Goucher College

Department of Physics and Astronomy

Handbook
2005 - 2006

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www.goucher.edu/physics

Welcome to the Department of Physics at Goucher College!

Whether you are thinking of majoring in physics or are planning to take a physics course to fulfill a general education requirement, you probably have many questions concerning physics and astronomy. What options do I have in studying physics at Goucher College? How can I get involved in original research with my physics professor? What career choices can I make with my physics degree? We hope that this handbook will help answer these and many other of your questions and introduce our department to you.

If you would like even more information, please do not hesitate to contact me or any member of our department.

September 2005

Sasha Dukan
Associate Professor and Chair

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Phone: (410) 337-6323

"…The Physics Department at Goucher is very keen on teaching students critical thinking and problem solving skills. Presented with a problem, be it experimental or theoretical, the trained physics student can navigate and negotiate herself through the solution in stepwise and analytical fashion. ….. I have been taught not to be a student crammed with facts, but to link, command and interweave the facts I do come across. I cannot readily regurgitate historical dates and thermodynamic equations, but I have been trained in their usefulness and value. I am learning how to explore, to criticize, to chew on and to scrutinize my studies…..Although I may not pursue physics directly in my intended field of study, I feel very strongly that the skills offered to me—with a foundation in the discipline of physics as well as broader study within the liberal arts curriculum---will be a very useful foundation to a physician."

Jay Zeck, Class of 2005
Physics with Concentration in Premedical Studies
M.D. student at George Washington University

Programs of Study

The Department of Physics offers several programs to students interested in Physics:

The Physics Major

The goal of the Department of Physics is to prepare students to acquire a high level of analytical thinking and problem solving abilities through in-depth study of challenging physical concepts, both theoretical and experimental. The Department, in collaboration with the Department of Physics & Astronomy at the Johns Hopkins University, offers a Major in Physics with two distinct tracks: Advanced and Applied Studies in Physics with concentration in Computer Science, Pre-medical studies and Materials Science. The core curriculum in both the Advanced and Applied Studies tracks prepares students for graduate schools and/or careers in physics such as Science Education, Research & Development, Design and Manufacturing, Government, and High Technology and Electronic Information. The recent study by the AIP (American Institute of Physics) shows Physics success stories in a variety of fields such as Acoustics, Computers, Consumer Goods, Energy Efficiency, the Environment, Global Positioning Systems, the Internet, Lasers, Liquid Crystals, Medical Imaging, New Materials, Telecommunication, and Transportation.

Students will have the opportunity to conduct scientific research with faculty in experimental and theoretical condensed matter physics, material science, atomic and molecular physics and optics at the Departments of Physics at Goucher College, the Johns Hopkins University, or the University of Maryland at Baltimore County. Other areas of research are available at the Johns Hopkins University Department of Physics and Astronomy, based on the qualifications of the students. Students present the results of their research at poster sessions within the division of Natural Science and Mathematics at Goucher College. In the past, such work has also been presented at professional conferences and been published with the student as co-author.

The following pages present typical course schedules for each program. Some courses are offered every other year (odd or even). The students who declared major or minor in physics before Fall 2005 should consult with the Departmental Chair regarding required courses.

The Physics Major (advanced studies track)

In addition to the required courses listed, students must take at least one of the electives listed. Courses marked 'JHU' are offered through the Johns Hopkins University. ENG 206 taken at any time satisfies the writing proficiency requirement. Information Literacy in the major is satisfied by PHY 220, and 280. Students should check all courses for the accompanying prerequisites.

Required Courses: The Physics Major (advanced studies track)

- PHY 125 - General Physics I
- PHY 126 - General Physics II
- PHY 220 - Modern Physics
- PHY 230 - Intermediate Physics Laboratory
- PHY 280 - Mathematical Methods in the Physical Sciences
- PHY 300 - Statistical Physics and Thermodynamics
- PHY 301 - Intermediate Electro-magnetic Theory
- PHY 303JHU - Introduction to Quantum Mechanics I
- PHY 310 - Electronics/Circuits
- PHY340 - Classical Mechanics
- PHY 395 - Independent Work in Physics
- MA 117 - Calculus I
- MA 118 - Calculus II
- MA 221 - Linear Algebra
- MA 222 - Calculus III
- CS 116 - Introduction to Computer Science
- CS 119 - Foundations of Computer Science

Elective Courses: The Physics Major (advanced studies track)

- PHY 304JHU - Introduction to Quantum Mechanics II
- PHY 313JHU - Introduction to Stellar Physics
- PHY 330 - Introduction to Material Science
- PHY314 JHU - Introduction to Galaxies and Active Galactic Nuclei

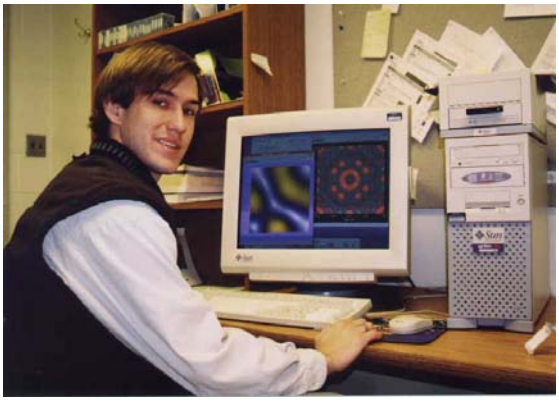
Sample schedule for a typical physics major on the advanced studies track.(Taking Physics in the Freshman Year).

Physics-Advanced Studies	Fall	Spring
Freshman	MA117 (Calculus-I) ENG104(English-I) PHY125(General Physics-I) Frontiers Connections	MA118(Calculus-II) ENG105(English-II-W) PHY126(General Physics-II) Gen-Ed (language-I)
Sophomore	MA222 (Calculus-III) PHY220 (Modern Phys.) PHY230 (Interm-Lab) Gen-Ed (Language-II) PHY.280	MA221 (Linear Algebra) Gen-Ed(language-III) Wellness Eng 206 (Scientific Writing)
Junior	PHY.340 (Class Mech) CS116 (Comp Science-I) Gen-Ed (Humanities)	PHY301(E&M) PHY300(Stat Mech) CS119 (Comp Science-II)
Senior	PHY395 (Research) PHY303*(QM-I) Gen-Ed (Social Science) PE Course	PHY310(Electronics) Gen-Ed (Arts) PHY330/PHY3xx (choice)

Sample schedule for a typical physics major on the advanced studies track.(Taking Physics in the Sophomore Year).

Physics-Advanced Studies	Fall	Spring
Freshman	MAl17 (Calculus-I) ENGl04 (English-I) Gen-Ed (Language-I) Frontiers Connections	MA118 (Calculus-II) ENG105 (English-II-W) Gen-Ed (Language-II)
Sophomore	MA222 (Calculus-III) PHY125 (General Physics-I) Gen-ed (Language-III) Gen-ed (Arts)	MA221 (Lin. Algebra) PHY126 (General Physics-II) Wellness Eng206 (Scientific Writing)
Junior	PHY220 (Modern Phys) PHY230 (Interm Lab) PHY280 (Math Meth) PHY340 (Class Mech)	PHY301 (E&M) PHY300 (Stat Mech) PE Course Gen-Ed (Social Science)
Senior	PHY395 (Research) PHY303* (QM-I)	PHY310 (Electronics) PHY3xx/PHY330(choice) Gen-ed (Humanities)

The Physics Major with Computer Science Concentration (applied studies track)



In addition to the required courses listed, students must take three elective courses out of which at least one must be at the 300 level. ENG 206 taken at any time satisfies the writing proficiency requirement. Information literacy requirement in the major is satisfied by PHY 220, and 280. Students should check all courses for the accompanying prerequisites.

Required Courses: The Physics Major with Computer Science Concentration

- PHY 125 - General Physics I
- PHY 126 - General Physics II
- PHY 220 - Modern Physics
- PHY 230 - Intermediate Physics Laboratory
- PHY 280 - Mathematical Methods in the Physical Sciences
- PHY 301 - Intermediate Electro-magnetic Theory
- PHY 310 - Electronics/Circuits
- PHY340 - Classical Mechanics
- PHY 395 - Independent Work in Physics
- CS 116 - Introduction to Computer Science
- CS 119 - Foundations of Computer Science
- MA 117 - Calculus I
- MA 118 - Calculus II
- MA 221 - Linear Algebra
- MA 222 - Calculus III

Elective Courses: The Physics Major with Computer Science Concentration

- CS 220 - Computer Organization and Assembly Language Programming
- CS 224 - Organization of Programming Languages
- CS 240 - Digital Logic Design
- CS 245 - Software Engineering
- PHY 300 - Statistical Physics and Thermodynamics
- PHY 330 - Introduction to Material Science

Sample schedule for a typical physics major with computer science concentration. (Taking Physics in the Freshman Year).

Physics-Computer Science	Fall	Spring
Freshman	MA117 (Calculus-I) ENG104(English-I) PHY125(General Physics-I) Frontiers Connections	MA118(Calculus-II) ENG105(English-II-W) PHY126(General Physics-II) Gen-Ed (language-I)
Sophomore	MA222 (Calc-III) PHY220 (Modern Phys.) PHY230 (Interm-Lab) Gen-Ed (Language-II)	MA221 (Linear Algebra) Gen-Ed(language-III) Wellness
Junior	PHY.280 Gen-Ed (Humanities) CS116 (Comp Science-I) Gen-Ed (Social Science)	PHY301(E&M) PHY300(Stat Mech-choice) Eng 206 (Scientific Writing) CS119 (Comp Science-II)
Senior	PHY.340 (Class Mech) PHY395 (Research) CS220/CS245 (choice) PE course	PHY310(Electronics) CS224/CS240 (choice) PHY330 (Materials-choice) Gen-Ed (Arts)

Sample schedule for a typical physics major with computer science concentration. (Taking Physics in the Sophomore Year).

Physics-Computer Science	Fall	Spring
Freshman	MAl17 (Calculus-I) ENGl04 (English-I) CS116 (Comp Science I) Frontiers Connections	MA118 (Calculus-II) ENG105 (English-II-W) CS119 (Comp Science-II) Gen-Ed (Language-I) Wellness
Sophomore	MA222 (Calculus-III) PHY125 (General Physics-I) CS220/CS245 (choice) Gen-Ed (Language-II)	MA221 (Lin Algebra) PHY126 (General Physics-II) CS224/240 (choice) Gen-ed (Language-III)
Junior	PHY220 (Modern Phys) PHY230 (Interm Lab) Gen-ed (Humanities) PHY280 (Math Meth)	PHY301 (E&M) PHY300 (Stat Mech-choice) Gen-ed (Arts) Eng206 (Scientific Writing)
Senior	PHY340 (Class Mech) PHY395 (Research) Gen-Ed (Social Science)	PHY310 (Electronics) PHY330 (Materials-Choice) PE Course

The Physics Major with Pre-medical Concentration (applied studies track)

In addition to the required courses listed, students must take at least one of the electives listed. Students should also consult with the Pre-med Advisor. ENG 206 taken at any time satisfies the writing proficiency requirement. Information Literacy in the major is satisfied by PHY 220, and 280. Students should check all courses for the accompanying prerequisites.

Required Courses: The Physics Major with Pre-medical Concentration

- PHY 125 - General Physics I
- PHY 126 - General Physics II
- PHY 220 - Modern Physics
- PHY 230 - Intermediate Physics Laboratory
- PHY 280 - Mathematical Methods in the Physical Sciences
- PHY 301 - Intermediate Electro-magnetic Theory
- PHY 310 - Electronics/Circuits
- PHY340 - Classical Mechanics
- PHY 395 - Independent Work in Physics
- BIO 105 - Biological Diversity II: The Vertebrates
- BIO 210 - Cell Biology and Biochemistry
- CHE 111 - Principles of Chemistry I
- CHE 112 - Principles of Chemistry I: Laboratory
- CHE 151 - Principles of Chemistry II: Lecture
- CHE 152 - Principles of Chemistry II: Laboratory
- CHE 230 - Organic Chemistry I
- CHE 235 - Organic Chemistry II
- MA 117 - Calculus I
- MA 118 - Calculus II

Elective Courses: The Physics Major with Pre-medical Concentration

- PHY 300 - Statistical Physics and Thermodynamics
- PHY 330 - Introduction to Material Science

Sample schedule for a typical physics major with pre-medical concentration.

Physics-Premedical Studies	Fall	Spring
Freshman	MA117 (Calculus-I) ENG104(English-I) PHY125(General Physics-I) Frontiers Connections	MA118(Calculus-II) ENG105(English-II-W) PHY126(General Physics-II) Gen-Ed (language-I)
Sophomore	CHE111/112 (Chem-I) PHY220 (Modern Phys.) PHY230 (Interm-Lab) BIO104(Bio-I) Gen-Ed (Language-II)	CHEM151/152 (Chem-II) BIO105 (Bio-II) Gen-Ed(language-III) Gen-Ed (Social Science) Wellness
Junior	BIO210 (Cell-Bio) CHE230 (Org Chem I) Gen-Ed (Humanities) PHY280 (Math Methods)	PHY301(E&M) PHY300(Stat Mech-choice) CHE235(Org Chem-II) Eng 206 (Scientific Writing) Take MCAT Exam
Senior	PHY.340 (Class Mech) PHY395 (Research) PE course	PHY310(Electronics) PHY330 (Materials-choice) Gen-Ed (Arts)

The Physics Major with Materials Science Concentration (applied studies track)

ENG 206 taken at any time satisfies the writing proficiency requirement. Information Literacy in the major is satisfied by PHY 220, and 280. Students should check all courses for the accompanying prerequisites.

Required Courses: The Physics Major with Materials Science Concentration

- PHY 125 - General Physics I
- PHY 126 - General Physics II
- PHY 220 - Modern Physics
- PHY 230 - Intermediate Physics Laboratory
- PHY 280 - Mathematical Methods in the Physical Sciences
- PHY 300 - Statistical Physics and Thermodynamics
- PHY 301 - Intermediate Electro-magnetic Theory
- PHY 310 - Electronics/Circuits
- PHY 330 - Introduction to Material Science
- PHY340 - Classical Mechanics
- PHY 395 - Independent Work in Physics
- MA 117 - Calculus I
- MA 221 - Linear Algebra
- MA 222 - Calculus III
- CHE 111 - Principles of Chemistry I
- CHE 112 - Principles of Chemistry I: Laboratory
- CHE 151 - Principles of Chemistry II: Lecture
- CHE 152 - Principles of Chemistry II: Laboratory
- CHE 265 - Physical Chemistry Fundamentals I
- CHE 265L - Physical Chemistry Fundamentals I Laboratory

Sample schedule for a typical physics major with materials science concentration.

Physics Major with Materials Science	Fall	Spring
Freshman	MA117 (Calculus-I) ENG104(English-I) PHY125(General Physics-I) Frontiers Connections	MA118(Calculus-II) ENG105(English-II-W) PHY126(General Physics-II) Gen-Ed (language-I)
Sophomore	MA222 (Calculus-III) PHY220 (Modern Phys.) PHY230 (Interm-Lab) Gen-Ed (Language-II) CHE 111/112 (Chem-I)	MA221 (Linear Algebra) CHE 151/152 (Chem-II) Gen-Ed(language-III) Wellness
Junior	CHE 265/265L (Phys Chem-I) PHY280(Math Meth) Gen-Ed (Humanities)	PHY301(E&M) PHY300(Stat Mech) Eng 206 (Scientific Writing) Gen-Ed (Social Science)
Senior	PHY395 (Research) PHY.340 (Class Mech) Gen-Ed (Arts) PE Course	PHY310(Electronics) PHY330 (Materials)

In *Introduction to Material Science* course, physics students Ann Thomas and Joel Tenenbaum built a model of a crystal and analyzed its structure.

3/2 Science & Engineering Program

Goucher College has established a dual degree program through which students earn both a bachelor of arts degree from Goucher and a bachelor of science degree from the G.W.C. Whiting School of Engineering of The Johns Hopkins University. The purpose of the program is to enable students to explore the liberal arts and sciences, while developing professional knowledge and experience in a specific field of engineering. Students in the program will be admitted initially by Goucher College, where they will typically spend three years fulfilling general education requirements and completing major requirements for the B.A. degree in biology, chemistry, computer science, mathematics, or physics. There are three distinct concentrations within the physics major that may be chosen. However, the Physics major with computer science concentration may be the best suited for the 3/2 engineering program for two reasons: (1) the schedule flexibility and (2) variation of the required courses. Successful students will then complete an additional two years at Johns Hopkins, during which requirements will be completed for the bachelor of science degree in one of the following disciplines: " Electrical and computer engineering, which includes the fields of communications, control systems, electronics, and digital systems. " Material science and engineering, which is concerned with the structure, properties, performance, processing, and production, of all materials. " Mechanical engineering, which deals with the concerns of energy through useful mechanical devices. " Biomedical engineering, which encompasses the application of engineering principles to medical and biological problems. " Chemical engineering, which relies on the laws of physics, chemistry, and mathematics to change the structures of chemical substances and purify new substances that are created in the process. " Civil engineering, which reflects the breadth of the engineering disciplines in the planning and design of buildings, bridges, transportation systems, and environmental programs. A typical student will complete one year of physics, one year of calculus in the Freshman Year. PHY220, PHY230, PHY(300 or 330), MA221 and 222 in the Sophomore Year. One course per semester should be taken at Hopkins during the student's third year at Goucher depending on the Engineering discipline. Students interested in pursuing the 3/2 Program are encouraged to speak with Dr. Ali Bakhshai (abakhsha@goucher.edu) for details on the various programs. This program is highly demanding and its completion in five years may be possible only if a student is exempt from some introductory courses or if courses are taken in the summer.

Required Courses: 3/2 Science & Engineering Program

- MA 117 - Calculus I
- MA 118 - Calculus II
- MA 221 - Linear Algebra
- MA 222 - Calculus III
- MA 231 - Differential Equations with Applications
- CS 116 - Introduction to Computer Science
- PHY 125 - General Physics I
- PHY 126 - General Physics II

- CHE 111 - Principles of Chemistry I
- CHE 112 - Principles of Chemistry I: Laboratory
- CHE 151 - Principles of Chemistry II: Lecture
- CHE 152 - Principles of Chemistry II: Laboratory

Post Baccalaureate Pre-Med Program

The Department also participates in Goucher's Post Baccalaureate Program by offering courses which prepare the returning student for the rigors of medical school by providing specific topical material and, more importantly, by providing a forum for instilling such skills as critical thinking, construction of logical arguments, and clear expression of ideas.

Required Courses: Post Baccalaureate Pre-Med Program

- PHY 542 - Principles of Physics I
- PHY 543 - Principles of Physics II

Honors in the Major

Majors in the Department of Physics are encouraged to strive for Honors in the major at the graduation. Departmental honors will be awarded on the basis of outstanding course work and additional independent research achievements. Students who wish to be considered for Honors in major should plan their schedule to include independent research as described in the guidelines below.

a) The Degree with Distinction
The degree with distinction is awarded to students who achieve a 3.5 cumulative grade point average (GPA) in a total of no fewer than 60 graded credits. For students who complete more than 75 credits in residence, 80 percent of the total credits must be completed on a graded basis. All graded credits taken in residence will be counted in calculating the GPA for the degree with distinction. Transfer students may not be able to take course pass/no pass and still qualify for the degree with distinction unless they take more than 60 credits in residence.
b) The Degree with Honors in Physics
Requirements for Honors in Physics:
1. A minimum grade point average of 3.5 in courses required for the physics major exclusive of 100 level courses.
2. A high level of achievement in either two semesters of independent research work or one summer independent research work plus one semester of independent research work under supervision of a faculty member from the Department of Physics. Results of independent work should be presented either at open seminar attended by students and faculty or in Senior Thesis graded by the physics faculty members. Final selection requires the approval of the majority of the faculty members in the Department of Physics.

Physics Minor

Minor in Physics prepares the student for graduate work or for entrance into professional schools, or forms part of the 3-2 Science and Engineering Program (for more information on this program, refer to the Science and Engineering page in the Goucher Catalogue).
In addition to the required courses, four electives must be taken, of which at least one is a 300 level course.

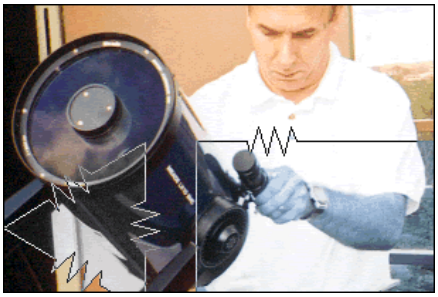
Required Courses: Physics Minor

- PHY 125 - General Physics I
- PHY 126 - General Physics II
- PHY 220 - Modern Physics
- PHY 230 - Intermediate Physics Laboratory
- MA 117 - Calculus I
- MA 118 - Calculus II

Elective Courses: Physics Minor

- PHY 280 - Mathematical Methods in the Physical Sciences
- PHY 300 - Statistical Physics and Thermodynamics
- PHY 310 - Electronics/Circuits
- PHY 330 - Introduction to Material Science
- PHY340 - Classical Mechanics
- PHY 395 - Independent Work in Physics
- CHE 265 - Physical Chemistry Fundamentals I
- MA 221 - Linear Algebra
- MA 222 - Calculus III
- MA 231 - Differential Equations with Applications

Service Courses



Courses at the introductory level in physics are planned to meet various needs. Physics 115 and 116 are designed to give a general survey of physics with emphasis on physical reasoning rather than mathematical analysis and are intended for students who plan to major in the life sciences, enter the health professions, or teach in the elementary schools. Physics 125, and 126 are more comprehensive and more analytical and are intended for students who plan to minor in physics or major in the physical sciences or mathematics. Astronomy 110 is intended to satisfy students' science distribution requirements.

Courses/Course Resources

Introduction to Astronomy

AST110 - 4 Credits

An introduction to the scientific methods of discovery that have led to the development of modern astronomy and its impact on our world view. Special focus and discussion on current scientific discoveries in astronomy. Three hours lecture and three hours laboratory. Fall semester, Repeated Spring semester.

Taught by Ali Bakhshai

Course Web Site: http://www.goucher.edu/physics/ast110/110syl-05.htm

Spanish-Astronomy in Grenada

AST110G - 8 Credits

Cross-listed as SP 130G. A regularly scheduled course in Spring semester at Goucher in combination with three-week intensive course in Spain during the month of May. This course will encourage a great deal of interdisciplinary study among our students by studying sciences and Spanish in a Spanish city that is known for its Astronomical observations such as IRAM (www.iram.es) and its multiethnic environment. Credits will be distributed as follows: 3 credits in spring (1.5 for SP 130g and 1.5 for AST 110); 5 credits in the summer (2.5 for SP 130G and 2.5 for AST 110. Prerequisites: Spanish 120. Spring/Summer. Offered 2004-05 and alternate years.

Taught by Ali Bakhshai

Principles of Physics I

PHY115 - 4 Credits

A non-calculus-based course using the new and untraditional method of interactive physics. Lecture and laboratory are combined and taught using an interactive method employing computers and guided inquiry through hands-on experiments. The method is designed to increase problem-solving and analytical thinking skills and to guide students toward a coherent and logical approach to an understanding of the world. Topics include Newtonian mechanics, fluids, kinematics and dynamics of linear and angular motions, universal gravitation, conservation of energy and momentum, elasticity and simple harmonic motion. Recommended with PHY 116 for students majoring in the life sciences. Six hours integrated lecture/laboratory. Prerequisite: Three years of high school mathematics. Fall Semester.

Taught by Marin Pichler

Course Web Site: http://www.goucher.edu/physics/phys115/PHY115syllabus.pdf

Principles of Physics II

PHY116 - 4 Credits

A continuation of PHY 115. Mechanical and electromagnetic wave motion, acoustics, resonance, the nature of light and color, geometrical and physical optics, static electricity, DC and AC circuits, electricity and magnetism. Six hours integrated lecture/laboratory. Prerequisite: PHY 115. Spring semester.

Course Web Site: http://www.goucher.edu/physics/phys116/116syl.htm

General Physics I
PHY125
A calculus-based course using the new and untraditional method of interactive physics. Lecture and laboratory are combined and taught using an interactive method employing computers and guided inquiry through hands-on experiments. The method is designed to increase problem-solving and analytical thinking skills and to guide students toward a coherent and logical approach to an understanding of the world. Topics include kinematics and dynamics of motion, oscillatory motion, and fluids. Six hours integrated lecture/laboratory. Prerequisite: MA 117 or permission of the instructor. Fall semester.
Taught by Sasha Dukan
Course Web Site: http://www.goucher.edu/physics/phys125/125syl.htm

General Physics II
PHY126 - 4 Credits
A continuation of PHY 125. Topics include wave motion, electricity and magnetism, physical and geometrical optics. Prerequisite: PHY 125 and MA 118, or concurrent enrollment in MA 118. Spring semester.
Course Web Site: http://www.goucher.edu/physics/phys126/126syl.html

Modern Physics
PHY220 - 3 Credits
An introductory course in non-classical physics for students who have completed calculus-based general physics. It is intended to introduce students to the frontiers of physics in a simple, comprehensible manner through discussions, problem solving, interactive computer simulations and additional readings. Topics include: basic ideas of quantum mechanics with experiments that revolutionized our understanding of nature, and lead to the development of new fields such as atomic and molecular physics, condensed matter physics, nuclear and elementary particle physics, astrophysics and cosmology. Prerequisite: PHY 126. Corequisite: PHY 230. First semester.
Taught by Sasha Dukan
Course Web Site: http://www.goucher.edu/physics/phys220/220syl.html

Intermediate Physics Lab
PHY230 - 2 Credits
Exploration of modern scientific methods. Measurement of several classical and modern physics constants. Experiments include: making superconducting samples and measuring TC and JC, e/m, Millikan Oil Drop, Photo-electric Effect, Davisson-Germer, Speed of Light, Franck-Hertz, Hall Effect, and Atomic Force Microscope measurements. Three hours laboratory. Corequisite: PHY 220.

Mathematical Methods in the Physical Sciences
PHY280 - 3.5 Credits
A comprehensive problem solving oriented course designed for students in physics, chemistry, and 3-2 engineering programs. Various mathematical methods as applied to the relevant problems

in the physical sciences are discussed. Topics: series, complex analysis, partial differentiation, vector analysis, calculus of variation, tensors, differential equations, special functions, integral transforms. Three hours lecture and one hour computer laboratory, utilizing the symbolic/numerical/graphical package Maple. Prerequisites: PHY 126 and MA 118 or permission of instructor. Second semester. Offered Fall 2006-07 and alternate years
Taught by Sasha Dukan
Course Web Site: http://www.goucher.edu/physics/phys280/280syl-04.html

Internship in Physics

PHY290 - Variable Credits
Internships in research laboratories in universities and industry. Arranged on the basis of the individual interest of the student. Graded Pass/No Pass only. Prerequisites: PHY 125 and 126, and appropriate upper-level courses. Department.
Course Web Site: http://www.goucher.edu/physics/physics_template.cfm?page_id=7

Statistical Physics and Thermodynamics

PHY300 - 3 Credits
A calculus-based course in which the basic concepts of thermodynamics are introduced from the microscopic point of view. Methods of statistical physics are used to define entropy and temperature, heat and work, ideal gas behavior. Applications to chemical reactions, Fermi and Bose systems in condensed matter physics and phase transformations are discussed. Prerequisite: PHY 220 or permission instructor. Spring semester. Offered 2006-07 and alternate years.
Taught by Marin Pichler
Course Web Site: http://www.goucher.edu/physics/phys300/phy330syl-04.html

Intermediate Electro-magnetic Theory

PHY301 - 3 Credits
Intermediate level discussion of Maxwell's Equations and their applications: electro-statics and dynamics, magnetic fields and magnetic effects, and electro-magnetic waves, both in vacuum and in materials. Pre-requisite PHY280. Spring semester. Offered 2006-2007 and alternate years.
Course Web Site: http://www.goucher.edu/physics/phys301/301syl.htm

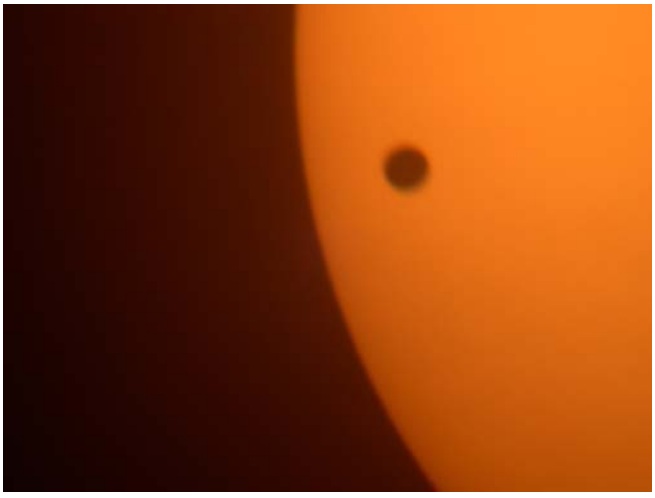
Electronics - Circuits

PHY310 - 4 Credits
An introduction to principles of electronic instrumentation that would enable students to choose appropriate instruments for a measurement or control problem. Topics include: dc & ac circuits, capacitors, diodes, transistors, operational amplifiers, waveform shaping, gates, flip-flops, registers and counters, and microprocessor basics. Three hours lecture and three hours laboratory. Spring semester. Offered 2005-2006 and alternate years. Taught by Marin Pichler.

Introduction to Materials Science
PHY330 - 3 Credits
This course uses investigative, hands-on laboratory projects to introduce students to the fast growing area of materials study and research. Team-taught by members from the physics and chemistry faculty, it models modern research collaborations and prepares students for increasingly interdisciplinary industry and research careers. Topics include study of metals, semiconductors, superconductors, and polymers using techniques of photoluminescence and AFM spectroscopy as well as carrier transport measurements. The integrated lecture/laboratory format emphasizes peer-led discussions and an innovative, expert/novice, peer-learning scheme. Prerequisite: PHY 220 or permission of instructor. Spring semester. Dukan/Sibley. Offered 2005-006 and alternate years. Taught by Sasha Dukan
Course Web Site: http://www.goucher.edu/physics/phys330/materials.html

Classical Mechanics
PHY340 - 3 Credits
This course presents kinematics and dynamics of particles using Newtonian, Langrangian and Hamiltonian techniques. Topics include central force motion, oscillations and normal mode analysis, non-linear dynamics, rotating rigid bodies and motion in non-inertial reference frames. Prerequisite: PHY 280 or permission of instructor. Fall semester. Offered 2007-08 and alternate years. Taught by Sasha Dukan

Independent Work in Physics
PHY395 - Variable Credits
Independent theoretical and laboratory work carried out under the supervision of a member of the department. May be one or two semesters. Prerequisites: Minor in physics and/or permission of instructor. First semester, repeated second semester.
Course Web Site: www.goucher.edu/physics/phys395/phys395.html



The Transit of Venus as captured by Department’s telescope with CCD camera.

Facilities

No distinction is made between Teaching and Research Facilities; students are encouraged to make use of our equipment for Collaborative Research and Independent Projects.

- Two up-to-date teaching classroom with the latest computer-aided laboratory equipment and teaching software.
- An Electronics Laboratory
- A Physics Instrumentation Laboratory
- A Low-Temperature Solid State Characterization Laboratory.
- Materials Science Sample Preparation Facilities.
- Three SUN workstations.
- A time-resolved (~500 pS) low temperature (~3K) photo-luminescence/fluorescence system.
- A time resolved (~150 pS) fluorescence/absorption spectrometer.
- Magneto-Optical Trap apparatus for cooling and trapping of Cesium atoms and ultracold molecule formation and spectroscopy.
- External cavity diode laser systems with active stabilization.
- A Quesant atomic force microscope
- A 12" LX200 Meade Schmidt-Cassegrain telescope, equipped with an SBIG ST-8E CCD camera with an automated filter system for color photographs. The telescope can also be fitted with an adaptive optics system and a spectrometer.
- Four Meade LX50 8" telescopes.
- Radio telescope CASSI.

Quesant Atomic Force Microscope is used both as a teaching and as a research tool.

Faculty/Staff

Ali Bakhshai, Ph.D.
Professor of Physics
Office: Hoffberger, G10-C
Phone: (410) 337-6320
E-mail: abakhsha@goucher.edu
Web Site: http://www.goucher.edu/physics/web-bakhshai/Index.htm

Biography:
Ph.D., University of Texas at Arlington, 1982 Experimental Condensed Matter Physics

Teaching Interests:
Postbac Physics and Intro to Astronomy

Research Interests:
Mechanical Alloying, Material Synthesis, Nanostructured Materials Via Ball Milling, Electrical Properties, Characteristics studies, and magnetic studies of bulk high temperature superconductors.
Micro-Hardness Characteristics and Morphology of Cr-Coating formed due to Mechanical Alloying.

Undergraduate Research Assistants:
John Sergeant, class of 2006- Summer 2005
Jay Zeck, class of 2005-Summer 2004
Gregory S. Dengler, class of 2005-Summer 2003
Jay Zeck, class of 2005-Summer 2002
Rajan Pragani, class of 2003-Summer 2002
Mark Ryclick, class of 1990-Summer 1989

Publications:
1. J. Zeck and A. Bakhshai, "Rotational Curve and Gravitational Mass of Galactic Interior at 21-cm Hydrogen Line Observance", Proceedings of the National Conference on Undergraduate Research (NCUR) 2005, Washington and Lee University, Virginia Military Institute, Lexington, Virginia, April 21-23, 2005.
2. G. Dengler, A.R. Torosyan, A. Bakhshai, "-Hardness Characteristics and Morphology of Cr-coating formed due to Mechanical Alloying", Proceedings of the National Conference on Undergraduate Research (NCUR) 2004, April 15-17, 2004. Proceedings of the ICP2004 (International Conference on Physics), Tehran, Iran, 2004.
3. J. Zeck, L. Takacs, and A. Bakhshai, "Significance of Loose Powder Ignition in Mechanochemical Reactions Based on Copper Oxides' Anomalistic Ignition Behaviors" Proceedings of the National Conference on Undergraduate Research (NCUR) 2003, March 13-15, 2003.

Sasha Dukan, Ph.D.
Associate Professor of Physics and Chair.
Office: Hoffberger, G10-e
Phone: (410) 337-6323
E-mail: sdukan@goucher.edu
Web Site: http://www.goucher.edu/physics/dukan/dukapage.html

Biography:

Ph.D., Johns Hopkins University, 1995 Theoretical Condensed Matter Physics

Research Interests:

Theoretical problems of superconductivity in magnetic field: high-temperature superconductors and other type-II superconductors. Funded by the National Science Foundation and the Research Corporation.

Teaching Interests:

General Physics, Modern Physics, Mathematical Methods in Physics, Statistical Physics, Classical Mechanics, Introduction to Materials Science

Undergraduate Research Assistants

Daniel Pines, class of 2006, Summer 2005
Joel Tenenbaum, class of 2006, Summer 2004
John Trafton, class of 2003, Summer 2002
Amanda Carr, class of 2002, Summer 2001 and 2002
T. Paul Powell, class of 2003, Summer 2001
Richard Howard, class of 2002, Summer 2000
John Oleszkiewicz, class of 2000, Summer 1998
Oskar Vafek, class of 1998, Summer 1997

Publications:

1. Joel Tenenbaum and Sasha Dukan, 'Differential Conductance of Type II Superconductors at High Magnetic Fields', *Proceedings of the National Conference On Undergraduate Research (NCUR)*, 2005.
2. Amanda Carr, John J. Trafton, Sasha Dukan, and Zlatko Tesanovic, 'Low-temperature specific heat of an extreme type-II superconductor at high magnetic fields,' *Physical Review B* 68, 174519 (2003).
3. Sasha Dukan, T. Paul Powel and Zlatko Tesanovic, 'Quasiparticle thermal conductivities in a type-II superconductor at high magnetic fields,' *Physical Review B* 66, 014517 (2002).
4. S. Dukan and O. Vafek, 'Anomalous Behavior of the Upper Critical Field in Strongly Type-II Superconductors at Low Temperatures,' *Physica C*, 309(3-4**)**, 295 (1998).

Marin Pichler, Ph.D.
Assistant Professor of Physics
Office: Office: Hoffberger G10-d
Phone: 410-337-6328
E-mail: marin.pichler@goucher.edu

Biography:
Ph.D, University of Connecticut, 2001 Experimental Atomic, Molecular and Optical Physics

Research Interests:
Ultracold molecules, cold reactive collisions, photoassociation and quantum degenerate systems. Applications of ultracold systems in quantum information processing; Femptosecond spectroscopy.

Teaching Interests:
General Physics, Modern Physics, Classical Mechanics, Modern Physics Lab, Electronics and Circuits.

Publications:
1. Marin Pichler, Hongmin Chen, William C. Stwalley, "Photoassociation spectroscopy of ultracold Cs below $6P_{3/2}$ limit," *J. Chem. Phys.* 121, 6779, 2004.
2. Jabez. J. McClelland, Shannon B. Hill, Marin Pichler, Robert J. Celotta "Nanotechnology with atom optics," *Sci. Tech. Adv. Materials*, 5, 575, 2004.
3. Marin Pichler, Hongmin Chen, William C. Stwalley, "Photoassociation spectroscopy of ultracold Cs below $6P_{1/2}$ limit," *J. Chem. Phys.* 121, 1736, 2004.
4. Marin Pichler, William C. Stwalley, Robert Beuc, Goran Pichler "Formation of ultracold Cs_2 molecules through the double minimum Cs_2 $3\ ^1\Sigma_u^+$ state," *Phys. Rev. A*, 69, 013403, 2004.
5. Ionut Prodan, Marin Pichler, Mark Junker, Randall G. Hulet "Intensity dependence of photoassiciation in a quantum degenerate atomic gas," *Phys. Rev. Lett.* 91, 080402, 2003.
6. M. Pichler et al. "Photoassociation of ultracold K atoms: Observation of high lying levels of 1_g~$1\ ^1\Pi_g$ molecular state of K_2," *J. Chem. Phys.*, 118, 7837, 2003.

Semyon Ginzburg

Physics Laboratory Support Staff
Office: Hoffberger, B29
Phone: (410) 337-6321
E-mail: sginzbur@goucher.edu
Web Site: ginzburg/ginzpage.htm

Biography:

B.S., State College of Education, Minsk, 1977 Methodology of Teaching Physics

1980 – 1989: Physics recourse teacher at the Science School for the Gifted and Talented Minsk, Belarus. Taught regular and advanced courses in physics at the High School level. Designed and taught special courses in physics for gifted and talented High School students. Researched and developed a new curriculum for High School physics, with particular emphasis on the fundamental laws and phenomena. Provided guidance for student's research projects. Tested and evaluated potential physics textbooks in the classroom. Supervised training of undergraduate students – teachers.

Research Interests:

Methods and Techniques in Physics Laboratory Experiments. Design of new physics lab experiments.

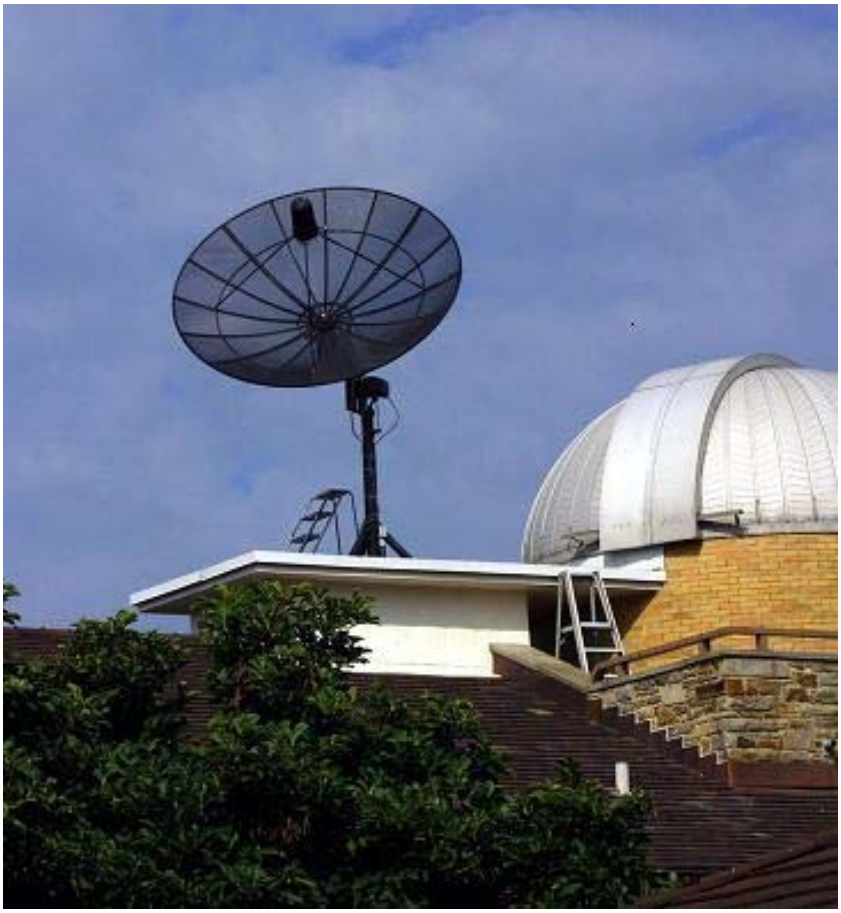
Student Research &Independent Projects

Student Research Projects typically require full time work under the supervision of a faculty member and result in either presentation at a professional meeting or publication in refereed journal with the student listed as co-author. There is monetary support available to students for these research projects.

Nano-Composites and Mechanical Alloying Via the Ball Milling Technique

Student Author: J. Sergeant
Faculty Author: A. Bakhshai

Ball milling technique has been utilized to produce nano-composites and to ascertain the fundamental parameters of the mechanochemical reaction and the mechanical alloying process. This is an innovative method of material synthesis that, compared to the current methods, is very cost effective and environmental friendly although it has not been thoroughly analyzed. There are some general understandings of mechanical alloying based on the basic thermodynamics of the reaction that have been widely accepted. Certain parameters of these theories have been investigated and confirmed through experimental data. These fundamental parameters help the understanding of the ball milling process.



Rotational Curve and Gravitational Mass of Galactic Interior at 21-cm Hydrogen Line Observance

Student Author: J. Zeck (Class of 2005).
Faculty Author: A. Bakhshai,

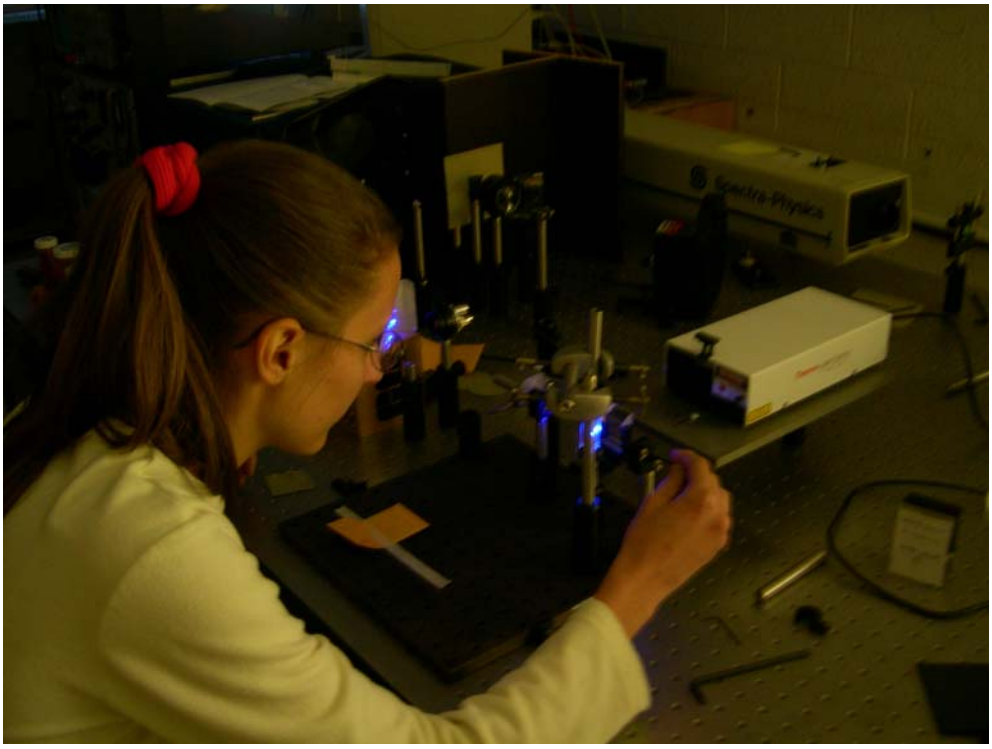
A Small Radio Telescope (SRT) was installed and calibrated to allow for interstellar hydrogen spectral readings at 1420 megahertz frequency. Observance of the 21-cm Hydrogen Line produced in accordance with this frequency allowed for a determination of the rotational velocity of the galaxy within the 8.5kpc region between the Sun and the center of the galaxy. Plotting rotational velocities as a function of galactic radius yielded a galactic rotation curve that approximately models the rotational behavior of the galaxy from the solar system to the galactic center. The rotational curve observed is relatively constant and thus characteristic of a system that has uniformly distributed mass. Stars and other known celestial masses are too few and scattered to account for such an observed distribution, thus assertions about the presence of interstellar 'dark matter' are justifiable. Rotational velocity values were also utilized to approximate the gravitational mass of the galaxy's interior.

Tunneling Properties of Type-II Superconductors in High Magnetic Fields
Student Author: Joel Tenenbaum (Class of 2006)
Faculty Author: Sasha Dukan

The tunneling conductance between the surface of an extreme type-II superconductor and the tip of a Scanning Tunneling Microscope (STM) in high magnetic field with temperature approaching zero is calculated. It is found that when the STM tip is placed at the position of a vortex, the differential conductance has an algebraic dependence on a bias voltage reflecting the presence of the gapless points in the quasiparticle excitation spectrum of a superconductor in high magnetic fields. The differential conductance as a function of a position of the STM tip and for a fixed value of a bias voltage has a six-fold symmetry of a triangular vortex lattice with the maxima located at the position of the vortices. Supported by the Research Corporation Cottrell College Science Award.

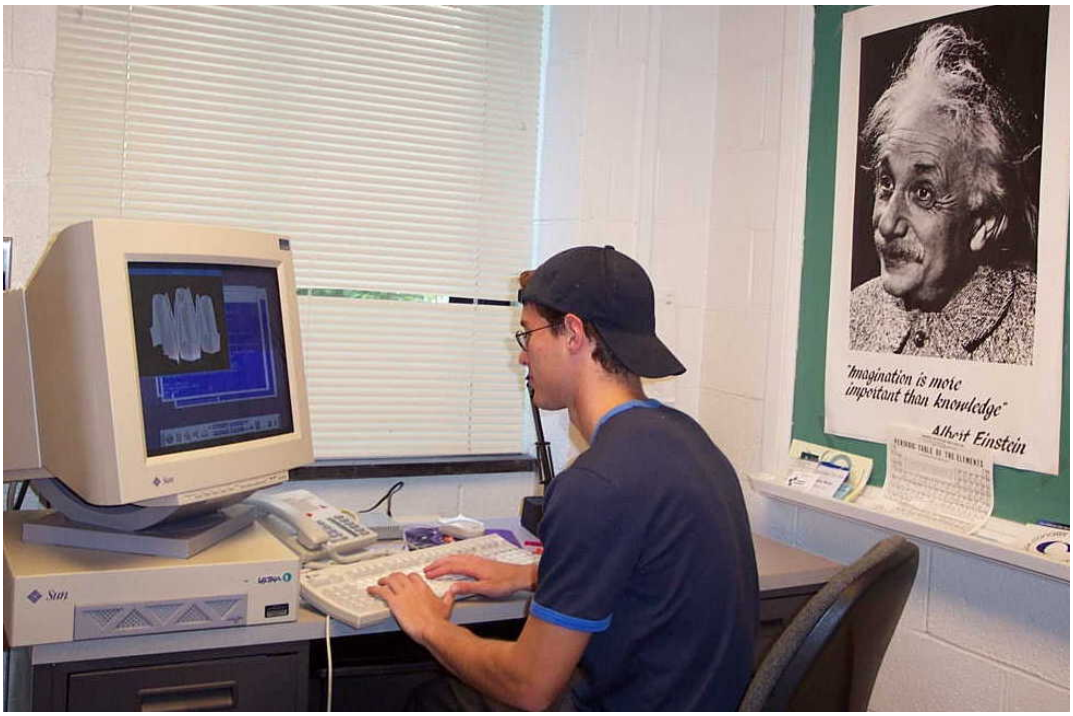
This work was selected by the Council of Undergraduate Research (CUR) to be presented at the 2005 Posters on the Hill at the National Capitol in Washington DC, as well as published in the Proceedings of the National Conference on the Undergraduate Research (NCUR) 2005.

Project Web Site:
http://www.goucher.edu/news/news_press_release_template.cfm?press_ID=893



Fluorescence Lifetime Measurements of Biological Spores and Pollens
Student Author: Ann Thomas (Class of 2006)

Concern about biological terror has increased greatly in the 21st century and hence, so has the need for accurate detection and identification of biological hazards. Optical techniques have shown to be useful for this purpose. By looking at the fluorescence lifetimes as a function of emission wavelength for different materials, there is the possibility that the data gathered from each material can be accurately compared with unknown materials using point detection. Although the lifetimes range between 2-6 ns, each material that was tested seemed to be distinguishable when compared. This led to a preliminary database for possible use in a future system. Ann Thomas presented her research at the National Conference on the Undergraduate Research (NCUR) in Lexington, Virginia as well as published her results in the NCUR proceedings. This research was supported by funds from the United States Army.



Numerical Study of the Specific Heat in Type-II Superconductors at High Magnetic Fields and Low Temperatures

Student Author: John Trafton (Class of 2003), Amanda Carr (Class of 2002)
Faculty Author: Sasha Dukan

Amanda Carr and John Trafton used Dr Dukan's theoretical model for the low-temperature behavior of the specific heat of type-II superconductors at high magnetic fields to develop C++ computer codes that calculate this quantity numerically for the realistic superconducting systems. They found the algebraic temperature dependence of the specific heat as a function of temperature as well as non-analytic magnetic field dependence. Amanda presented her work at the Goucher's student EXPO after she came back from her study abroad semester in Hungary. John has continued this work and applied it to the boro-carbide superconductor YNi_2B_2C and co-authored a paper published in the Physical Review B. This research was supported by the Research Corporation Cottrell College Science Award.

Project Web Site: http://www.goucher.edu/physics/dukan/dukanweb.html

Publications authored by Goucher Physics Students

J. Zeck and A. Bakhshai, “Rotational Curve and Gravitational Mass of Galactic Interior at 21-cm Hydrogen Line Observance”, *Proceedings of the National Conference on Undergraduate Research (NCUR) 2005, Washington and Lee University, Virginia Military Institute, Lexington, Virginia, April 21-23, 2005.*

Joel Tenenbaum and Sasha Dukan, 'Differential Conductance of Type II Superconductors at High Magnetic Fields', *Proceedings of the National Conference On Undergraduate Research (NCUR), 2005*.

Ann Thomas, David Sands and Dave Baum, 'Emission Wavelength Dependence of Fluorescence Lifetimes of Spores and Polens', *Proceedings of the National Conference On Undergraduate Research (NCUR), 2005*

G. Dengler, A.R. Torosyan, A. Bakhshai, “-Hardness Characteristics and Morphology of Cr-coating formed due to Mechanical Alloying”, Proceedings of the National Conference on Undergraduate Research (NCUR) 2004, April 15-17, 2004. *Proceedings of the ICP2004 (International Conference on Physics), Tehran, Iran, page 7, 2004.*

J. Zeck, L. Takacs, and A. Bakhshai, **“**Significance of Loose Powder Ignition in Mechanochemical Reactions Based on Copper Oxides’ Anomalistic Ignition Behaviors” *Proceedings of the National Conference on Undergraduate Research (NCUR) 2003, March 13-15, 2003*.

A. L. Carr, J. J. Trafton, S. Dukan and Z. Tesanovic, "Low-Temperature Specific Heat of an Extreme Type-II Superconductor at High Magnetic Fields, Phys. Rev. B 68, 174519 (2003).

A. Bakhshai, **R. Pragani**, and L. Takacs, 'Self-Propagating Reaction Induced by Ball Milling in a Mixture of Cu_2O and Al Powders,' *Metallurgical and Materials Transactions A, 33A, 3521-3526 (2002).*

S. Dukan **T.P. Powell** and Z. Tesanovic, *"Quasiparticle Thermal Conductivities in a Type-II Superconductor at High Magnetic Field", Phys. Rev. B 66 (1), 014517 (2002).*

S. Dukan and **O. Vafek,** *"Anomalous Behavior of the Upper Critical Field in Strongly Type-II Superconductors at Low Temperatures",Physica C, 309 (3-4), 295 (1998).*

The Goucher College Physics Club

The Goucher Physics Club was founded in the fall of 2002 as a means for students interested in the discipline to ask questions, share ideas, thoughts and organize events pertinent to interest in the subject. This broad base was established in the hopeful venture toward future club growth. Formal and informal talks, often co-organized with the Physics Department, are essential to keeping the interest level in physics vivid on campus. In the past, team-building actions (such as *physics* polo shirts) also have helped add to recognition and unity among the few but proud physicists of Goucher.
Physics itself can be a trying subject with many complexities and subtleties that often require a well-resourced student. It is the hope of the first members that The Physics Club of Goucher College can develop to be such a resource.

Jay C. Zeck,
Class of 2005
Club Founder, President 2002-2004

Executive Board:
Ann Thomas, *President*
Myrrha Andersen, *Treasurer*

Physics Seminars and Colloquia

2005: Dr. Drazen Zanchi, professor of theoretical physics at the University of Paris, presented the latest findings about how the physico-chemical process involved in aging red wine may be related to its heart-healthy effects.

2004: Dr. Lawrence Krauss, 'Einstein's Biggest Blunder? : A Cosmic Mystery Story.' Each year, the department sponsors the Taylor Lecture Fund lecture in Physics. Dinner after the lecture allows our students to interact more intimately with our guest. In 2004 Lecturer was Dr. Lawrence Krauss. The title of his talk was: "Einstein's Biggest Blunder?: A Cosmic Mystery Story."

2003: Dr. Harry Shipman, 'Bioastronomy: New Understandings of Life in the Universe.' Dr. Shipman holds an appointment as the Annie Jump Cannon Professor in the Physics Department at the University of Delaware. His visit was sponsored by the American Astronomical Society's Harlow Shapely Visiting Lectureship Program.

2002: Meet the Scientist: Richard DeVito, 'Stealth Fighters and Razor Blades: A Scientist's Life in Industry.' Mr. DeVito has worked in industry for fifteen years, during which he has held positions at Litton-Itek, Gillette, Corning Netoptix, and Unaxis. Currently, Mr. DeVito is with a start-up company involved with Atomic Layer Deposition for the semiconductor field. Sponsored by the Taylor Lecture Fund.

Awards, Internships, and Jobs

Awards

The Department of Physics offers the Mary Ross Flowers '28 Award in Astronomy ($500) every year for the best research project, either observational or theoretical, in Astronomy or Astrophysics. Each applicant will present a talk to the faculty, who will decide the winner. Contact Dr. Ali Bakhshai for information.

Up to two summer stipends of $3500/ten weeks for research in Computational Physics is offered by Dr. Dukan.

Internship Information

The Career Development Office (CDO) has a packet of forms and information for you, including a checklist of the necessary actions you must take. The 'Off Campus Experience' does not have to be fulfilled through an internship, nor do internships need to be undertaken in the summer; however, it is anticipated that most physics majors will do so.

There are many opportunities available for students to work in industry or at research institutions in the Baltimore area:

- American Association for the Advancement of Science.
- Applied Physics Laboratory
- Ciena
- Federal Bureau of Investigation
- Geophysical Laboratory
- Institute of Paper Science and Technology
- NIST
- Smithsonian Environmental Research Center.
- Space Telescope Science Institute.
- Goddard Earth Sciences and Technology Center

Internships located across the nation include:

- IBM Summer Internships for Women & Minorities in Physics
- AT&T Summer Internships for Women & Minorities in Physics
- UNCF/Merck Science Initiative (Minorities)
- APS/IBM Research Internship for Undergraduate Women

Student Placement

Alumni:

Greg Dengler
Physics Major
Class of 2005. Currently in the Masters Program at Georgetown University in Washington D.C.

Jay Zeck
Physics Major
Class of 2005. Currently in the M.D. Program at George Washington University in Washington, DC.

Richard Howard
Physics Major
Class of 2002. Currently working for high-tech company in Maryland.

John Oleszkiewicz
Physics Minor
Class of 2000. Obtained his M.S. in Computer Science from the Johns Hopkins University in 2002 and is currently working in industry in Maryland.

Bridget Wildt
Physics Minor
Class of 2001. Employed by Huber Engineered Materials. Currently applying to Graduate Programs in Material Science.

Oskar Vafek
Physics Minor
Class of 1998. Earned Ph.D. in Theoretical Physics at the Johns Hopkins University. Currently a post-doctoral fellow at Stanford University under Nobel Prize winning Professor Robert Laughlin.

Amanda Carr
Physics Research Student
Class of 2002. Currently working in Washington, D.C.

Gueorgui Gueorguiev
Physics Minor
Class of 2000. Currently in the Ph.D. Program in Astronomy at Ball State University.

T. Paul Powell
Physics Research Student
Class of 2003. Selected by Teach for America for a position in Los Angeles.

Rajan Pragani
Physics Research Student
Class of 2003. Currently in the Chemistry Ph.D. program at the University of Michigan.

John Trafton
Physics Research Student
Class of 2003. Currently in the Applied Mathematics Masters program at the University of Maryland College Park.