Annual Progress Report (Year 2)

Research Experiences for Undergraduates in
Physics and Astronomy

NSF-REU Grant 1262810

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 2014

REU students and mentors

REU Summer 2014 Participants

NAME	INSTITUTION	MENTOR	RESEARCH
Julianna Pfadt	University of Alabama	D. Shvydka	Medical Physics
Daniel Kondratov	NYU- Polytech. Sch. Eng.	L. Anderson-Huang	Astrophysics
Tyler Frey	University of Toledo	T. Megeath	Astrophysics
Anna Barnes	University of Toledo	N. Podraza	Plasma Physics
*Sarah Burkhart	Arizona State University	A. Witt	Astrophysics
Ace (Walter) Furman	Reed College	D. Ellis, R. Irving	Atomic Physics
Christopher Bisbee	Macalester College	V. Karpov	Condensed Matter
Travis Bean	University of Toledo	T. Kvale, R. Irving	Atomic Physics
**Brooke Paquin	University of Toledo	Y. Yan	Condensed Matter
Alexa Van Hattum	Brown University	J. Amar	Condensed Matter
Luke Meech	Itasca Community College	T. Kvale, R. Irving	Plasma Physics
Ryon Michalak	University of Toledo	M. Heben	Condensed Matter
Christopher Robinette	University of Toledo	T. Kvale, R. Irving	Plasma Physics
Andrew Polasky	Carleton College	R. Ellingson	Plasma Physics
John Burt	Itasca Community College	S. Khare	Computational Phys.

* Mainly supported by the UT Physics and Astronomy with minor funding (Travel & Housing) from REU but fully participated in the REU program.
** Supported by the UT Physics and Astronomy but fully participated in the REU program.

II. SUMMARY OF SUMMER 2014

Introduction

The Summer 2014 NSF-REU program in Physics and Astronomy, directed by Dr. Richard Irving and Professor Thomas Kvale, gave enhanced research opportunities to 13 undergraduate students from 9 colleges and universities in 6 states. Student participants were chosen competitively out of 92 applications from students in 36 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. Five 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 of our alumni REU students was interviewed on the PBS documentary, "*MAKERS: Women in Space*" about the Orion spacecraft. From this summer's participants, one presented her research at a national conference and there will be at least two more presentations at national conferences of the research from this past summer's participants. In addition, one other continued his research with the Nevada Terawatt Facility (NTF) during this academic year and we expect at least one manuscript from this past summer's (2014) participants is in preparation and will be submitted shortly to a refereed journal and/or presented at conferences.

This was the second year of collaborating with national facilities to give the students a "blended" research experience in a national research facility. Again this year, two students conducted research in high temperature plasma physics at UT and through our collaboration with 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. PI Irving and 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 2014) 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 of the student participants coming from outside of Toledo 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. We encouraged Residence Life to house all undergraduate students participating in other research programs close to the REU students.

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, sports and board games, and various ventures to local restaurants. Some of the other 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. In July, we were also fortunate to arrange a field trip to the Davis-Besse Nuclear Power Station, located 30 miles from Toledo.

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 2014 BROWN BAG SEMINARS (Noon – MH 4009)

May 27 **REU Orientation**
June 03 **Scott Lee** *"Dinosaur Locomotion"*
June 12 **David Pearson** *"Medical Physics at UTMC"*
June 17 **Dr. Alison Crocker** (guest speaker) *"The Price of Stars: Star formation efficiencies in galaxies"*
June 19 **Nikolas Podraza** *"Photovoltaics at UT"*
June 26 **REU Progress Reports**
July 04 **Independence Day Celebration**
July 10 **Gregory Warrell**. *"Medical Physics Research"*
July 15 **Lawrence Anderson** *"Perception of Vision"*
July 17 **Rajendra Khanal** *"Carbon Nanomaterials"*
July 21 **Emily Safron** *"Protostellar accretion outbursts in the Orion Molecular Cloud Complex"*
July 28 **Student Final Presentations**
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.

UGR2980: Issues in Research and Scholarship
(Summer Semester III, 2014)
Topics and Speakers
Class Meetings: Thursdays, 9am-10am (6/5 – 7/24)
Location: Wolf Hall Room 1205.

May 29 "*Meet and Greet*" – **Lakeesha Ransom**, Dean, Jesup Scott Honors College
"*Summer Schedule & Procedures*" – **Thomas Kvale**, Office of Undergrad. Research
"*Laboratory Safety*" – **Heather Lorenz**, Office of Safety & Health
Pizza Lunch

June 05 "*Research Ethics and Compliance*" – **Walter Edinger**, Office of Research

June 12 "*Advanced Research in the Library*" – **Wade Lee**, University Libraries

June 19 "*Math in Academic and Industrial Research*" – **David Corliss**, PhD Astrophysics and Ford Motor Company

June 26 "*Seelio & Recording Research*" – **Holly Stuart**, Educational Services Director, Seelio

July 03 **Independence Day Holiday -- No presentation**

July 10 "*Ethics in Research*" – **William Messer**, Vice President of Research, Univ. of Toledo

July 17 "*Business Prospects and Patents*" – **Mark Fox**, Office of Research and **Molly Reams Thompson**, Director, Office of Research & Innovation

July 24 "*Summer Overview and Summation"* – **Thomas Kvale** and **Lindsey Haubert**, Graduate Assistant, Office of Undergraduate Research

July 31 (All day) **Summer Research Presentations (Student Union SU2582-84):**

- 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 -- Margaret Traband, Senior Vice Provost for Academic Affairs**
- 12:15pm - 1:00pm **Pizza Lunch and Poster Session 2**
- 1:00pm - 3:00pm **Oral Session 2**

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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.

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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Physics and Astronomy Summer Workshop 2014

As part of commitment to the outreach aspect of our REU program, REU students participated in a workshop to help local area teachers design a Project-Based Science (PBS) lab

Figure 1. REU students and teachers who attended the workshop are pictured above.

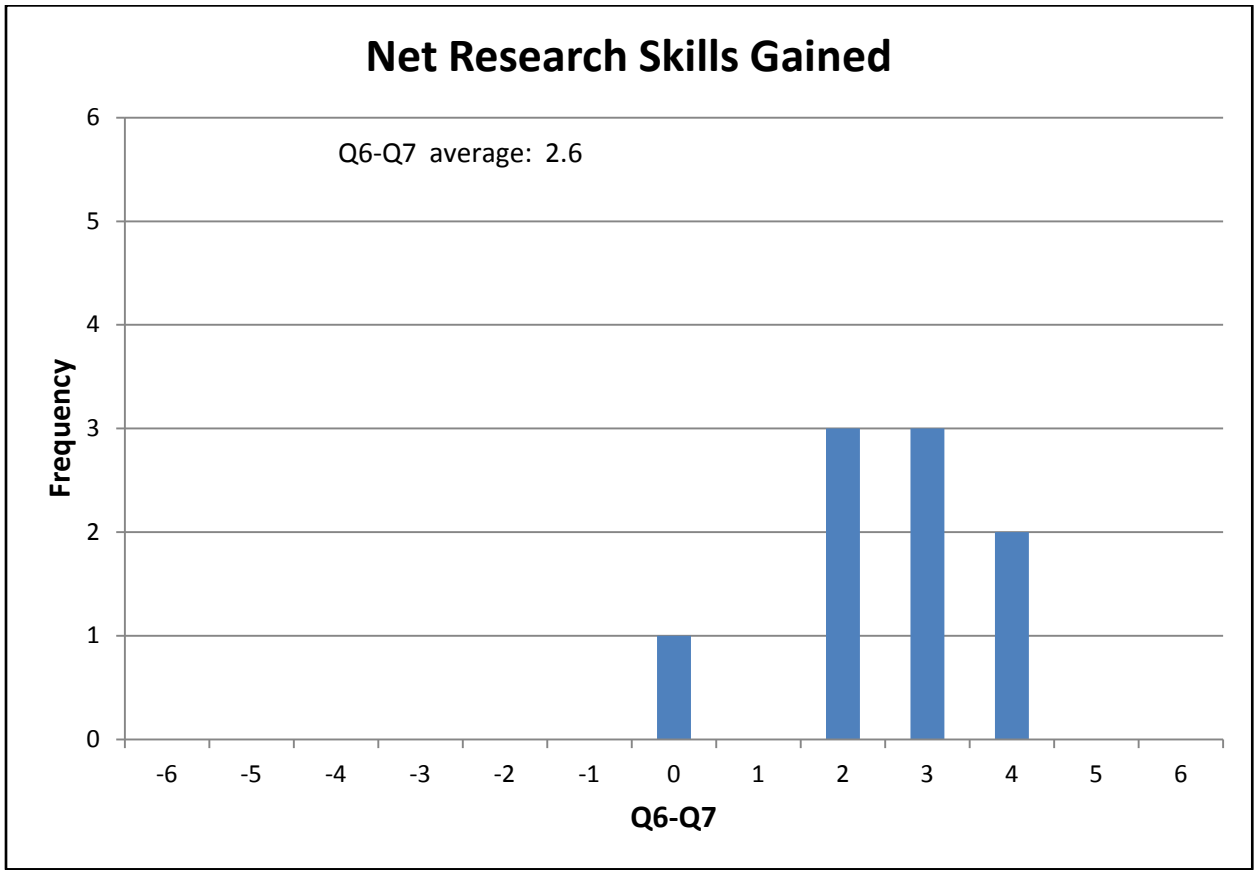
activity linked to the renewable energies. The student lead effort involved the REU students helping the teachers each construct and test dye sensitized solar cells. One of the goals for the teachers from this three hour lab session would be to implement the activity in an appropriate science course at their home institution as a hands-on learning experience for students.

The group of teachers (Great Lakes Region—K-12 school districts) were part of Leadership for Educators: Academy for Driving Economic Revitalization in Science (LEADERS) program, funded by the National Science Foundation, grant #0927996.

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

N. Heidarian, R.E. Irving, A.M. Ritchey, S.R. Federman, D.G. Ellis, S. Cheng, L.J. Curtis, **W.A. Furman (2014)**, *Lifetimes and Oscillator Strengths for Ultraviolet Transitions in Pb II*, (in preparation, anticipated journal: Astrophysical Journal)

Conference Presentations

Sarah M. Burkhart (2014) and Adolf N. Witt, – *An Investigation into PAH Destruction in Nearby Supernova Remnants, North Polar Spur and Cygnus Loop*, 225th Annual American Astronomical Society (AAS) Meeting, Seattle, WA, Abstract 256.13, p. 283 (January, 2015).

N. Heidarian, R.E. Irving, A.M. Ritchey, S.R. Federman, D.G. Ellis, S. Cheng, L.J. Curtis, **W.A. Furman (2014)**, *Lifetimes and Oscillator Strengths for Ultraviolet Transitions in Pb II*, 46th Annual DAMOP Meeting of The American Physical Society, Columbus, Ohio (June, 2015).

Adam M. Ritchey, Negar Heidarian, Richard E. Irving, Steven R.Federman, David G. Ellis, Song Cheng, Larry J. Curtis, **W. A. Furman (2014)**, *The Interstellar Abundance of Lead: Experimental Oscillator Strengths for Pb II λ1203 and λ1433 and New Detections of Pb II in the Interstellar Medium*, International Astronomical Union (IAU) General Assembly meeting, Honolulu, Hawaii (August 2015).

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. In summer 2014, we continued our collaboration with the Nevada Terawatt Facility on the campus of the University of Nevada, Reno, where two of our students (accompanied by Irving and Kvale) conducted their research in high temperature plasma physics. This collaboration permitted the students to experience contributing to a large research effort. PI Irving and Co-PI Kvale served as the students' co-mentors at Toledo and we had frequent communication with the NTF researchers through Skype and/or email exchanges. One of the students (Robinette) continued his research into the academic year and made a subsequent trip to NTF to test equipment he designed and constructed. 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 2014 APPLICATIONS

Geographical distribution by undergraduate institution

(Applications REU - 92 / REU Offers Made- 19 / REU Accepted- 13)

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

ARIZONA
Arizona State University (2/0/0)

ARKANSAS
Arkansas State University (1/0/0)

CALIFORNIA
California Polytechnic State Univ. (1/0/0)
Clark University (1/0/0)
Harvey Mudd College (1/0/0)
Univ. of CA, Berkeley (1/0/0)
University of Redlands (1/0/0)

COLORADO
Colorado Mesa University (1/0/0)
University of Colorado, Boulder (1/0/0)

FLORIDA
Florida International University (1/0/0)
Embry Riddle Aeronautical Univ. (1/0/0)
Florida University of Florida (1/0/0)

GEORGIA
Agnes Scott College (1/0/0)
Emory University (1/0/0)

IDAHO
Brigham Young University - Idaho (1/0/0)

ILLINOIS
Brown University (1/0/0)
Elmhurst College (1/0/0)
Loyola University Chicago (1/0/0)
Univ. of IL., Urbana-Champaign (1/0/0)

INDIANA
University of Notre Dame (1/0/0)
Valparaiso University (1/0/0)

IOWA
Grinnell College (1/0/0)

KENTUCKY
Berea College (1/0/0)

MARYLAND
McDaniel College (1/0/0)

MASSACHUSETTS
Brandeis University (1/0/0)

MICHIGAN
Albion College (1/0/0)
Monroe Community College (1/0/0)
Saginaw Valley State Univ. (1/0/0)

MINNESOTA
Gustavus Adolphus College (2/0/0)
Itasca Community College (2/0/0)
Macalester College (1/0/0)

MISSISSIPPI
Univ. of Southern Mississippi (1/0/0)

MISSOURI
Drury University (1/0/0)
Truman State University (1/0/0)

NEW MEXICO
New Mexico State University (1/0/0)

NEW YORK
Alfred University (1/0/0)
Columbia University (1/0/0)

Fordham University (1/0/0)
Ithaca College (1/0/0)
St. Lawrence University (1/0/0)
SUNY-Albany (1/0/0)
SUNY-Stony Brook (1/0/0)
University of Rochester (1/0/0)

NORTH CAROLINA
North Carolina State University (1/0/0)

OHIO
Bowling Green State University (1/0/0)
Cleveland State University (1/0/0)
John Carroll University (1/0/0)
Kent State University (2/0/0)
Oberlin College (1/0/0)
The College of Wooster (1/0/0)
University of Cincinnati (1/0/0)
University of Toledo (5/0/0)
Xavier University (1/0/0)

OKLAHOMA
Southern Nazarene University (1/0/0)
Univ. of Science and Arts of Okla. (1/0/0)

OREGON
Oregon State University (1/0/0)
Reed College (4/0/0)

PENNSYLVANIA
Bryn Mawr College (1/0/0)
Carnegie Mellon University (1/0/0)
Washington and Jefferson College (1/0/0)
University of Scranton (1/0/0)
West Chester Univ. of Pennsylvania (1/0/0)

PUERTO RICO
Univ. of Puerto Rico - Rio Piedras (1/0/0)
Univ. of Puerto Rico, Mayaguez (1/0/0)

RHODE ISLAND
Brown University (1/0/0)

SOUTH CAROLINA
Bob Jones University (1/0/0)

TENNESSEE
East Tennessee State University (1/0/0)

TEXAS
University of Houston (1/0/0)
University of Texas at Dallas (1/0/0)
University of Dallas (1/0/0)

UTAH
Utah State University (1/0/0)
Weber State University (1/0/0)

VERMONT
Saint Michaels College (1/0/0)

VIRGINIA
Hampden-Sydney College (1/0/0)

WASHINGTON
University of Washington (1/0/0)
Whitman College (1/0/0)

WEST VIRGINIA
West Virginia University (1/0/0)

WISCONSIN
Univ. of Wisconsin, Parkside (1/0/0)
Univ. of Wisconsin, River Falls (1/0/0)
Univ. of Wisconsin, Whitewater (1/0/0)

NSF-REU Participant* Demographics

Summer 2014

Gender
Female: 3*
Male: 10
*In addition, 2 other women participated in our program funded by other sources.

Class Rank (As of Spring semester 2014)
Freshman: 0
Sophomore: 7
Junior: 6
Senior: 0

Ethnicity
American Indian: 0
Alaskan Native: 0
Asian American: 0
(or Pacific Islands)
African American: 0
Hispanic American: 0
European American: ….....…… 13
Other:

Home State
California ….....…… 1
Kentucky……..…… 2
Michigan 1
Minnesota 3
Ohio 5
Virginia ….....…… 1

Home Institution
Brown University ……..... 1
Carleton College ……..... 1
Itasca Community College …..... 2
Macalester College ……..... 1
NYU- Polytech. Sch. Eng. …..... 1
Reed College ……..... 1
University of Alabama ……..... 1
University of Toledo ……..... 5

Students with minor REU funding or from other sources
Arizona State University ……..... 1
University of Toledo ……..... 1

REU Students Grade Point Average: 3.3

IV. RESEARCH

REU 2014 Final Presentations
Each talk is scheduled for 12 minutes allowing 3 additional minutes for questions.

Monday, July 28th Room: MH 4009

12:00	**Julianna Pfadt**	*Monte Carlo Simulation of Ionization Chamber Energy Response Function* (D. Shvydka)
12:15	**Daniel Kondratov**	(L. Anderson-Huang) (rescheduled for Wednesday)
12:30	**Tyler Frey**	*Measuring Accretion Rates of Protoplanetary Disks Around Young Stars in Cepheus OB3b* (T. Megeath)

Tuesday, July 29th Room: MH 4009

12:00	**Anna Barnes**	*Plasma Chemistry in Solar Cell Production & Ellipsometric Spectra of LSAT* (N. Podraza)
12:15	**Sarah Burkhart**	*An Investigation into Interstellar Dust: PAHs vs Large Grains* (A. Witt)
12:30	**Ace (Walter) Furman**	*Atomic Structure of Pb II: Forbidden Transitions and ANDC* (D. Ellis, R. Irving)
12:45	**Christopher Bisbee**	*Electric Field Distributions of Cylindrical Filament ReRAM Cells* (V. Karpov)
1:00	**Travis Bean**	*Photodetachment of* Zr^- (T. Kvale, R. Irving)

Wednesday, July 30th Room: MH 4009

12:00	**Brooke Paquin**	*Zinc Phosphide Thin Films Grown by Close Space Sublimation* (Y. Yan)
12:15	**Alexa Van Hattum**	*Effects of Size-dependent Island-edge Barriers on Submonolayer Nucleation* (J. Amar)
12:30	**Luke Meech**	(T. Darling, B. Hammel, A. Covington, T. Kvale, R. Irving)
12:45	**Christopher Robinette**	(T. Darling, B. Hammel, A. Covington, T. Kvale, R. Irving)
1:00	**Andrew Polasky**	*Localized Surface Plasmon Resonance in* FeS_2 *Nanocrystals* (R. Ellingson)
1:15	**John Burt**	*Database creation for the material properties of transition metal nitrides* (S. Khare)
1:30	**Daniel Kondratov**	(L. Anderson-Huang)

ABSTRACTS OF REU FINAL REPORTS
The University of Toledo, Department of Physics & Astronomy
SUMMER 2014 (Faculty Mentor on parenthesis)

Atomic, Molecular, and Optical Physics

Travis Bean, *Characterizing the UNR Velocity Map Imaging System in the Photodetachment Experiments at the UNR-NIRF* (T. Kvale)

The Velocity Map Imaging System (VMI) has been implemented in a Laser Photodetachment Electron Spectroscopy (LPES) system to measure the electron affinities and the 3-D imaging of photoelectrons produced by photodetachment of negative ions. A weak electric field in the laser-negative ion beam interaction region directs the outgoing photoelectrons to a detector system. The intensity pattern of the image follows the relation: $I(\theta) = A(1 + \beta P_2 \cos\theta)$, where θ is the angle between the negative ion velocity vector and the photoelectron initial velocity vector, P_2 is the Legendre polynomial, and A is a constant. From the angular distribution of the image, the β parameter can be determined. The β parameter is important in that it carries with it information of the angular momentum of the photoelectron and the internal angular momentum of the negative ion and subsequent neutral atom states. Because the interaction region occupies an extended region and not just a point, the VMI system acts as a thick lens with spherical aberration. In order to obtain accurate values of β, the spherical aberration conditions need to be known so appropriate correction factors can be applied. This research involved using a numerical simulation program, SIMION, to accurately model the interaction region of the VMI system and thus obtain an understanding of the spherical aberration conditions of the VMI system.

Ace (Walter) Furman, *Measurement and Theoretical Calculation of the Radiative Meanlife of the 1433 Å Transition in Pb II* (R. Irving and D. Ellis)

The University of Toledo Heavy Ion Accelerator (THIA) was used to measure the radiative meanlife of the 1433 Å transition in lead II. Lead ions were accelerated into a carbon foil, where they excited and then de-excited, thus releasing photons. The photon intensity was measured as a function of time. After using an ANDC method to eliminate cascade effects, the mean lifetime was estimated from the experimental data to be 1.4 ± 0.1 ns. Moreover, an atomic simulation software, GRASP 2K, was used to calculate the theoretical mean life to be 1.6 ns. GRASP was also used to calculated mixing coefficients both in lead II and in other ions in its isoelectronic series to further explore the mechanisms behind these transitions.

Computational Physics

John Burt, *Community-Based Ceramics Database for High Performance Coatings* (S. Khare)

Estimates of available data in the scientific literature for structural, elastic, mechanical and electronic properties of solids related to coatings applications maybe conservatively placed in the 100,000 range. To make full use of this vast resource of computational knowledge, we have created such a platform, an open-access community-based ceramics database with an emphasis on high performance coatings. Our database handles large amounts of data with features of data selection tools and rapid search capabilities. It has active display features for generating a variety of formats of tables and graphs and has recently been beta-test/launched. Users can choose which fields to query corresponding to their computed or experimentally

measured properties of interest in a web-based user- friendly form. The resulting data can be brought in to tabular and graphic formats automatically displayed on demand to generate a visual representation of the dataset of choice. All entries are linked to the original papers on the web with full citation information through DOI or other identifiers. Participation and contribution from the coatings community is sought, encouraged and welcomed. The database is presently already populated with data from a few hundred materials and is expected to grow through the community's contributions. Being community-based, users can also be contributors, with the privilege to add/edit/delete entries from their own contributions. The names and contact information of the contributors are displayed as an appreciation for their efforts, and also as a means to enhance peer reviewing. We hope this platform can attract the community's attention, usage and contribution, and fulfill its purpose to serve as an active and essential data hub in the field of coatings science and technology.

Plasma Physics

Luke Meech and **Christopher (Alex) Robinette**, *Characterization of X-ray emission during X-Pinch Shock Testing with Copper Target* (R. Irving, T. Kvale)

The goal of this experiment is to sample high energy photon emissions to determine the characteristics of the pulse created by an X-Pinch configuration in the Zebra located at the Nevada Terawatt Facility, University of Nevada, Reno (UNR-NTF). Due to the nature of the pulse, speed and energy, little is known about the shape or energy distribution of the emitted photons. These factors also create issues when attempting to directly measure the electron beam produced. Using Kodak BioMax MS film in a variety of container geometries, to limit low energy background, we attempted to find the shape of the pulse as well as the energy distribution of the photons. This information allows for an indirect measurement of beam intensity and energy. As well as give more information for safety personnel regarding radiation precautions. During these tests x-ray scattering was examined closely for any anomalous behavior. Using this data we observed an unknown scattering event involving the scatter angle from an Al backscatter plate. This will be further tested and analyzed in a future experiment.

Collaborative research project conducted at The University of Toledo and Nevada Terawatt Facility at The University of Nevada, Reno. Dr. Timothy Darling is the senior scientist for this experiment at UNR-NTF and was a co-mentor of L.M. and C.R.

Andrew (Drew) Polasky, *Localized Surface Plasmon Resonance in FeS_2 Nanocrystals* (R. Ellingson)

FeS_2 is, in many ways, an ideal candidate for a solar cell material. It is readily available, cheap to process, and non-toxic, with a bulk band-gap energy of 0.95 eV. However, the presence of a surface plasmon resonance in the material interferes with the absorption of sunlight, effectively reducing the surface band-gap energy to an unusable level. The plasmon peak of Iron sulfide nanocrystals in solution was found to vary consistently with the dielectric constant of the solvent. Oxidation of films of the nanocrystals showed an increase in the band gap, likely due to the presence of Iron Oxides or Iron Sulphate, which have band gaps around 2 eV, and could interfere with the plasmon resonance developing.

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Astrophysics

Daniel Kondratov, *Computer Simulation of Radiation Through a Stellar Atmosphere* (L. Anderson-Huang)

The project involved modeling electromagnetic radiation in a single atomic transition through a self-consistent stellar atmosphere. The stellar atmosphere was modeled on a three dimensional grid allowing for momentum transfer forward or back in six directions. The radiation was treated at frequency intervals throughout the Doppler line width of the scattered light. These parameters formed a linear matrix representing the numerical equations. Doppler shifts due to bulk motions are expected to enhance and/or redirect the radiation pressure on the fluid, resulting in an unstable turbulent medium. Preliminary results were presented.

Tyler Frey, *Discovery Channel Telescope U, B and I-band Observations of the Cep OB3b Cluster* (T. Megeath)

Cepheus OB3b is one of the two most massive young (< 5 Myr) clusters within 1 kpc in the Sun. We analyze Discovery Channel Telescope U, B and I-band imaging of this cluster designed to measure UV excesses from young stars due to accretion. The excesses measure the rate gas is accreted onto the stars from circumstellar disks. By measuring the rate of gas accretion for stars of different ages, we can trace the time evolution of the gas disks. More specifically, the accretion rates provide an indirect measure of evolving gas surface density during the time these disks may be forming planets, and thereby provide constraints on the timescale for the formation of gas giants.

Condensed Matter Physics

Anna Barnes, *Optical Band Gap and Infrared Vibrational Modes for LSAT Single Crystal Obtained via Infrared to Ultraviolet Range Spectroscopic Ellipsometry* (N. Podraza)

$(La_{0.18}Sr_{0.82})(Al_{0.59}Ta_{0.41})O_3$ (LSAT) is a single crystal material commonly used as a substrate for epitaxial film growth. Optical properties of LSAT for the range of 0.033 to 5.887 eV were determined from spectroscopic ellipsometry measurements of the complex dielectric function, ε, and the complex index of refraction, N. The indirect band gap is determined to be 4.72 ± 0.01 eV and the lowest direct gap energy is found to be 5.70 ± 0.01 eV. Eleven transverse optical phonon infrared vibrational modes originating from tantalum oxide (Ta-O), lanthanum oxide (La-O), and aluminum oxide (Al-O) bonding in LSAT are identified over the range from 240 to 870 cm^{-1}.

Christopher Bisbee *Electric Field Distributions of Cylindrical Filament ReRAM Cells* (V. Karpov)

In order to investigate the switching characteristics of Redox Random Access Memory Cells (ReRAM) in terms of their energetic properties, I built a number of computer simulations that replicate these types of systems. Using Comsol Multiphysics software, I determined that when a fixed voltage is applied to each electrode in the electrode-filament system, we should not expect to see any should expect filament growth to occur spontaneously. I also explored the balance between establishing a fixed voltage between the electrodes quickly while still optimizing the switching time of these cells.

Alexa Van Hattum, *Effects of size-dependent island-edge barriers on submonolayer nucleation, utilizing a modified Union-Find-Delete algorithm* (J. Amar)

The effects of size-dependent island-edge barriers on submonolayer nucleation are studied via kinetic Monte Carlo simulations of a simplified model of epitaxial thin-film growth. Standard nucleation theory predicts an exponent $\chi = i/(i+2)$ (where i is the critical island size) relating the island density N at a fixed coverage q to the ratio between diffusion rate D and the deposition rate F, $N \sim (D/F)^{-\chi}$. In contrast, Attachment Limited Aggregation (ALA) assumes that a barrier to attachment to islands leads to a higher prediction of $\chi = 2i/(i+3)$. The viability of ALA as an explanation for recent experimental values of χ greater than 1 is examined. Regimes with a critical island size, i, of 1 and 3 are simulated, along with two cases of a barrier to monomer attachment. In the first case, a size-independent barrier for attachment of a diffusing monomer to another monomer or island is assumed, while in the second case, there is only a barrier for attachment to islands larger than a given size S. Our results support a previous conjecture that barriers to island attachment extend the transient regime of island nucleation. Additionally, it appears that size-dependent barriers lead to the onset of island coalescence at a lower coverage q as well as a shortened aggregation regime. However, our results do not indicate that barriers to monomer attachment increase the value of χ. In the first case, corresponding to a island-size independent monomer attachment barrier, we find that the exponent χ is seen to decrease with the inclusion of a barrier to any attachment. With a size-dependent barrier to attachment, there is no clear observed trend in the values of χ with varying S. These results do not support ALA alone as the explanation for the unusually high values of χ observed experimentally.

Ryon Michalak, *Electron Transport at Low Temperatures in Single-Walled Carbon Nanotubes* (M. Heben)

Several proposals for quantum computing devices are based on individual or thin films comprised of single-wall carbon nanotubes. In this project, single-wall carbon nanotubes were synthesized by pulsed laser vaporization, purified, and formed into thin-films by a spray deposition process. The current transport mechanisms were studied as a function of temperature using a closed-cycle helium refrigerator, customized software, and Keithley source meter. Several approaches were taken to modify the tunneling barriers between tubes in the film in an effort to create delocalized electronic states. These included evaporation of metallic species, and inclusion of organometallic compounds. In all cases, tube-tube connectivity was limited, as indicated by a thermally activated transport process.

Medical Physics

Julianna Pfadt, *"Monte Carlo Simulation of Ionization Chamber Energy Response Function"* (D. Shvydka)

Determination of photon beam spectra is often conducted through transmission measurements, which are relatively simple to implement, but fairly difficult to analyze. A recently published article describes an advanced approach to data collection and analysis for MeV photon spectra restoration, where one of the steps requires energy response functions for different build-up caps used in measurements. Calculation of such response functions is possible only through Monte Carlo (MC) simulations. My goal was to obtain the energy response function for brass build-up cap used by the Department of Radiation Oncology for transmission measurements. In order to validate my MC simulation geometry, the first step was to recreate the published response function for an ion chamber with a water-mimicking acrylic (PMMA) cap. After that was successfully accomplished, I was able to modify the input files to obtain a

response function for the brass cap; data for this material does not exist in the literature. In the course of this project I learned MCNP5, a radiation transport software package, which allowed me to create input files that include the geometry, materials, source, and tally specifications necessary to simulate 21 different energies ranging from .1 MeV to 10 MeV. I have also created input files modeling the transmission measurement geometry setup; these simulation results will be used to compare with the measured data.

Other students conducting research in Summer 2014 supported mainly by other sources

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Astrophysics

Sarah Burkhart, *An Investigation into Interstellar Dust: PAHs vs. Large Grains* (Adolf Witt)

Interstellar dust exists everywhere in the Milky Way but can be seen most easily in the galactic plane, as the dust grains absorb starlight and cause reddening and extinction. There is a wide range of sizes of dust grains, but we are focusing on PAHs (polycyclic aromatic hydrocarbon molecules), about 1 nm in linear size, and larger dust grains of about 100 nm in linear size. Our goal in conducting this research was to look at the PAH/large dust grain emission intensity ratio in different environments to see how PAHs are affected by supernova remnants, optical thickness, and variations in the UV radiation field.

Mainly supported by the UT Physics and Astronomy with minor funding (Travel & Housing) from REU but fully participated in the REU program.

Condensed Matter Physics

Brooke Paquin*, *Zinc Phosphide Thin Films Grown by Close Space Sublimation* (Y. Yan)

Zinc Phosphide (Zn_3P_2) thin films are grown by close-spaced sublimation and fabricated into Mg Schottky Diodes. Zinc Phosphide of varying thickness (6-10μm) is grown on silver coated Soda Lime glass. A thin layer of thermally deposited Mg is then added to aid in the junction, followed by a thick top contact of Mg. Devices were then annealed. JV displayed a profound amount of shunting and no photo reactive behavior possibly due to undesired doping of Na from Soda Lime glass or MgO from the surface of the device. Doping of Na using thermally deposited NaF as well as Bromine etches are used to test these possible contributing issues to making a working Zinc Phosphide device. Results concluded that these are not the key issues causing shunting and further investigation is needed.

*Supported by the UT Physics and Astronomy but fully participated in the REU program.

V. STUDENT PROGRAM EVALUATION

NSF-REU Physics and Astronomy
2014

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

2014 mean (9 responses/pop. 14): 2.0

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

2014 mean (9 responses/pop. 14): 2.0

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

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

2014 mean (9 responses/pop. 14): 2.3

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

2014 mean (9 responses/pop. 14): 1.8

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

2014 mean (9 responses/pop. 14): 2.9

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

2014 mean (9 responses/pop. 14): 5.0

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

2014 mean (9 responses/pop. 14): 2.4

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

2014 mean (9 responses/pop. 14): 4.8

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

2014 mean (9 responses/pop. 14): 2.6

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

2014 mean (9 responses/pop. 14): 3.6

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

2014 mean (8 responses/pop. 14): 3.4

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

2014 mean (8 responses/pop. 14): 2.9

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

2014 mean (8 responses/pop. 14): 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

2014 mean (8 responses/pop. 14): 1.8

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

2014 mean (8 responses/pop. 14): 3.9

Critical Reflection Questions/Comments

From 2014 REU Summer Program

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

- Looks good on a resume and a good learning opportunity
- Interest in the topic to get an idea what a career in research would be like
- Prepare for graduate school
- I am interested in doing research generally and spoke to my mother about another interesting project.
- Experience, personal interest
- Because I have never done any research on this kind of level, have only done things for a class.
- To continue my research during the summer
- I wanted to continue the research I had been doing over fall and spring semesters

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

- My research this summer was a continuation of what I had been doing, so my prior knowledge of how to work with the programs and equipment was useful.
- Experiences I've had in the last year of research really gave me a jump start to my summer work.
- Material Science
- Programming skills, modern physics class
- Atomic and nuclear physics was helpful at times but other than that I didn't know much about this topic coming into the project.
- Previous research experience, Physics I, II, III
- Computer science classes, a little physics and chemistry knowledge
- Coding knowledge

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

- More knowledge of chemistry, language experience
- Astronomy
- It would have helped to have taken more chemistry courses
- More prior communication with mentors
- Plasma Physics, my degree doesn't require this but it would have been helpful
- I do have some gaps of general PV knowledge that would have really helped
- Optics class (taking next fall)

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

- How to work with power tools (i.e. to cut metal)
- JV Curve data was a big one
- I learned a lot of new things that are extremely interesting, but the one that I can use is in seeing the importance of providing a positive working environment that I experienced during the research
- The use of specific simulation programs
- I learned a great deal about plasmon effects in metals and semi-conductors
- About parts and their importance In the ISM
- I learned KMC simulations w/code knowledge; behavior of X w/barriers
- Web knowledge, dxdoi.ord

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

- Union – find-delete as approved to island counting
- Learned fun tolls in DS9, data analysis
- A variety of lab techniques
- Mathematical methods for equation manipulation
- Some really nice people make the day better
- New characterizations methods and abstract ideas
- Met lots of cool new people through the REU

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

- A paper will be published
- It will help further future research for me and for others
- Helped someone with their thesis work for the PhD
- Provide factual support for astrophysical and material applications and research
- Could impact future dust research concerning PAHs and UV variations
- New appreciation of union-find

Additional comments;

- Seminars on Thursday could be much more beneficial
- The communication prior to coming to Toledo could be much more helpful
- Dr. Witt is an amazing mentor
- The beginning could have been more structured. Thanks!
- Great experience, can't thank you enough.
- The learning aspect of the REU wasn't much fun for me because previous to the start of the REU I realized I didn't want to go to grad school and I am bored of studying physics. But I have nothing against the REU program itself – just wasn't for me!

VIII. SUMMER 2014 PICTURES

REU's @ Work! A collage of the various REU activities over the summer 2014. High resolution versions of each picture are available upon request. In addition, we captured the students' REU final presentations 2014 in You-Tube movies. The link to the set of movies is: https://www.youtube.com/playlist?list=PLP3ZFN0CK6y4yhxxDJgtzyc9VY2WE9usQ. 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.

REU's having fun! A collage of the various REU activities over the summer 2014. High resolution versions of each picture are available upon request. In addition, we captured the students' REU final presentations 2014 in You-Tube movies. The link to the set of movies is: https://www.youtube.com/playlist?list=PLP3ZFN0CK6y4yhxxDJgtzyc9VY2WE9usQ. 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