Annual Progress Report (Year 3)

Research Experiences for Undergraduates in Physics and Astronomy

NSF-REU Grant PHY-0097367

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

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Thomas J. Kvale
Scott A. Lee

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RESEARCH PARTICIPANTS in the NSF-REU PROGRAM
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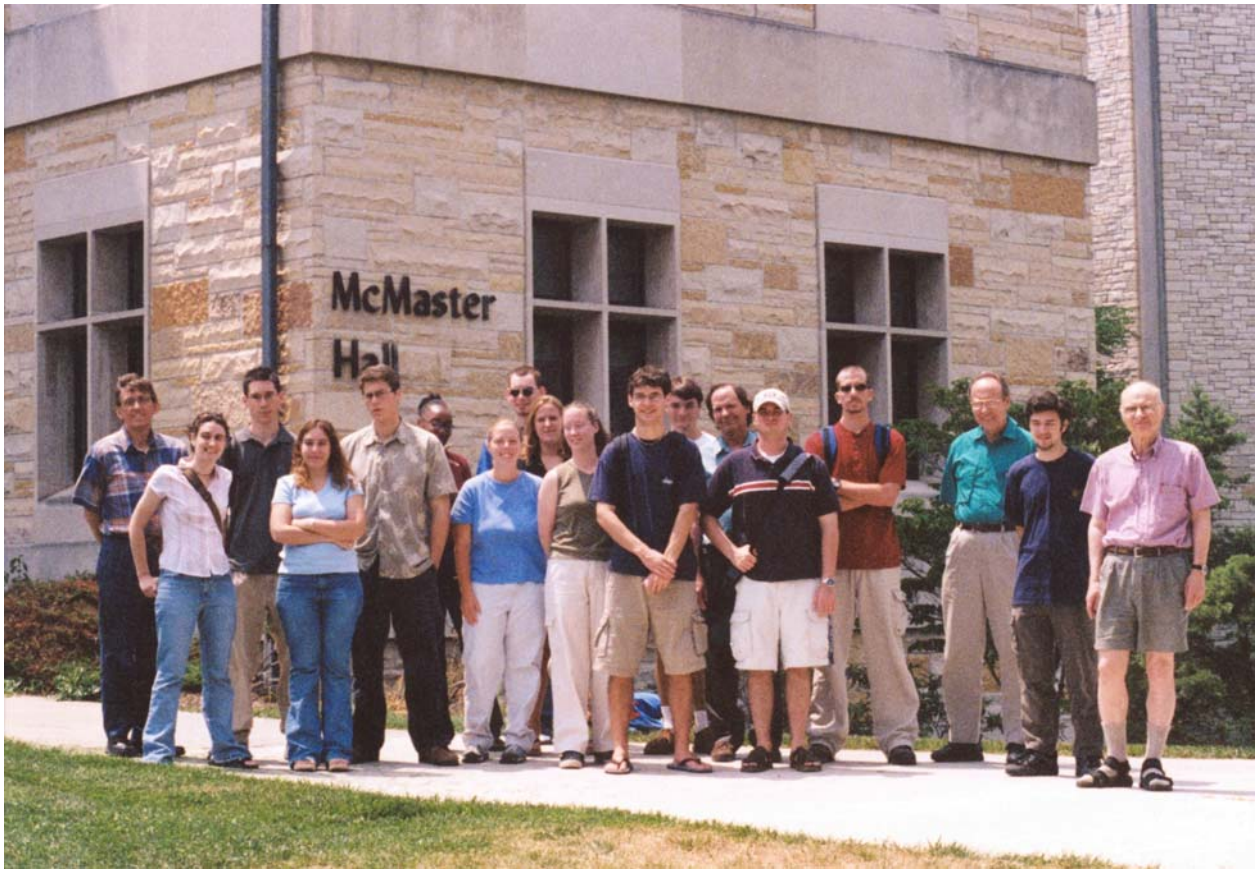
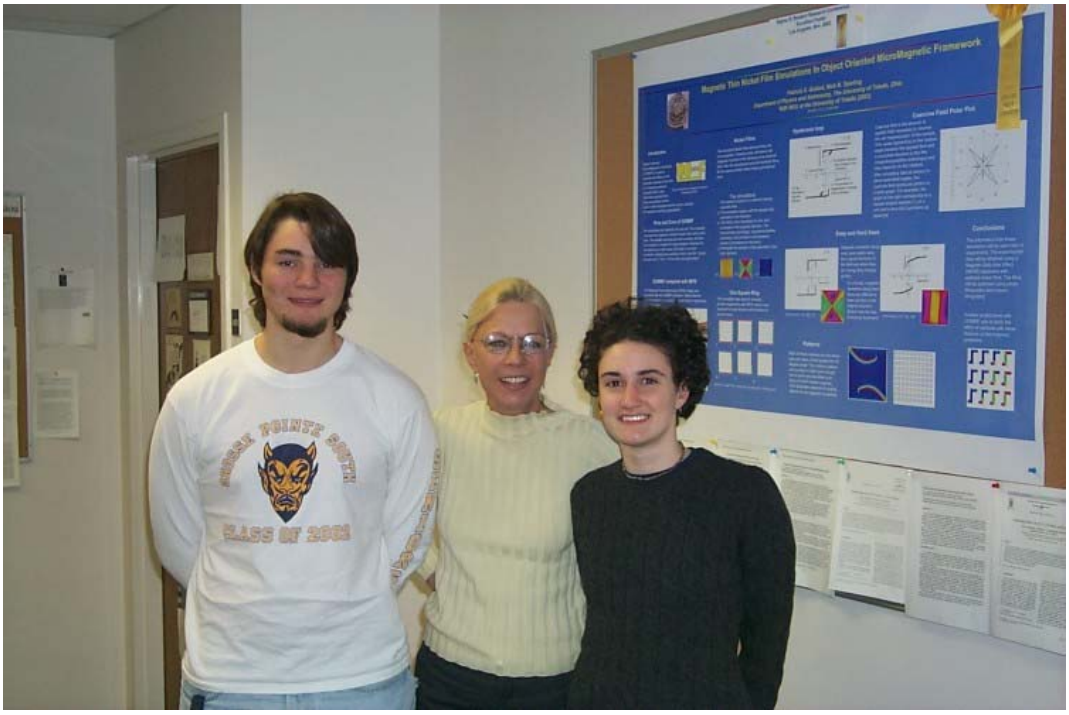
DEPARTMENT OF PHYSICS & ASTRONOMY
THE UNIVERSITY OF TOLEDO



Left to Right: A.D. Compaan, **Patricia Gallant**, **Matthew Wescott**, **Samantha Dizor**, **Joseph Sawvel**, **Erin Hardy**, **Sarah Hickman**, **Travis Smith**, **Julie Deanna**, **Jacquelyn Must**, **Benjamin Johnson**, **Nicholas Sperling**, L.S. Anderson-Huang, **Matthew Frost**, **Michael Baker**, A.N. Witt, **Joshua Thomas**, L.J. Curtis.



Left-to-Right: **Nicholas Sperling*** (2003), Prof. R.A. Lukaszew (Faculty REU Advisor), **Patricia Gallant*** (2003) by their award-winning poster presented at the Sigma Xi, The Scientific Research Society, 2003 Student Research Conference, November 14-15, 2003, Los Angeles, CA.

P. Gallant and N. Sperling Sigma Xi Poster Abstracts

O-12

Low Cost Scanning Tunneling Microscope and OOMMF Simulations

Nicholas Sperling (University of Toledo), Advisor: Ale Lukaszew (University of Toledo).

Using circuit designs from the "SXM Project" at the Westfalische Wilhelms-Universitat Munster, a new prototype scanning tunneling microscope (STM) is in the process of being developed. The key features of this STM will be its relative low cost and the portability into an ultra-high vacuum system. The purpose of this device will be to do high, and possibly atomic, resolution on micromagnetic materials. This device will have to use materials readily available for the construction of the mechanical components, and they must be able to interface properly with the electronic components at hand. Since the study of the micromagnetic thin films are the core of the research, we have been using the Object-Oriented Micromagnetic Framework (OOMMF) released by the National Institute of Standards and Technology (NIST). The code has been slightly modified to facilitate the generation of hysteresis loops of thin Ni films. The code has also been used to simulate experimental data taken on Nickel films.

O-14

Magnetic Properties of Thin Films

Patricia Gallant (University of Toledo), Advisor: Ale Lukaszew (University of Toledo).

A description of the properties of thin films of nickel and iron nitride that I have been studying. I have studied the magnetization in several epitaxial thin films of various thicknesses. I used Object Orientated MircoMagnetic Framework (OOMMF) to simulate the reversal and compare it with data gained experimentally using longitudinal Magneto-Optic Kerr Effect (MOKE). I also performed studies on the surface morphology of the films using Atomic Force Microscopy (AFM) to discover correlations between the surface morphology and the magnetic properties. I compared the surface roughness of FeN films of two thicknesses and epitaxial Ni samples before and after annealing at mild temperature (300ºC).

SUMMARY REPORT

Introduction

The Summer 2003 NSF-REU program in Physics and Astronomy at Toledo gave enhanced research opportunities to 12 undergraduate students from 8 colleges and universities in 5 states spread from Florida to Arizona and California. We also provided partial support from the NSF-REU grant to two additional UT students that were primarily funded through their advisors' grants. This supplement brought up their level of support to be commensurate with the students fully supported by the REU grant. Student participants were chosen competitively from the 91 applications from students in 29 different states in all parts of the U.S., plus one US citizen student in a Canadian university. All the participants were serious and talented young scientists, who tackled substantial problems, participating in all stages of a project, from formulation to conclusion, including oral and written presentations of results. The gender distribution (including the two additional UT students) of the participants this year were 8 men (57%) and 6 women (43%). The initial web announcement (with secondary links to additional material) can be found at:

http://www.physics.utoledo.edu/~wwwreu/reusummer2003/nsf-reu2003a.html

We are pleased to report that Summer 2003 was a success from both the students' and faculty mentors' perspectives. Eight talks were presented by the REU participants. Patricia Gallant and Nicholas Sperling were awarded top honors for their poster presentation at the 2003 National Meeting of Sigma Xi in Los Angeles, CA in November 2003. Four refereed publications involving REU student co-authors were published in 2003; two manuscripts have been submitted to refereed journals; and four additional manuscripts are in preparation.

Advertisement and Selection

This year we utilized a web-based advertisement and application system. The only paper announcement sent to institutions was a very brief letter alerting the prospective students to our website and a paper copy of our Application form in case the students didn't have readily available access to the internet. The web materials are appended to this report. The table on pages 8 and 9 shows the geographic distribution of inquiries, applicants, offers, and participants. The selection committee was composed of Thomas Kvale (PI) and Scott Lee (Co-PI). This committee also performed the initial matches of the prospective students with their faculty mentors. Various criteria were used for the selection and matching, including the student's course background and class performance, out-of-class experiences, research interests, faculty recommendations, and personal goals. We also tried to select students with a variety of personal, educational, and geographical backgrounds. Although we were successful in these areas, we will again try harder to attract more persons of under-represented groups in our program. Listed below are the organizations we encouraged to post our REU announcement.

- Society of Black Physicists
- American Indian Science and Engineering Society (www.aises.org)
- Society for Advancement of Chicanos and Native Americans in Science (www.sacnas.org)
- American Astrophysical Society (www.aas.org)
- over 130 colleges and universities (mainly in the Midwest, but some scattered all over the US).

Registration, Housing, and Social Activities

All student participants were registered in PHYS4910, *Research Problems in Physics and Astronomy*, for 1 semester hour credit. The REU program paid all the instructional and other required fees. We find that there are many advantages to having the REU participants be registered UT students with all associated benefits and privileges. One of the major benefits is access to the university health center. Other benefits include: course credit to transfer back to the student's home institution if desired, access to recreational facilities, and borrowing privileges at the University library.

This year the student participants lived in the same campus dormitory, with the NSF-REU grant providing the housing costs. One of the goals of the NSF-REU program is to enable social interactions among the students, who will become the scientists of tomorrow. This infrastructure of friendships leads to the fruitful exchange of ideas, which is useful in the advancement of physics and astronomy. We feel that we can best accomplish this goal by housing the students together on campus. The director of Student Housing on the campus of the University of Toledo has cooperated with us fully in this respect for the past 12 summers of NSF-REU support. The students stayed in the Academic (Honors) House, which is organized into suites adjoining a common area that encouraged social interactions among the REU students.

Social activities were coordinated by two UT participants (Jackie Must and Josh Thomas) who are officers in the UT chapter of SPS. This worked out very well and the students formed a close-knit group. Some of the special events included a departmental picnic, trips to Cedar Point Amusement Park, the Toledo Museum of Art, and the Toledo Zoo, plus many informal activities, including an evening at Tony Packo's, Toledo's famous ethnic Hungarian restaurant. The Annual windsurfing adventures at Maumee Bay State Park, courtesy of Professor Alvin D. Compaan and his graduate students were very well received.

Weekly Seminars

During the first week, the students attended an orientation seminar to cover the basic items such as ID cards, parking, health services, food services, stipend checks, etc. After that, a weekly "Brown Bag" seminar series played an important part of our summer program. Faculty members and/or outside speakers presented a talk over the lunch hour for the chosen day. This bag lunch format fosters more of an informal atmosphere, which the students appreciate when it is their turn to give a presentation at the close of the summer session. This weekly meeting of the entire REU group also provided an opportunity to plan social events and field trips, and discuss any topics of interest to the group. The whole department was invited to attend the Bag Lunches, and the participation was very good with many graduate students and faculty members also attending each week. The Bag lunches provided a useful departmental weekly gathering, otherwise absent in the summer. The talks at these weekly meetings were for the most part similar to standard physics research talks, but chosen to be appropriate for the REU audience, and with all the speakers being careful to give undergraduate-level introductions. The list of talks is given later in this Report. We also required the students to give a 5 minute presentation of their research about midway into their summer period. These midway progress talks went well and kept the students focused on their projects. We plan to repeat this mid-term Progress talks for this coming summer.

Reports and Conclusion

We feel it is important to involve the students with all aspects of the scientific research process. To the extent possible, depending on the nature of the project, students participate in the selection of the problem, the choice of research method, the collection and analysis of data, the formulation of conclusions, and the presentation of the results. The research problems are parts of ongoing faculty research programs, which are in most cases supported by external grants. At the same time, every effort is made to identify a piece of the research for which the REU student has the primary responsibility. The students are asked to write a final report, including a carefully-written abstract which could be submitted as a contribution to a regional or national meeting, as well as give a 15 minute presentation at a Bag Lunch in the final week of their research period. The typical length of the final reports is about 20 - 25 pages. These requirements have helped the students to be experienced in technical writing and presentations. The REU students were coauthors on four refereed publications in 2003. Two manuscripts (with REU students as first authors!) are currently in the refereeing process and four additional manuscripts are in preparation. At least eight presentations were made this year at conferences. One poster combination presentation won "Excellent Poster" award at the national 2003 Sigma Xi Student Research Conference.

NSF-REU SUMMER 2003 APPLICATIONS

Geographical distribution by undergraduate institution

(Applications Received / REU Offers Made /REU Accepted)

Arizona
Northern Arizona University ..... (1/1/1)
University of Arizona ..... (1/0/0)

Arkansas
University of Arkansas ..... (1/1/0)

California
Cal. Polytechnic University ..... (1/0/0)
Harvey Mudd College ..... (1/0/0)
UC, Santa Barbara ..... (1/0/0)
Sierra Community College ..... (2/1/1)

Colorado
Colorado School of Mines ..... (1/0/0)
Univ. of Colorado, Denver ..... (1/0/0)

Florida
Florida Inst. of Tech ..... (1/0/0)
Jacksonville University ..... (1/1/1)

Georgia
North Georgia. Coll. & State Univ. .. (1/0/0)

Illinois
U.Illinois-Urbana Champaign ..... (2/0/0)

Indiana
Ball State University ..... (1/0/0)
Purdue University ..... (1/0/0)
Rose-Hulman Inst. of Tech. ..... (1/0/0)
Taylor University ..... (1/0/0)
Valparaiso University ..... (1/1/0)

Iowa
Grinnell College ..... (1/1/0)

Kansas
Bethel College ..... (1/0/0)
Southwestern College ..... (1/1/0)

Kentucky
Transylvania University ..... (1/0/0)

Massachusetts
Harvard University ..... (1/0/0)
Mass. Inst. of Tech. ..... (2/0/0)

Michigan
Albion College ..... (1/0/0)
Alma College ..... (1/0/0)
Kalamazoo College ..... (2/0/0)
Michigan State University ..... (1/0/0)
Michigan Tech. University ..... (1/0/0)

Minnesota
Bethel College ..... (2/0/0)
Carleton College ..... (1/0/0)
Winona State University ..... (2/1/0)

Missouri
Truman State University ..... (1/0/0)

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

New York
Bard College ..... (1/0/0)
Cornell University ..... (3/0/0)
St. John Fisher College ..... (1/1/0)
Utica College of Syracuse ..... (1/0/0)
Worcester Polytechnic Inst. ..... (1/0/0)

North Carolina
Guilford College ..... (1/1/1)

Ohio
Baldwin-Wallace College ..... (1/0/0)
Bluffton College ..... (1/0/0)
Bowling Green State Univ. ..... (1/0/0)
College of Wooster ..... (1/0/0)
Heidelberg College ..... (1/0/0)
John Carroll University ..... (1/1/0)
Kent State University ..... (1/1/1)
Muskingum College ..... (1/1/1)
Oberlin College ..... (2/2/0)
Ohio Northern University ..... (1/0/0)
University of Dayton ..... (1/1/1)
University of Toledo ..... (11/5/5)

Oklahoma
Cameron University ..... (1/0/0)

Oregon
Linfield College ..... (1/1/0)
Oregon State University ..... (2/1/0)
Reed College ..... (5/1/0)
University of Oregon ..... (2/0/0)

Pennsylvania
Bucknell College ..... (3/0/0)
Carnegie Mellon University ..... (2/1/0)
Grove City College ..... (2/0/0)
Lycoming College ..... (1/0/0)
Westminster College ..... (1/0/0)

South Carolina
College of Charleston ..... (1/0/0)
Bob Jones University ..... (1/0/0)

Texas
University of Texas at Austin ..... (1/0/0)

Utah
Brigham Young University ..... (1/0/0)

Virginia
Randolph-Macon Woman's Coll. .... (1/0/0)

Washington
Western Washington Univ. ..... (1/0/0)

West Virginia
Bethany College ..... (1/1/0)

Wisconsin
Beloit College ..... (1/0/0)
Univ. of Wisconsin-Madison ..... (1/0/0)

CANADA
University of Waterloo ..... (1/0/0)

NSF-REU SUMMER 2003 PARTICIPANTS

NAME	HOME INSTITUTION	FACULTY ADVISOR	RESEARCH AREA
Michael Baker	Northern Arizona University	Brian Bagley	Optronics
Julie DeAnna	University of Toledo	I. Parsai/L. Curtis	Medical Physics
Samantha Dizor	Jacksonville University	Victor Karpov	Condensed Matter
Matthew Frost	Kent State University	David Ellis	Atomic Physics
Patrica Gallant	University of Toledo	Ale Lukaszew	Condensed Matter
Erin Hardy	University of Toledo	Philip James	Astronomy
Sarah Hickman	Muskingum College	Al Compaan	Condensed Matter
Benjamin Johnson	University of Dayton	L. Anderson-Huang	Astronomy
Jacquelyn Must	University of Toledo	Adolf Witt	Astronomy
Joseph Sawvel	Guiford College	Xunming Deng	Condensed Matter
Travis Smith	University of Toledo	Jacques Amar	Condensed Matter
Nicholas Sperling	University of Toledo	Ale Lukaszew	Condensed Matter
Joshua Thomas	University of Toledo	Thomas Kvale	Atomic Physics
Matthew Wescott	Sierra Community College	Brian Bagley	Condensed Matter

NSF-REU STUDENT DEMOGRAPHICS

Summer 2003

Gender	
Female:	6
Male:	8*

Entering Fall Class Rank (after Summer)	
Freshman:	0
Sophomore:	2
Junior:	5
Senior:	7
Higher:	0

Ethnicity	
International Student:	0
American Indian:	0
Alaskan Native:	0
Asian American: (or Pacific Islands)	0
African American:	1
Hispanic American:	0
Caucasian/White:	13*
Other:	0

Home State	
Arizona	1
California	1
Michigan	1
North Carolina	1
Ohio	9
Pennsylvania	1

Home Institution:	
Guiford College	1
Jacksonville Univ.	1
Kent State University	1
Muskingum College	1
North. Arizona Univ.	1
Sierra Comm. Coll. (transferred to CalTech)	1
Univ. of Dayton	1
University of Toledo	7*

REU Students Grade Point Average: 3.45

* Includes two UT students with partial REU support.

NSF-REU SUMMER 2003 BROWN BAG SEMINARS
TUESDAY NOON - MH 4009
L.S. Anderson-Huang, COORDINATOR

June 3	L.S. Anderson-Huang	*Constructing Visual Reality*
June 10	J.G. Amar	*Kinetics of Submonolayer & Multilayer Epitaxial Growth*
June 17	B.W. Bopp	*Producing Elegant--and Bulletproof--PowerPoint*
June 24	R.A. Lukaszew	*Interfacing a Computer to your Experiment: How to Go About It*
July 1	REU Students	Progress Reports
July 8	A.N. Witt	*Dust Between the Stars*
July 15	L.J. Curtis	*Exponentials Before 1900*
July 22	Cedar Point Trip	
July 29	D.G. Ellis	*Close Encounters: Electron Correlation in Atomic Wave Functions*
August 5-6-7	REU Students	*What I Did This Summer*

2003 REU Final Oral Reports

12 minute talk with a 3 minute question/answer session.

Tuesday noon 5 August MH4009

12:00	Nicholas Sperling	"*Low cost scanning tunneling microscope and OOMMF simulations,*" (R.A. Lukaszew)
12:15	Ben Johnson	"*Modeling Microturbulence in Stellar Atmospheres,*" (L.S. Anderson-Huang)
12:30	Matt Wescott	"*Optical Logic Using a Symmetric Mach-Zehnder Interferometer,*" (B.G. Bagley)
12:45	Matthew Frost	"*Improvement in Computing Atomic Energy Levels Using the MCHF Method,*" (D.G. Ellis)

Wednesday noon 6 August MH4009

12:00	Travis Smith	"*Parallel Kinetic Monte Carlo Simulations on a Shared Memory Multiprocessor System,* (J.G. Amar)
12:15	Julie DeAnna	"*Patient Positioning Using the BAT System,*" (I. Parsai, L.J. Curtis)
12:30	Erin Hardy	"*Martian Cloud Motion,* (P.B. James)
12:45	Patricia Gallant	"*Magnetic Propertites of Nickel Thin Films,*" (R.A. Lukaszew)
13:00	Michael Baker	"*Gain Flattening with Passive Optical Integrated Circuitry,* (B.G. Bagley)

Thursday noon 7 August MH4009

12:00	Jackie Must	"*Clumpy Dust in Reflection Nebulae,*" (A.N. Witt)
12:15	Sarah Hickman	"*Modulated PL in CdS/CdTe Solar Cells,*" (A.D. Compaan)
12:30	Joe Sawvel	"*Optoelectronics Properties of Amorphous and Nanocrystalline Silicon Alloys,*" (X. Deng)
12:45	Josh Thomas	"*A Design and Performance Study of Electrostatic Faraday Cup Detectors,*" (T.J. Kvale)
13:00	Samantha Dizor	"*Photoluminescence Fatigue in CdTe/CdS Solar Cells,*" (V.G. Karpov)
13:15	Hamzah Tariq*	"*Conversion of the Data Acquisition Code into C++ for Ion Energy–Loss Spectroscopy Measurements,*" Senior Computer Science project, UT/EECS, (T.J. Kvale)

* Additional UT undergraduate summer research student not supported by the REU grant.

ABSTRACTS OF REU FINAL REPORTS

The University of Toledo
Department of Physics & Astronomy
SUMMER 2003
(Faculty Mentor on parenthesis)

Astrophysics/Astronomy

Erin Hardy *"Martian Cloud Motion"* (Philip James)

In the late summer of 2003, Mars will make its closest approach to Earth in almost 60,000 years. Consequentially, during this period more detailed surveys of the Martian atmosphere can be taken using the Hubble Space Telescope's Advanced Camera for Surveys system. Images are acquired over a single 45 minute orbit. During the course of one orbit, the planet rotates 10 degrees, making image projection a necessity. The first, middle and last images are taken with F435W, a blue-violet, cloud-sensitive filter. These recovered images are then processed and analyzed to track cloud motion from image to image. Although each image set consists of 3 shots, only the first and last shots are used, since the small change in time does not provide much in the way of cloud activity. The images acquired from the pertinent set are centered at sub-Earth latitudes of 17.8E and sub-Earth longitudes of 3.69E and 13.42E. The set was obtained May 9, 2003, with the images taken at 05:17:54 and 05:57:55 UT, respectively.

Benjamin Johnson *"Modeling Microturbulence in Stellar Atmospheres"* (Lawrence Anderson-Huang)

Current stellar modeling agrees very well with observed spectra over all wavelengths related to carrying the flux with one exception: the widths of the absorption lines. Observed line widths turn out to be slightly larger than they should be for the derived temperature. This discrepancy can often be resolved by introducing so-call “microturbulent” velocities. Atmospheric modelers currently just add arbitrary amounts of microturbulence until the line profiles match. The intention of this project is to model the turbulence in three dimensions using the equations of motion for a radiating fluid. A computer program was developed and tested which creates a successful three-dimensional model of a gray stellar atmosphere with radiation-driven velocities that with further additions can be used to model microturbulence.

Jacquelyn Must *"The Effects of Clumpy Dust on Hubble's Law for Reflection Nebulae"* (Adolf Witt)

Edwin Hubble did research on reflection nebulae in 1922. He found a relation between the magnitudes of the illuminating stars and the logs of the radii of the reflection nebulae. Much scatter was present in his graph that was not due to observational error. In this paper we investigate the clumpy structures within reflection nebulae to determine if they are the cause of the large scatter seen in Hubble's graph. Observational data from the van den Bergh (1966) reflection nebula catalogue [1] and the Racine (1968) star catalogue [2] were used in this study along with a radiative transfer model of reflection nebulae.

1. van den Bergh, S., Astron. J. 71, 990 (1966)
2. Racine, R., Astron. J. 73, 233 (1968).

Atomic/Molecular/Optical Physics

Matthew Frost *"Method for Improving MCHF Calculations of Atomic Energy Levels and Wave Functions"* (David Ellis)

The Multiple Configuration Hartree-Fock Method for Atoms provides reasonably accurate results in determining energies of atoms, with the exception of atoms that have a high occurrence of electron correlation. A new *Psi* function, $\Psi' = \Psi + \alpha\Phi$ was determined in order to account for these correlations. Here, *Phi* is a new basis function for an atom with *n* electrons, orthogonal to all the MCHF orbitals, in which two electrons are described using correlated variables, with *n-2* electrons in MCHF orbitals. Then the energy is minimized by varying the amplitude *alpha*. Once the necessary methods were developed, a program was written and trails were run. These results were compared to accurate solutions for non-relativistic energies in helium and lithium. The final result is an improved approximation of energies where electron correlations are concerned, but no substantial change where electron correlations are minimal.

Joshua Thomas *"A Design and Performance Study of Electrostatic Faraday Cup Detectors"* (Thomas Kvale)

Faraday cups have been used in accelerators for many years as a detector to measure beam currents. As such, they typically play an important role in the determination of interaction cross sections and understanding their operation is crucial to the accuracy of the reported measurements. When an energetic particle strikes the metal surface of the Faraday cup, secondary electrons are emitted from that surface. These escaping electrons then appear as positive current entering the detector, which will give an inaccurate particle current reading. We have conducted a study of the traditional cylindrically-symmetric Faraday cup design which utilizes an opposing electric field to recapture the secondary electrons versus a new design which utilizes a transverse electric field. A direct comparison between the new and old design was conducted for proton impact at 25 keV and the new design shows a vast improvement in recapturing electrons at a common suppression voltage. Further analysis of the measured current as a function of voltage provides a direct measurement of the secondary emission coefficient and the kinetic energy distribution of the secondary electrons. Manuscripts reporting both the Faraday cup design study and the measurement of secondary emission coefficients are in progress and will be submitted for publication.

Biological/Health/Medical Physics

Julie DeAnna *"Patient Positioning Using the B-mode Acquisition and Targeting System (BAT)"* (Lorenzo Curtis, Ishmael Parsai)

Patients have always been aligned for their prostate treatments, but the alignment procedures never accounted for the changes in the inside of the body until the BAT positioning system was developed. BAT allows doctors or therapists to position the patient to precisely align the body with the treatment plan from day one. This process helps to make sure the patient's body inside and out is in the same alignment every day and thus greatly cuts down the margin of error. Proper alignment using BAT helps to cut down on the margin of error and greatly increases a patient's chance of completely getting rid of the cancer. The results from this project found that the error between patient positioning by the previous method and the BAT method is up to 27.69% of the target area.

This error would mean that some cancerous tissue may not be treated while nearby healthy tissue would be irradiated.

Condensed Matter Physics

Michael Baker *"Gain Flattening With Passive Optical Integrated Circuitry"* (Brian Bagley)

The current trend in the communications industry is an increased utilization of fiber optics and optical integrated circuitry, due to the increased bandwidth and reduced transmission loss versus traditional electronic methods. The current model for commercial fiber optic use is "Fiber to the Curb" in which the fiber for a particular block is run to a common curb side terminal, then converted to an electronic signal and sent via coaxial cables to the individual customers. The next generation standard, "Fiber to the Premises" (FTTP), will rely exclusively on fiber optics, from source to customer. A passive gain flattener was designed using dual-channel directional couplers and simulated with BeamPROP 4.0. A 1550 nm beam was launched into a four-way splitter constructed with square channels and a core-cladding index difference of 0.01492. Couplers of various lengths were used to dump a percentage of the splitter's output power to the environment. Final circuit outputs were within 0.5% of the expected values.

Samantha Dizor *"Photoluminescence Fatigue in CdTe/CdS Solar Cells"* (Victor Karpov)

This project was aimed at studying transient effects in the photoluminescence from thin-film photovoltaics. More specifically, it was observed that junction photoluminescence intensity (PL) in a polycrystalline CdTe/CdS solar cell gradually decreased with time, similar to the PL fatigue in chalcogenide glasses. PL vs. time was studied at different laser beam powers and temperatures for both contact-free and metallized regions. We discriminated between the fatigue per se and concomitant short-time PL intensity drop due to the laser heating. The fatigue value shows substantial variations between different spots on the sample. It was found to be more profound at higher temperatures and laser beam powers where its value can be as large as 80 percent in two hours. At low temperatures and beam powers it saturates rather quickly not exceeding 10 percent of the initial PL intensity. For the first time a phenomenon of delayed degradation (fatigue) was observed where the device kept losing its efficiency after the laser beam was terminated. To verify that phenomenon we also studied possible effects of delayed degradation caused by the standard light soak and strong forward bias. We attributed the observed phenomena to defect creation by the light-generated electrons and holes. The defects provide additional non-radiative recombination channels thus decreasing PL. Simultaneously, this negative feedback makes the defect-generation rate slowing down, so that the PL fatigue saturates. We proposed a simple analytical model that fits the data.

Patricia Gallant *"Magnetic Properties of Thin Nickel Films"* (Alejandra Lukaszew)

This paper describes the properties of thin films of nickel and iron nitride that I have been studying. I have studied the magnetization in several epitaxial thin films of various thicknesses. I used Object Orientated MicroMagnetic Framework (OOMMF) to simulate the reversal and compare it with data gained experimentally using longitudinal Magneto-Optic Kerr Effect (MOKE). I also performed studies on the surface morphology of the films using Atomic Force Microscopy (AFM) to discover correlations between the surface morphology and the magnetic properties. I compared

the surface roughness of FeN films of two thicknesses and epitaxial Ni samples before and after annealing at mild temperature (300ºC).

Sarah Hickman *"Modulated PL in CdS/CdTe Solar Cells"* (Alvin Compaan)

Electromodulated photoluminescence (EMPL) is useful for collecting data to study the differences between stressed and unstressed solar cells. EMPL measurements are taken by applying a 164mV peak-to-peak modulated voltage across a solar cell while illuminating it with a 632.8nm, 8mW HeNe laser. The signal was collected through a lock-in amplifier, and then analyzed. Using this method, three different CdS/CdTe solar cells, both stressed and unstressed were studied. The results were interpreted using a widely accepted electric field model of a cell. This model indicates that the EMPL signal should be greatest near open circuit voltage, where the electric field is the weakest at the junction between the CdS and CdTe. This proved true in the case of the unstressed cell, but was not valid in the stressed samples. We used EMPL to study the effects of stress on cells, which were stressed by illumination under a one-sun solar simulator with a temperature of 60°C. One cell was stressed at open circuit voltage, while a negative 2V bias was applied across the other cell. The stressed samples produced EMPL graphs that had no real defined peak and had very low signal near open circuit. This was contrary to the expected result, and is not yet fully understood. It is, however, believed that the lack of a peak, especially near open circuit, is due to defects that are created near the CdS/CdTe junction during stressing.

Joseph Sawvel *"Optoelectronic Properties of Amorphous and Nanocrystalline Silicon Alloys"* (Xunming Deng)

In this project we analyzed the structure of amorphous and nanocrystalline silicon and silicon germanium films via Raman Spectroscopy. We also analyzed the photo and dark conductivity of several nanocrystalline silicon and silicon germanium materials deposited using hot-wire chemical vapor deposition process. The third aspect of the project was the construction and utilization of a Constant Photo Current Apparatus. The CPM could be used to measure the density of defects in the band gap of amorphous silicon and silicon germanium alloys

Travis Smith *"Parallel Kinetic Monte Carlo Simulations on a Shared Memory Multiprocessor System"* (Jacques Amar)

In order to simulate non-equilibrium processes over larger time scales and for realistic size systems, it is desirable to use parallel computing. Unfortunately, the standard algorithm for simulating activated processes, kinetic Monte Carlo (KMC) , is inherently serial and thus only suitable for use with a single processor. Recently, however, our group has developed parallel (KMC) algorithms which have been successfully tested on a Beowulf cluster using Message Passing Interface (MPI) Application Program Interface (API). Due to the lack of communication overhead such algorithms should be even more efficient on shared-memory machines. As a first step in investigating this possibility, I have been developing a parallel KMC code to simulate one-dimensional irreversible epitaxial growth on a shared memory machine using OpenMP. We have verified and tested this code on the Sunfire and Origin 2000 computers at the Ohio Supercomputer Center (OSC) using multiple processors. Unfortunately, so far we have not obtained a significant speed increase using this method. However, we believe that this is not due to a fundamental limitation in the algorithm but rather to computational and/or compiler limitations. In the near future, we hope to increase the parallel efficiency of our code so that it can then be applied

to more complex and realistic problems.

Nicholas Sperling *"Low cost scanning tunneling microscope and OOMMF simulations"* (Alejandra Lukaszew)

Using circuit designs from the "SXM Project" [I] at the Westfalische Wilhelms-Universitat Munster, a new prototype scanning tunneling microscope (STM) is in the process of being developed. The key features of this STM will be its relative low cost and the portability into an ultra-high vacuum system. The purpose of this device will be to do high, and possibly atomic, resolution on micromagnetic materials. This device will have to use materials readily available for the construction of the mechanical components, and they must be able to interface properly with the electronic components at hand. Since the study of the micromagnetic thin films are the core of the research, we have been using the Object-Oriented Micromagnetic Framework (OOMMF) released by the National Institute of Standards and Technology (NIST). The code has been slightly modified to facilitate the generation of hystersis loops of thin Ni films. The code has also been used to simulate experimental data taken on Nickel films.

Matthew Wescott *"Symmetric Mach-Zehnder Interferometer Optical Logic Device"* (Brian Bagley and Robert Deck)

The all-optical computer is a controversial idea. Most agree that it would be very powerful however, many challenge its functionality or even the possibility of its construction. There are many challenges to constructing a useful optical computer, but many of the problems are being overcome by better components, particularly logic devices. One of the problems with optical computing is the difficulty of controlling the relative phase of two input signals. Another is the inherent difficulty in cascading the logic devices. Most schemes of doing logic optically have both of these problems; a few have neither. One of the more promising logic devices involves the symmetric Mach-Zehnder interferometer. By incorporating a three-channel directional coupler into the input stage of the device, its size can be reduced. This project involved the theoretical analysis of the slab approximation with coupled mode theory.

NSF-REU External Publications and Presentations
(Calendar Year 2003)

REFEREED PUBLICATIONS. (REU students' names in **bold face type*** with year of participation.)

1. Diana Shvydka, **Christopher Verzella*** (2002), V. G. Karpov and A. D. Compaan, *"Photoluminescence Fatigue and Related Degradation in Thin-Film Photovoltaics,"* J. Appl. Phys. 94, 3901 (2003).

2. Diana Shvydka, **Christopher Verzella*** (2002), and V. G. Karpov, *"Photoluminescence fatigue in CdTe photovoltaics,"* Mat. Res. Soc. Symposium Proceedings, 763, 189 (2003).

3. K. J. Price, A. Vasko, **Levi Gorrell*** (2002) and A. D. Compaan, *"Temperature-Dependent Electroluminescence from CdTe/CdS solar cells,"* Mat. Res. Soc. Symposium Proceedings, 763, 195 (2003).

4. John P. Wisniewski, Nancy D. Morrison, Karen S. Bjorkman, Anatoly S. Miroshnichenko, **Amanda C. Gault*** (2001), Jennifer L. Hoffman, Marilyn R. Meade, and Jason M. Nett, *"Spectroscopic and Spectropolarimetric Observations of V838 Monocerotis,"* ApJ, 588, 486, (2003).

5. **Thomas Crenny*** (2001) and S.R. Federman, *"Reanalysis of* Copernicus *Measurements on Interstellar Carbon Monoxide,"* Astrophysical Journal, (2003) submitted

6. **Joshua Thomas*** (2001, 2003), G.S, Hodges, D.G. Seely, N. Moroz, and T.J. Kvale *"Performance Enhancement Study of an Electrostatic Faraday Cup Detector,"* Meas. Sci. and Technol. (2003) submitted

MANUSCRIPTS in Preparation (to be submitted for publication -- titles and co-authors tentative)

1. **Marleen Martinez*** (2002), K. Pan, S.R. Federman, and D.L. Lambert, *"Filamentary Nature of Interstellar Gas toward the Pleiades Revealed by Absorption Lines"*
   Anticipated Journal: Astrophysical Journal

2. G.S, Hodges, **Joshua Thomas*** (2001, 2003), T.J. Kvale, D.G. Seely, N. Moroz, *"Secondary Emission Coefficients of 10 - 50 keV Protons Striking Copper Targets"*
   Anticipated Journal: Nuclear Instruments and Methods B: Beam Interactions

3. **Nicholas Sperling*** (2003), **Patricia Gallant*** (2003), D. Pearson, and R.A. Lukaszew, *"Magnetic Properties of FeN Thin Films"*
   Anticipated Journal: Journal of Applied Physics

4. Adolf N. Witt, **Jacquelyn Must*** (2002, 2003), and Karl D. Grodon, *"Clumpy Structure in Reflection Nebulae.I. The Hubble Diagram"*
   Anticipated Journal: Astronomical Journal

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

1. **Amanda C. Gault*** (2000, 2001), "*Circumstellar Disk Diagnostics from Polarimetry and Infrared Excesses*," 24th Annual Sigma Xi Student Research Symposium, University of Toledo, Undergraduate Student Research Division, UDG05, April 11, 2003.

2. **Levi Gorrell*** (2002), "*Electroluminescence in CdTe solar cells at varying temperatures,*" 24th Annual Sigma Xi Student Research Symposium, University of Toledo, Undergraduate Student Research Division, UDG13, April 11, 2003.

3. **Joshua D. Thomas*** (2001, 2003), "*Design Improvements in Data Collection Faraday Cup Detectors*," 24th Annual Sigma Xi Student Research Symposium, University of Toledo, Undergraduate Student Research Division, UDG14, April 11, 2003.

4. **Jacquelyn Must*** (2002, 2003), "*Clumpy Dust in Reflection Nebulae,*" 24th Annual Sigma Xi Student Research Symposium, University of Toledo, Undergraduate Student Research Division, UDG15, April 11, 2003.

5. **Amanda Gault*** (2001), *"Circumstellar Disk Diagnostics from Polarimetry and Infrared Excesses,"* NASA/Ohio Space Grant Consortium Eleventh Annual Student Research Symposium Proceedings, OAI, OH, April 25, 2003.

6. **Marleen Martinez*** (2002), *"The Abundance of CH^+ in the Vicinity of the Pleiades,"* University of Washington's 6th Annual Undergraduate Research Symposium, May 16, 2003.

7. M. Adibzadeh and C. E. Theodosiou, and **Nicholas Harmon*** (2002), *"Comprehensive calculations for elastic electron scattering from Zn, Cd, and Hg atoms,"* 56th Gaseous Electronics Conference, San Francisco, October 21-24, 2003.

8. **Nicholas Sperling*** (2003), "*Low Cost Scanning Tunneling Microscope and OOMF Simulations,*" 2003 Sigma Xi Student Research Conference, poster O-12, Nov. 14-15, 2003, Los Angeles, CA. and **Patricia Gallant*** (2003), "*Magnetic Properties of Thin Films,*" 2003 Sigma Xi Student Research Conference, poster O-14, Nov. 14-15, 2003, Los Angeles, CA. (**Excellent Poster award)**

PROGRAM EVALUATION -- 2003

NSF-REU Summer Research Program

Department of Physics & Astronomy, The University of Toledo

To help us improve our summer research program in future years, please give us your confidential opinion on the following questions. Thanks very much.

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

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

2003 mean (pop.10): 1.4

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

2003 mean (pop.10): 1.5

How do you rate your summer research experience in helping prepare you for graduate study?

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

2003 mean (pop.10): 1.6

How do you rate your faculty advisor's interactions in helping you in your summer research experience?

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

2003 mean (pop.10): 1.3

How do you rate the weekly seminar series in helping you learn more about physics and astronomy?

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

2003 mean (pop.10): 2.6

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

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

2003 mean (pop.10): 2.8

How do you rate your summer experience personally?

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

2003 mean (pop.10): 1.4

How do you rate your summer experience educationally?

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

2003 mean (pop.10): 1.2

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

2003 mean (pop.10): 3.8

What do you think about having some of the seminar talks on subjects such as: "choosing a graduate school", "careers in physics and astronomy", "how to achieve greater diversity among physicists", etc., rather than only the traditional scientific talks such as we had this summer?

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

2003 mean (pop.10): 3.1

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

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

2003 mean (pop.10): 3.5

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

2003 mean (pop.10): 3.9

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

2003 mean (pop.10): 3.6

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

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

2003 mean (pop.10): 2.0

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

- I loved the research I was doing. My advisor was there to help me and showed me what I needed to do. I really enjoyed windsurfing, especially once I had the hang of it. The seminars need to be a little shorter and brought down to our level a little bit more. Also, having someone give a talk on one of the topics mentioned earlier would be nice. The BBQ's are also very nice and Cedar Point is a lot of fun.
- The best thing about my summer experience is how much I have learned about the subject I studied.
- Worst: busy w/ other activities and did not afford most social activities. Best: learned a lot.
- I enjoyed the research. It was helpful to get a better idea of what it is like to work in this field. It was a great experience.
- It was very fun meeting new people from other universities in the physics program.
- It was great to get lab experience. It was very helpful to work with a large group of people that can explain things in various ways.
- I met a lot of good people and it allowed me an excellent chance to participate in some research. Thank you.
- Not enough science-based field trips I'm told this COSI place has a lot of science, yet we didn't seem to go. I was sober entirely too often-you need an on-campus bar. And a guide for the 21+ students to the local bars.

Please list any additional comments.

- This summer was a lot of fun for me and because of it I now know that I want to go to grad. school and get my Ph.D. The faculty and staff are very helpful and played a role in making my stay here an enjoyable one. When I apply for grad school, Toledo will be on my list.
- We could have used a little bit more information about what to expect before we got here.
- Cliques were established the first day - Toledo kids & the non-Toledo kids never interacted w/ each other until the very end.
- More specific information about the program would have been helpful before coming to UT.

Research Experiences for Undergraduates in Physics and Astronomy Summer 2003

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

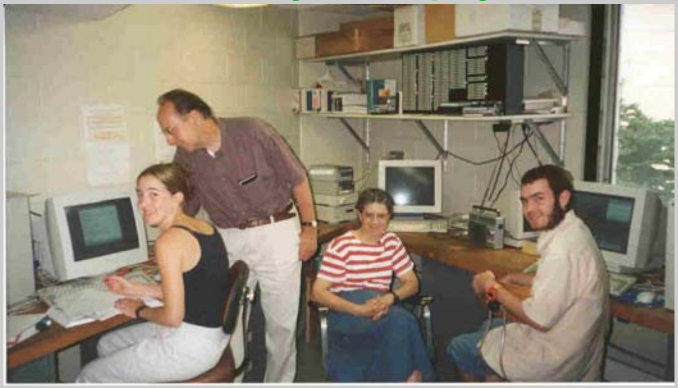
Appendix: Paper Program announcement and application form

Research Experiences for Undergraduates in Physics and Astronomy

Summer 2003

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

Astronomy/Astrophysics



Material Science

Atomic Physics

Condensed Matter

June 02, 2003 - August 08, 2003	Research opportunities are also available in:
Stipend: $3,500 for the 10 week session. Housing: Dorm provided in addition to stipend. Selections start March 07 and continue until all positions filled. For details please visit our website: www.physics.utoledo.edu and click on REU.	Biological Physics, Optoelectronics, and Plasma Physics

www.physics.utoledo.edu and click on REU

APPLICATION for the University of Toledo
NSF-REU Summer Research Program
02 June 2003 - 08 August 2003

Name (First, Middle Initial, Last): _____

Permanent address (line 1): _____

Permanent address (line 2): _____

Permanent address (line 3): _____

Permanent address City, State, Zip Code: _____

Email Address: _____

Telephone Number: _____

College or university you are currently attending: _____

Class level at the end of Spring semester 2003: (Freshman, Sophomore, Junior, Senior) _____

Current address (line 1): _____

Current address (line 2): _____

Current address (line 3): _____

Current address City, State, Zip Code: _____

Email Address: _____

Telephone Number: _____

US citizen (or permanent resident): YES ____ NO ____

Please number your top three (1 - 2 - 3) choices for research in the subfields of Physics and Astronomy represented in our department.

Astronomy/Astrophysics: _____
Atomic physics: _____
Biological physics: _____
Condensed matter physics: _____
Materials science: _____
Optical physics: _____
Plasma physics: _____

Please indicate your preference (1 - 2 - 3) for the type of research you are interested in doing.
Experimental/observational: _____
Computational: _____
Theoretical: _____

Please arrange for **two letters** of recommendation and your **college transcript** to be sent to me at the address listed at the end of this Application.

Reference #1 Name: _____
Address (line 1): _____
Address (line 2): _____
Address (line 3): _____
City, State, Zip Code: _____

Email Address: _____
Telephone Number: _____

Reference #2 Name: _____
Address (line 1): _____
Address (line 2): _____
Address (line 3): _____
City, State, Zip Code: _____

Email Address: _____
Telephone Number: _____

Please have your letters of recommendation and the official transcript sent to:

Prof. Thomas Kvale, REU director
University of Toledo
Department of Physics & Astronomy, M/S 111
Toledo, OH 43606

Please include a brief description of your computer-, apparatus-, experimental-, and/or electronics-skills, and other relevant information for us to consider. You may use a separate sheet of paper if desired.

We will send you an acknowledgment of receipt of your application as soon as possible. If you can, please also send an email note to me (tjk@physics.utoledo.edu) informing me of your application.
Thank you for your interest in our research program. Please have all materials sent to us by Friday, March 07, for fullest consideration.