the link when the Annual Report is posted on-line on our website.