2006 GRADUATE PROGRAMS

in Physics, Astronomy, and Related Fields

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in Physics, Astronomy, and Related Fields

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FOREWORD

The *2006 Graduate Programs in Physics, Astronomy, and Related Fields* provides information on graduate programs in North America. This is the thirtieth annual edition.

The great majority of the U.S. physics and astronomy doctoral programs and most master's programs in both fields are featured. Coverage of Canadian departments is somewhat less complete. A substantial number of physics-related fields are listed, including nuclear engineering, electrical engineering, chemical physics, materials science, meteorology, geophysics, medical physics, and oceanography departments. The astronomy-related fields, such as astrophysics, atmospheric, space physics, cosmic rays, and others, are covered as well. The field of Acoustics is presented by a growing number of Departments, and there are indications that even more schools will be listed in the future editions.

I am thankful to the department chairs and administrative assistants for supplying information on their graduate and research programs. Without such cooperation and assistance, this publication and other AIP information-gathering projects that benefit the physics and astronomy communities could not be accomplished.

I also thank the AIP staff who are responsible for this book's production, especially the staff of the Special Publications and Proceedings Department and the AIP data preparation staff.

The *2006 Graduate Programs in Physics, Astronomy, and Related Fields* has an online component—GradschoolShopper.com, a one-stop site for researching graduate programs in physics, astronomy, and related fields. GradschoolShopper.com, launched by AIP in September 2001, adds a new dimension to this publication—searchability, greater accessibility, and convenience. In addition to a searchable online version of the publication, the Web site features helpful links to resources for students and academics. I invite you to visit GradschoolShopper.com.

I hope that students, their advisers, and others interested in graduate science education will find this publication useful. I welcome your suggestions for improvements in the format or content of this publication. We are committed to making every version a better product.

Marc H. Brodsky
Executive Director and CEO
September 2005

INTRODUCTION

The *2006 Graduate Programs in Physics, Astronomy, and Related Fields* is designed to provide easily accessible, comparative information on graduate programs and research in physics and in fields based upon the principles of physics. Students planning graduate study, faculty advisers, and others interested in comparative information on graduate programs and physics research will find this information valuable. This is the twenty-fourth annual edition of the book.

The content and format of this edition have remained the same as the previous edition. Two features have appeared in all editions. First, the information on each department is presented, as much as possible, in a tabular format to make it easier to compare information from different departments and to make the listings more compact. Second, for each department information is presented concerning its research expenditures and sources of support. Care should be taken in using this information. While it does give some indication of the level of research activity in a particular research specialty, there certainly is not a one-to-one correspondence between research expenditures and the quality of the research program.

It should be noted that the same approach was used to fund the preparation and distribution of this edition as for the previous editions. Listed graduate departments paid a listing charge to cover the cost of preparing the book and distributing a copy to all departments in North America offering at least a bachelor's degree in physics, astronomy, electrical engineering, or nuclear engineering, and to all engineering schools. Accordingly, AIP was able to prepare a new edition which it otherwise could not have afforded; the book is receiving much wider distribution and hence will have greater use by students than would otherwise be the case. Almost all physics and astronomy doctoral programs in the United States and most master's programs are included. AIP anticipates that the number of listed departments will remain essentially constant in future editions.

Organization of the Book

Each entry in the book describes the graduate programs offered by an academic department at an institution of higher learning in North America. These entries are organized geographically with separate parts for institutions in the United States, Canada, and Mexico. Within these parts, entries are organized alphabetically by state or province and within each state or province alphabetically by the name of the institution. If more than one department at an institution is listed, the physics department is listed first, the astronomy department is listed second, and the departments in related fields follow.

There are three mechanisms by which a user can locate the listing of a department at a particular institution. First, if the state or province in which the institution is located is known, the entry can be found relatively quickly from Appendix I, or directly in Parts I, II, or III. Second, Appendix II provides an alphabetical listing of institutions and departments. Third, Appendix III lists institutions and departments by field and highest degree offered.

Both Appendices IV and V are geographically arranged lists that give the reader a synopsis of physics and related-field programs, and the subjects that they offer, for the United States, Canada, and Mexico. These lists include most of the programs featured in the main listings. The main difference between them is that Appendix IV, "Research Specialties of Doctoral Programs," covers the course offerings for Ph.D. programs in physics and related fields, while Appendix V, "Areas of Concentration of Master's Programs," covers master's offerings for almost all of the same programs.

Departments Included

All known departments in North America that had programs leading to a Ph.D. or Master's degree in physics, astronomy, or a physics-related field were invited to submit entries. Additional departments, including medical physics, geophysics, chemical physics, materials science, electrical engineering, nuclear engineering, meteorology, and oceanography departments that have physics-oriented research programs, were also invited to submit entries.

The response was excellent. Almost all major U.S. physics doctoral programs and most astronomy programs are listed. There are 239 departments from 203 institutions included in this book. Many of these departments offer graduate degrees in physics-related fields such as those mentioned above.

A few departments with new graduate programs or with graduate programs in a related field may have been omitted because the AIP staff was unaware of them. If so, we would appreciate receiving information about them so they can be included in the 2007 edition.

CONTENTS

PART I

UNITED STATES

Geographic Listing of Graduate Programs

ALABAMA AGRICULTURAL AND MECHANICAL UNIVERSITY

DEPARTMENT OF PHYSICS

P.O. Box 1268
Huntsville, Alabama 35762
Web page: http://www.physics.aamu.edu

Students Accepted For Degree	FIELDS		
	Physics	Astronomy	Related Fields
Doctorate	X		
Master's	X		

1. General

President: Dr. Virginia Caples
Dean of Graduate School: Dr. Chandra Reddy
Department Chairman: Dr. M. D. Aggarwal
Department Telephone Number: (256) 372-5305
Type of Institution: University
Control: Public
Setting: Urban
Total Faculty: 307
Total Graduate Faculty: 243
Total Students: 5,965
Total Graduate Students: 1,278
Annual Graduate Tuition:
In-state residents: $360*/cr. hr.
Out-of-state residents: $540**/cr. hr.
Tuition rates for: 2005–06
Deferred tuition plan: No
Annual Other Fees: $265
Term: Semester

*$360 is per semester hour for In-state residents.
**$540 is per semester hour for Out-of-state residents.

2. Number of Faculty in Department

The combined total of full-time faculty in the three professorial ranks is 13. The combined total of full-time, part-time, and other faculty at all ranks is 28.

3. Admission, Financial Aid, and Housing

Address admission inquiries to: Dean, School of Graduate Studies
Graduate application fee required: $25
Admission deadline (Fall admission): 7/1
Admission information: For fall admission, 2003–04, 10 students were accepted from 35 applicants.
Admission requirements: For admission to the graduate programs, a Bachelor's degree in Physical Science/Electrical Engineering Materials Science/optics is required with a minimum undergraduate GPA of 3.00* specified. The GRE is required. The minimum acceptable score for admission is total—850 combined for M.S. The GRE Advanced is required. The minimum acceptable score for admission is 1,000 for Ph.D. The average GRE scores for admissions were total—900. The average GRE Advanced score for admissions was 900. Students from non-English speaking countries are required to demonstrate proficiency in English via the TOEFL exam. Minimum acceptable score for admission is 550.
Undergraduate preparation assumed: Physics: Holliday, Resnick, and Krane, *Physics Part I & II*; Modern Physics: Beiser, *Concepts of Modern Physics*; Mechanics: Arya, *Introduction to Classical Mechanics*; Methods in Mathematical Physics: Boas, *Mathematical Methods in the Physical Sciences*; Electricity and Magnetism: Lorrain, Corson, and Lorrain, *Electric Fields and Waves*.
Address financial aid inquiries to: Dean, School of Graduate Studies, Alabama A&M University, Normal, AL 35762
GAPSFAS application required: Yes
Financial aid deadline: 8/1
Loans available: Yes
On-campus, graduate student housing available: Yes
On-campus, married student housing available: No

*3.00 on 4.00 scale. Students with Bachelor's degrees in optical science or optical engineering programs will be eligible for admission in optics program and with materials science, or materials engineering in materials program.

4. Graduate Degree Requirements

Master's: For admission to the Master of Science program in physics, applicants must have received a Bachelor's degree from a recognized university with a major in any of the physical sciences or electrical engineering or materials science or optics and must have an overall GPA of 3.00 (based on a 4.00 system). Also, students with Bachelor's degrees in optical science, optical engineering programs will be eligible for admission into the optics program and with materials science, or materials engineering programs into materials program. Students with a degree in an area other than physics may be required to take prerequisite undergraduate physics courses.
Thesis Option: The students must complete at least 24 semester hours of course work with a minimum of 12 hours in area of concentration, and write a thesis (6 semester hours credit) on an approved topic under the supervision of a thesis advisor, and satisfactorily defend the finding of the thesis before a committee of faculty appointed by the department and appointed by the Dean of Graduate Studies.
Non-Thesis Option: The students must complete at least 30 semester hours of course work with at least 15 of these being in the area of concentration and pass a comprehensive examination given by the department.
Doctorate: The program is open for admission to students who satisfy the general criteria for admission to graduate-school and who also meet the departmental requirements for admission to the graduate program in the specialization of choice. The applicants with a B.S. in Physics must have an overall GPA of 3.30 (based on a 4.00 system) in the area of concentration and also must have a GRE score of 50 percent in the applicant's major area. These applicants, as well as applicants with Master's degrees, must pass the various examinations described later. Graduates with a major in any of the physical sciences and a minor in physics, as well as graduates in electrical engineering, are eligible for conditional admission. Such students may be required to take additional courses in physics to attain regular status. Students from non-English speaking countries are required to demonstrate proficiency in English via the University's English Competency test for graduate students. A minimum score of 550 on the Test for English as a Foreign Language (TOEFL) WILL BE RE-

QUIRED FOR ADMISSION. Applicants who hold an M.S. Degree in the particular specialization, namely optics or materials science, will be granted provisional admission based on their performance at the Master's level as evidenced by the corresponding transcripts and also based on letters of recommendation from the departmental faculty where they graduated. Such applicants also must have a minimum GPA of 3.30 (based on a 4.00 system) in the major area. Persons holding the M.S. in traditional physics or electrical engineering or chemistry may be eligible for admission subject to the condition given above in this paragraph. Those students may be required to complete some Master's level courses. However, credit will be given only for courses which are in the list of required or optional courses for the specialization to which the applicant will be admitted. In order to earn the Ph.D. degree, a graduate student must earn a total of at least 60 semester hours of credit, with 45 hours in the area of specialization (optics or materials science) and 15 in the general area of physics. In addition to this, a student must pass a departmental qualifying examination before completing 24 semester hours of graduate credits and must also pass a departmental comprehensive examination before being admitted to the Ph.D. candidacy. Also, the student must do research on an approved topic, earn 12 semester hours of credit for the dissertation, and defend the findings of research before a committee of faculty members. A student cannot register for more than 6 credit hours of dissertation during a given semester. A student may skip the M.S. and proceed to the Ph.D. program. There is no foreign language requirement for the degree, but all students will be required to show proficiency in the use of computers. A student must pass three examinations in the following sequence before the degree is awarded:

1. All students seeking a Ph.D. must pass a qualifying examination before completing 24 semester hours of graduate credits. A person who has been admitted on the basis of a Master's degree may take the qualifying examination after the first semester in the program.
2. All students must take a written departmental candidacy examination in the area of specialization before filing for candidacy. This examination must be passed at least nine months before the expected graduation date. A student is considered as a Ph.D. candidate only after passing the departmental examination.

Thesis: Theses may be written *in absentia*.

Table B—Appointments to Graduate Students, 2004–05

Title of Appointee	Appointments		Academic Load Allowed in Credit Hours	Hours of Service Per Week	Stipend for Academic Year ($)
	Total	First year			
			Semester		
Teaching Assistant	4	0	9	20	12,000
Research Assistant	16	1	9	20	15,000
Fellowships	2	0	9	0	18,000
Total	22	1			

5. Personnel Engaged in Separately Budgeted Research, 7/03–7/04

Professorial faculty	12
Other faculty	5
Graduate students	22
Undergraduate students	4
Nonteaching research personnel	6
Total	49

6. Separately Budgeted Research Expenditures by Source of Support

	Departmental Research	Physics-related Research Outside Department
Federal government	$1,950,000	$
Private, non-profit organizations	50,000	
Total	$2,000,000	$

7. Separately Funded and Managed Laboratories

Center for Irradiation of Materials	$1,000,000
Total	$1,000,000

Table C—Separately Budgeted Research Expenditures

Research Specialty	No. of Grants	Expenditures ($)
Materials Sci./Metallurgy	10	1,050,000
Optics	6	900,000
Space Science	2	450,000
Total	18	2,400,000

FACULTY

Eminent Scholar

Lal, R. B., Ph.D., Agra, 1963. Solid state physics; materials science; crystal growth.

Professor Emeritus

Lee, C. T., Ph.D., Rice, 1967. Quantum optics.

Professors

Aggarwal, M.D., Ph.D., Calcutta, 1974. Crystal growth and characterization.

Edwards, Matthew E., Ph.D., Howard Univ., 1977. Materials science/solid state physics/laser optics.

Ila, Daryush, Ph.D., Lowell, 1987. Condensed matter.

Lal, R. B., Ph.D., Agra, 1963. Solid state physics: materials science; crystal growth.

Reddy, B. R., Ph.D., Indian Inst. of Tech., Kanpur, 1981. Laser spectroscopy.

Sharma, A., Ph.D., Columbia Univ., 1982. Optics.

Tan, A., Ph.D., Univ. of Alabama, Huntsville, 1979. Space science.

Wang, J. C., Ph.D., Massachusetts, 1976. Solid state physics; materials science.

Associate Professors

Dokhanian, Mostafa, Optics, Applied Physics, Ph.D., 1999. Alabama A&M University. Optics.
He, K. X., Ph.D., Rensselaer Polytechnic Institute, 1987. Laser physics.
Williams, A., Ph.D., Massachusetts, 1978. Nuclear physics.

Assistant Professors

Chang, Jian-Min, Materials Science, Physics, Ph.D., 1997. Alabama A&M University.
Schamschula, M., Ph.D., Univ. of Alabama, Huntsville, 1994. Optics.

Part-time

Watson, W. C., Ed.D., Rutgers University, 1983. Science education.

Adjunct Professors

Hathaway, David H., Ph.D., Univ. of Colorado, 1979. Astrophysics.
Koshak, William J., Ph.D., Univ. of Arizona. Atmospheric physics.
Nash-Stevenson, Dr. Shelia, Ph.D., AAMU, 1993. Applied physics.
Phanord, Diendonne D., PhD., Univ. of Illinois, 1988. Mathematical physics.
Ruffin, Dr. Paul, Ph.D., Univ. of Alabama, 1986. Optics, physics.
Wu, Shi T., Ph.D., Univ. of Colorado, 1967. Aerospace Engineering Science.

Research Associates

Bhatnagar, V. P., Ph.D., Delphi Univ., Delhi, 1968, P. Eng. (Elec. Eng.) Toronto, 1991. Space physics.
Curley, Michael, Ph.D., AAMU, 1997. Applied physics.
Evelyn, A. L., Ph.D., AAMU, 1998.
Kukhtareva, Tanya, M.S. Kiev Univ., Ukraine, 1972.
Wladislaw, Lyatsky, Ph.D., Univ. of St. Petersburg, Russia, 1968.

Research Professor

Zimmerman, R., Ph.D., Massachusetts Institute of Tech., 1952. Physics.

Research Associate Professors

Batra, Ph.D., I.T.T., Delhi, India, 1981. Materials science, physics.
Kukhtarev, N., Ph.D., Institute of Physics, Kiev, Ukraine, 1973.
Sarkisov, Sergey, Ph.D., Kiev University, Ukraine, 1986. Optics.

RESEARCH SPECIALTIES AND STAFF

Theoretical

Atmospheric Physics. Tan, Wladislaw.
Materials Science. J. C. Wang.
Optics. Lee.
Nonlinear Adaptive Optics. N. Kukhtarev.

Experimental

Materials Science. Aggarwal, Batra, Chang, Evelyn, Ila, Lal, Zimmerman.
Optics. Curley, Dokhanian, Edwards, He, Kalluru, Kukhtarev, Kukhtareva, Reddy, Sarkisov, Schamschula, Sharma, Williams.

FACULTY PUBLICATIONS

Aggarwal, M. D.

A. K. Batra, C. R. Carmichael-Owens, M. Simmons, M. D. Aggarwal, and R. B. Lal, "Design of a Solution Crystal Growth Crystallizer with a Versatile Electronic Reciprocal Motion Control for a Crystals Holder," Crystal Research & Technology, **40**(8), 755–758 (2005).

P. Guggilla, A. K. Batra, M. D. Aggarwal, and R. B. Lal, "Investigation on nanocomposites for pyroelectric infrared sensors," Proc. SPIE **5724**, 295–300 (2005).

A. K. Batra, T. Gebre, K. Bhat, M. D. Aggarwal, R. B. Lal, "Growth and characteristics of organic and semiorganic nonlinear optical crystals," accepted for presentation at Photonics West—Showcasing the Age of Light SPIE conference 5351 on Organic Photonic Materials and Devices VI to be held at San Jose Convention Center, San Jose, CA during January 24–29, 2004.

A. K. Batra, M. Simmons, P. Guggilla, M. D. Aggarwal, and R. B. Lal, "Studies of electrical conduction in pyroelectric DTGS:PVDF composites," accepted for presentation at Phontonics West—Showcasing the Age of Light SPIE conference 5351 on Organic Photonic Materials and Devices VI to be held at San Jose Convention Center, San Jose, CA during January 24–29, 2004.

A. K. Batra, J. R. Currie, M. D. Aggarwal, and R. B. Lal, "Predicted frequency response of integrated pyroelectric PNZT infrared detectors," Integrated Ferroelectrics **63**, 191 (2004).

S. Seif, M. A. Alim, A. K. Batra, M. D. Aggarwal, and R. B. Lal, "The voltage transformation behavior in unloaded piezoelectric transformers," Ferroelectrics, **313**, 33 (2004).

Batra, A. K.

A. K. Batra, C. R. Carmichael-Owens, M. Simmons, M. D. Aggarwal, and R. B. Lal, "Design of a Solution Crystal Growth Crystallizer with a Versatile Electronic Reciprocal Motion Control for a Crystals Holder," Crystal Research & Technology, **40**(8), 755–758 (2005).

A. K. Batra, M. Simmons, P. Guggilla, M. D. Aggarwal, and R. B. Lal, "Studies on DTGS:PVDF Composites for Pyroelectric Infrared Detectors," Integrated Ferroelectrics, **63**, 161–163 (2004).

S. Seif, K. Bhat, A. K. Batra, M. D. Aggarwal, R. B. Lal, "Effect of Cr(III) impurity on the Growth Kinetics of Potassium dihydrogen phosphate and Triglycine sulfate Crystals Grown from Aqueous Solutions," Materials Letters, **58**, 991–994 (2004).

S. Seif, M. A. Alim, A. K. Batra, M. D. Aggarwal, and R. B. Lal, "The Voltage transformation behavior in unloaded piezoelectric transformers," Ferroelectrics, **313**, 33 (2004).

T. Gebre, A. K. Batra, P. Guggilla, M. D. Aggarwal, and R. B. Lal, "Pyroelectric properties of pure and doped lithium niobate crystals for infrared sensors," Ferroelectric Letters, **31**, 131 (2004).

Bhatnagar, V. P.

V. P. Bhatnagar, A. Tan, and R. Ramachandaran, "The Response of the Exospheric Temperature to the Auroral Heating impulse during Geomagnetic Disturbances, submitted for presentation to International Association of Geomagnetism and Aeronomy, Toulouse, France (2005), and submitted to J. Atmosph. & Solar Terr. Physics.

V. P. Bhatnagar, G. A. Germany, and A. Tan, "Satellite Ballistic coefficients and the Lower Thermosphere," Geophysical Research Letters, **32**, 021627 (2005).

V. P. Bhatnagar, Sections on Space Physics, CRC Handbook of Geophysics, Astrophysics and Astronomy (Ed) R. H. Matzner, CRC Press (USA), 2002.

R. H. Wiens, V. P. Bhatnagar, and G. Thuillier, "Geomagnetic storm heating effects on the low lattitude dayside thermosphere from WINDII observations at equinox," J. Atmos. Solar Terr. Physics, **64**, 1393 (2002).

R. Wiens, V. P. Bhatnagar, and L. L. Cogger, WINDII observations of night glow enhancements in South Atlantic Magnetic Anomaly Zone, Geophysics Research Letters, **26**(15), 2355 (1999).

Curley, Michael

S. Sarkisov, M. Curley, B. Peterson, S. Sarkisov II, G. Edlin, R. Snow, J. York, and J. Rushing, "Cloud-cover mitigation of the influence of atmospheric turbulence on propagation of laser beams," Proceedings of SPIE Conference, San Jose, January 22–27 (2005).

S. Sarkisov, M. Curley, S. Sarkisov II, "Generating circulation in nonlinear optical fluids with weak laser radiation," Proceedings of SPIE, San Diego, 4–6 (Aug. 2003).

N. Kukhtarev, T. Kukhareva, J. Jones, E. R. Ward, S. Sarkisov, M. Curley, "Interaction of microorganism (Fungi and bacteria) with optical and electronics materials," Proceedings of SPIE, **47**, 272 (2002).

S. Sarkisov, M. Curley, N. Kukhtarev, A. Fields, G. Adamovsky, C. Smith, and L. Moore, "Holographic surface gratings in iron-doped lithium niobate," Applied Physics Letters, **79**, 7 (Aug. 2001).

S. Sarkisov, M. Curley, G. Adamovsky, "Polymer single-arm optical waveguide interferometer for detection of toxic materials," Proc. SPIE **4461**, 284, San Diego 1–2 (Aug. 2001).

Edwards, Matthew

N. V. Kukhtarev, T. Kukhtarev, M. E. Edwards, J. Jones, M. Bayssie, S. F. Lyuksyutov, R. Reagan, P. Buchhave, "Smart Running-Grating Interferometer for Holographic Optical Trapping of Nano- and Micro-particles," J. of Applied Physics, **97**, 054301 (2005).

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T. Gebre, D. Edwards, M. D. Aggarwal, A. K. Batra, M. E. Edwards, D. Patel, L. Huey, and R. B. Lal, "Electrooptic Characterization and Czochralski Growth Technique of Pure and Doped Lithium Niobate Crystals," SPIE **5560**(4) (2004).

H. Jaenisch, J. Handley, A. Lim, M. Filipovic, G. White, A. Hons, G. Deragopian, M. Schneider, M. Edwards, "Data Modeling for Virtual Observatory data mining," SPIE Astronomical Telescopes and Instumentation 2004, Glasgow, Scotland, UK, (June 2004).

M. E. Edwards, N. Kukhtarev, T. Kukhtarev, M. Bayssie, J.-C. Wang, M. Reagan, and S. Lyiksyutov, "Voltage Pulsations in Photogalvanic Crystals as Power Supply for EO-Modulator," I, SPIE **5363**(15), 98–106 (2004).

He, Kexiang

T. Thompson and K. X. He, "Fabricating and Characterization of High Reflecting Parabolic Mirrors for a YB:YAG Thin Disk Laser." Submitted to 2005 Sino-German high level expert symposium on optical coatings, Shanghai, China (May 17–21, 2005).

K. X. He, A. Chow, J. Mo, and W. Zhuo, "Biomedical applications of laser," Journal of Northwest University for Nationalities (Natural Science), **25** (1) (2004).

K. X. He, A. Chow, J. Mo, and W. Zhuo, "Numerical Value Results of Guassian beam Focussing," Journal of Northwest University for Nationalities (Natural Science), **24**, (3) 1–4 (2003).

C. Holden, K. X. He, A. S. Chow, and J. D. Mo, "The complicated vortex flow over delta wing studied by laser sheet visualization and computational simulation," Fourth International conference on nonlinear Mechanics, Shanghai, P. R. China (August 13–16 2002).

K. X. He, M. Curley, J. C. Wang, I. Jones III, A. Chow, J. Mo, and C. Holden, "Novel light scattering technique by visible laser (632.8 nm) for microstructural investigation of the two dimensional periodic array," Microstructural Investigation and Analysis, EUROMAT–**4**, p. 34, edited by B. Jouffrey and J. Svejcar, WILEY-VCH (2000).

Ila, Daryush

M. A. Parada, R. A. Minamisawa, A. de Almeida, C. Muntele, R. L. Zimmerman, I. Muntele, and D. Ila, "Fluoropolymer Studies for Radiation Dosymetry," Brazialian Jr. of Physics, **34**, 948 (3A) (2004).

C. Muntele, I. Muntele, R. Zimmerman, D. Ila, "Nitrogen beam RBS for concentration uniformity measurements of SiO2:Au thin layer co-depositions," Nucl. Instr. and Meth. in Phys. Res. B **759**, 219 (2004).

O. Innegraeve, X. Blanchet, C. I. Muntele, I. C. Muntele, R. L. Zimmerman, L. Popa-Simil, D. Voiculescu, P. M. Racolta, and D. Ila, "PIXE Pollution Studies Across Europe," Nucl. Instr. and Meth. in Phys. Res. B **191**, 219–220 (2004).

G. Savigny, J. R. Currie Jr., D. Ila, R. L. Zimmerman, C. I. Muntele, R. Mu, A. Ueda, "Ion beam induced modification of nano-layers containing vanadium and silica," Surface and Coatings Technology (2004) (accepted, pending publication).

Kukhtarev, Nickolai

N. Kukhtarev, T. Kukhtareva, Holographic Recording in $YALO_3$:Mn, Optical Memory and Neural Networks, **12**, (2) (2003).

W. Su, C. Sun, N. Kukhtarev, A. Chiou, "Polarization-multiplexed volume holograms in $LiNbO_3$ with 90-deg geometry," Optical Eng. **42**(1) (2003).

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Yu. P. Gnatenko, A. O. Borshch, N. Kukhtarev, T. Kukhtareva, I. O. Faryna, V. I. Volkov, P. M. Bukivskij, R. V. Gamernyk, V. I. Rudenko, S. Yu. Paranchych, "Optical photoelectric and photorefractive properties of Ti-doped CdTe crystals," J. Appl. Phys. **94**(8) 4896 (15 Oct. 2003).

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P. P. Banerjee, M. R. Chatterjee, N. Kukhtarev, T. Kukhtareva, Volume Holographic Recording and Readout for 90-degree Geometry (invited paper), submitted to Optical Engineering (2004).

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THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

DEPARTMENT OF PHYSICS

Birmingham, Alabama 35294

Students Accepted For Degree	FIELDS		
	Physics	Astronomy	Related Fields
Doctorate	X		
Master's	X		

1. General

President: Carol Z. Garrison
Interim Dean of Graduate School: James B. McClintock
Department Chairman: David L. Shealy
Graduate Program Director: Yogesh K. Vohra
Department Telephone Number: (205) 934-4736
Type of Institution: University
Control: Public
Setting: Urban
Total Faculty: 2,059
Total Graduate Faculty: 1,265
Total Students: 16,693
Total Graduate Students: 4,275
Annual Graduate Tuition:
In-state residents: Full-time—$162/cr. hr. (tuition)
Out-of-state residents: Full time—$405/cr. hr
Tuition rates for: 2004–05
Deferred tuition plan: No
Term: Semester
Note: Semester hours credit awarded

2. Number of Faculty in Department

The combined total of full-time faculty in the five professorial ranks is 18. The combined total of full-time, part-time, and other faculty at all ranks is 22.

3. Admission, Financial Aid, and Housing

Address admission inquiries to: Graduate School Office, HUC 511, 1530 3rd Avenue South, Birmingham, AL 35294-1150
Graduate application fee required: $35 (U.S. citizen); $60 (foreign applicant)
Admission deadline (Fall admission): 7/1
Admission information: For fall admission, 2004–05, 4 students were accepted.
Admission requirements: For admission to the graduate programs, a Bachelor's degree in physics is required with a minimum GPA of B specified. The GRE is required. The GRE Advanced is strongly urged. The average GRE score for 2004–2005 admissions was 1,237 (total). Students from non-English speaking countries are required to demonstrate proficiency in English via the TOEFL exam. Minimum acceptable score for admission is 550.
Undergraduate preparation assumed: Halliday and Resnick & Walker, *Fundamentals of Physics*; Thornton & Rex, *Modern Physics*; Fowles, *Analytical Mechanics*; Reitz, Milford, and Christy, *Electromagnetic Theory*; Reif, *Statistical Physics, Berkeley Course Vol. 5*; Zettilli, Nouredine, *Quantum Mechanics*.
Address financial aid inquiries to: David L. Shealy, Chairman, Department of Physics
GAPSFAS application required: No
Financial aid deadline: Priority deadline 4/1
Loans available: Yes
Address housing inquiries to: Housing Office.
On-campus, single student housing available: Yes
Cost/month: $200–400
On-campus, family housing available: No

Table A—Faculty, Enrollments, and Degrees Granted

Research Specialty	2004–05 Faculty	Enrollment[1] Fall 2004		No. of Degrees Granted[2] 2004–05 (2000–05)			Median No. of Years for 2004–05 Ph.D.'s
		Master's	Doctorate	Master's	Terminal Master's	Doctorate	
Astrophysics	4	0	2	0(2)	0(1)	0(1)	–
Biophysics	2	0	1	0(1)	0(0)	0(0)	–
Condensed Matter Physics	9	2	15	1(5)	0(4)	3(6)	–
Optics	3	1	5	3(7)	0(0)	2(4)	–
Physics Education	4	0	0	0(0)	0(0)	0(0)	–
Total		3	23	4(15)	0(5)	5(11)	
Full-time Grad. Stud.		3	23				
Part-time Grad. Stud.		0	0				
First-year Grad. Stud.		3	3	2			
Median Years in Grad. Study (2004–05 Degrees)				3	3.5	4.5	–

Undergraduate Degrees, 2004–05 (2000–05): 2(12)

[1]Students not yet committed to a research specialty are entered under non-specialized.
[2]Five-year totals in parentheses.

4. Graduate Degree Requirements

Masters: 30 semester-hours of credit with thesis; minimum B (3.0 average); no residency requirements. Thesis is optional with approval of faculty. An additional "Interdisciplinary Track" for an M.S. degree with thesis option is also offered to non-physics majors and requires a minimum of 12 hours of graduate-level courses offered by other departments.
Doctorate: Minimum residence of three full-time academic years or equivalent periods of part-time enrollment with minimum GPA of B (3.0). Pass: oral placement exam on basic physics concepts; comprehensive exam covering the areas of classical mechanics, quantum mechanics, electromagnetic theory and two selected topics from thermodynamics/statistical mechanics, optics, or solid state physics in no more than two attempts; oral exam on area of research specialization; oral defense of written dissertation proposal; and oral final defense of dissertation.
Thesis: Thesis may be written *in absentia*.
Special Equipment, Facilities, and Programs: The department has active research programs in applied and theoretical astrophysics, biophysics, condensed matter physics, materials science, nanophysics, optics, lasers and laser spectroscopy. Opportunities exist for interaction with major government laboratories including NASA AMES Research Center; Jet Propulsion Lab; NASA Goddard Space Flight Center; NASA Marshall Space Flight Center; the Advanced Photon Source (APS) at Argonne National Lab; the National Synchrotron

Light Source (NSLS) at Brookhaven National Lab; the Lawrence Livermore National Lab; Oak Ridge National Lab; Sandia National Lab; the Naval Research Lab; Wright Patterson Air Force Base–Air Force Research Lab; and the National Cancer Institute at NIH.

Graduate Students and faculty have collaborative research Programs with several universities (Auburn University, University of Alabama at Huntsville, Arizona State University, North Carolina State University, Stanford University, University of California at San Diego, University of California at Los Angeles, and the General Physics Institute of the Russian Academy of Sciences), as well as with the UAB Medical Center. The department is part of a tri-campus interdisciplinary Materials Science Program.

Astrophysics and Solar-System Physics Labs have capabilities for Raman Imagery using Dilor XY 0.8-m 3-stage Raman spectrometer for acquisition of point spectra and Raman images displaying the distribution of molecular components, with Coherent krypton ion multi-λ laser (blue to IR) and Olympus BX40 microscope enabling common focusing for visible and laser illumination of the sample to 0.5 μm resolution (Lab for Paleobiological Chemical Imagery); Raman Spectroscopy using field-tested mini-Raman spectrometer with Control Development optics, operating at 785 nm or 670 nm, including SDL 8530 (785 nm, 300 mW) and Process Instruments PI-ECL-670-150 (670 nm, 150 mW) lasers, with EIC Raman probes for 785 nm and 670 nm: Transmission Spectroscopy (UV, Vis, IR) using Hewlett-Packard UV/Vis Diode Array Spectrophotometer for spectra from 190–400 nm; Vacuum-UV Spectrometer, for spectra from 100–250 nm; ThermoMattson InfinityGold FTIR Spectrometer for IR spectra in the range from 1–25 μm, resolutions to 0.5 cm^{-1}; Mattson Pollaris FTIR Spectrometer for spectra in the mid-IR (2.5–25 μm), resolutions to 1 cm^{-1}; far-IR to 400 μm with attachments; Mössbauer Spectroscopy with MS-1200 Ranger Scientific spectrometer at 0.01% linearity for transmission and backscatter; 50 mCi Co-57 source; Sample temperatures to 10K with ARS Displex Cryostat to 1000K with furnace; GMW water-cooled magnet for sample fields to 2.5 T; Chemical Analysis using Buck Scientific Gas Chromatograph, Model 910, with FID and PID detectors; D-Star Instruments Isocratic Liquid Chromatograph, model DLC-20; Dycor Quadrupole Mass Spectrometer; Sample Preparation using two ARS closed-cycle helium expansion systems and temperature controllers for T=6.5–300K; UV Photolysis System (Opthos) with microwave generator for 100–250 nm photons; Parr Instruments Reactor, D3141-1, for processing with H_2O at high T and high P; 2" diameter Lindberg Tube Furnace to 1500C with controller.

Biophysics Lab has capabilities for time-correlated single photon counting and laser tweezers operations using the following equipment: Coherent Verdi (10W)/Mira 900 D Ti:sapphire laser system, with frequency doubler/tripler, ps/fs operation, "pulse picker" (for lower excitation rate), broad-tuning optics set; Spectra Physics Model 171 argon ion laser: 12W, modelocked or continuous; Spectra Physics Dye Laser: mode locked, cavity-dumped (500 mW) or continuous (1W), 12 ps pulse, tunable 580–620 nm (frequency-doubled 295–305 nm) in usual operation. Other capabilities include Fluorometer using SPEX 1998 model, PC-controlled, 180–650 nm excitation, 180–700 nm emission, high sensitivity photon-counting electronics, full spectral corrections, spectral analysis software, Bioelectrospec TIRF system, remote fiber collection system (5 mm diameter 4-m length); Absorption Spectrophotometer using JASCO V-530 with ETC-505T thermoelectric temperature controller (programmable through JASCO), 180–1100 nm; Fluorescence Decay Systems using PRA time correlated single photon counting (TCSPC) system with 8192-channel multichannel analyzer, 500-ps system response time (FWHM); PicoQuant TimeHarp 200 TCSPC PC computer-board, two 50-ps PMTs (Hamamatsu R3809U-50 UV/VIS and R3809U-59 NIR) emission monochromator or wavelength filters, Globals multicomponent global convolution fitting software; Olympus IX-70 inverted microscope: Total Internal Reflection Fluorescence (TIRF)/Laser Tweezers input optics (including TIRF objective), Prior ProScan computerized stage, SIS F-View CCD camera with Microsuite Biological Suite/Scopeview software, 5-mm diam/4-m long fiber optic to relay fluorescence to SPEX fluorometer, multiphoton imaging & spectroscopy with Ti:sapphire laser system; Zeiss IM inverted microscope: with MTI SIT camera plus intensifier, CDS motorized stage.

Computational Physics Lab has switched 10/100 Mbps LAN with gigabit ethernet connectivity to campus backbone and two OC3 links to the SouthernCross Roads (SoX) Internet2 Gigapop in Atlanta. This departmental network supports UNIX and Microsoft operating systems running on a range of workstations in faculty, staff, and graduate student offices and labs. The department has a 24 seat pc-cluster for use by general physics students with CAPA, Activ-Physics, MAPLE7, Photoshop7, SigmaPlot 2001, Scientific Word, FrameMaker, and other software for research and educational activities. Physics participates in the operation and use of Beowulf clusters of parallel computing systems, Verari Systems cluster with 128 AMD CPUs, (Dell PowerEdge 6350 server with 32 Intel xeon CPUs running LINUX, another Dell PowerEdge cluster with 60 Intel Xeon CPUs and 16 AMD Opetron CPUs); active storage cluster (Dell 2650/1650) with 3TB online storage with LTO backup system. The department has access to two systems housed at the Alabama Supercomputer Center in Huntsville. One system is a SGI Altix 350 with 56 Itanium 2's operating at 1.4 GHZ providing an overall capacity of 20 GFLOPS. The second system is a Cray XDL with 144 Opteran processors operating at 2.2 GHZ for an overall capacity of 634 GFLOPS. Physics faculty and students have Internet2 access to national supercomputer centers.

Materials Research Equipment and Facilities include Materials Growth and Processing with 1.2 kW and 6 kW Microwave Plasma Chemical Vapor deposition systems for growth of homoepitaxial diamond and nanostructured diamond coatings on metals. Pulsed Laser Deposition Facility for growth of thin films including a Lamda Physik LPX305i Excimer laser, a unique custom-made deposition system developed in collaboration with Neocera, Inc., and a Novel Nanoparticle Beam Pulsed Laser Deposition. Aerosol Reactor for Synthesis and Processing of Nanostructured Materials. Physical Vapor Deposition (Denton Discovery-24 sputtering system equipped with 3-RF/DC capable magnetron sources), and solution deposition (Laurel Technologies programmable WS-400-6NPP spinner, HeatPulse 610 rapid thermal processing system, and programmable stirring hot plate) techniques. Annealing furnaces and thermal evaporators. Materials Characterization Facilities with Bruker EMX EPR spectrometer with 10 GHz microwave bridge. Oxford Instruments ESR900

Continuous Flow Cryostat APD Closed Cycle Low Temperature System. Senteck 400 single-wavelength Ellipsometer. Philips Thin film X-ray diffractometer. Micro-Raman and Photoluminescence spectroscopy for thin films. Nanoindentation facility with Atomic Force Microscopy. Veeco Explorer Atomic Force Microscope with liquid scanning capability. Keithley Model 82 CV measurement system; HP4284 LCR Meter Micro-scratch tester for thin film adhesion measurements. Romulus IV micro-scratch tester for thin film adhesion measurements. Quantum Design and model MPMS-5S SQUID magnetometer, Lake Shore model 7000 ac susceptometers.

Other Equipment: Diamond anvil cells capable of generating multi-megabar pressures. Electric Discharge Machining of small holes down to 10 microns in diameter in metallic gaskets. Laser heating facility for samples in diamond anvil cells.

Laser and Nonlinear Optics Labs include Absorption spectroscopy performed with a Shimadzu UV-VIS-NIR double beam spectrophotometer UV 3101PC and with a cavity ring down spectrometer coupled to a tunable (200–1200 nm) alexandrite-LiF:F_2^+ color center laser (CCL) combination; Fluorescence and Raman spectroscopies centered around CCS-450 (Janis) closed cycle refrigerator system. Numerous pulsed and CW lasers can be configured for samples excitation. Among them, a Spectra-Physics model GRC-230 injection seeded Nd:YAG laser with frequency doubling, tripling, and quadrupling coupled to two LightAge Raman shifters (H_2 and D_2), and tunable (1100–1250, 550–600, 280–300 nm) LiF:F_2^- CCL; Light Age Alexandrite Laser System PAL101 with variable temporal and spectral outputs coupled to LiF:F_2^+ CCL (800–1200 nm) with frequency doubling, tripling, quadrupling and difference frequency generation (200–8000 nm); Continuum PY61-10 high energy picosecond Nd:YAG; 500 Hz repetition rate 1 mJ diode pumped Nd:YAG laser "PULSAR 200" with a pulse duration of 1.5–2 ns with frequency doubling and tripling option. CW lasers include, SDL824 tunable diode laser, several external cavity multi-wavelength diode lasers, Er-fiber 1550 nm, 10 W linearly polarized ELD laser (IPG Photonics), and several home made Er fiber laser pumped microchip and external cavity mid-IR (2–3 μm) tunable lasers based on Cr_2^+:ZnS and ZnSe lasers. These are equipped with several spectrometers/spectrographs for measuring fluorescence, excitation, and Raman spectra and kinetics of fluorescence. These include the portable Ocean Optics R2000 fiber coupled Raman system and several Acton Research Corp. SpectraPro scanning monochromators/imaging spectrographs-(SpectraPro 750, 500, 150) with gratings covering UV (200 nm)-middle IR (14000 nm) spectral range coupled to two Princeton Instruments ICCD. Other detectors include numerous PMTs, TE-cooled PbS and InGaAS detector for the 0.7–3 μm range, and a LN-cooled HgCdTe and fast InSb detectors for the 2–14 and 2–5 μm range, respectively. Data acquisition is performed with ARC NCL Spectral Management System, two Standford Instrument boxcar-averages and EGG Instruments 7265 lock-in amplifier interfaced with PC. There is extensive equipment for Z-scan and DFWM characterization of nonlinear optical materials. Spiricon LBA 100 beam profiler is available for beam diagnostics and Wavemeter W-4500 (Burleigh) system for wavelength measurements.

Table B—Appointments to Graduate Students, 2004–05

Title of Appointee	Appointments: Total	Appointments: First year	Academic Load Allowed in Credit Hours	Hours of Service Per Week	Stipend for Academic Year ($)
			Semester		
Teaching Assistant	6	2	9	20	17,500[1]
Research Assistant	9	3	6–9	20	15,640–22,316[2]
Fellowship	8	1	6–12	0	16,000–30,000[3]
Total	23	6			

[1]The department pays tuition and fees for Teaching Assistants.
[2]Research Assistant stipends include tuition and fees.
[3]In addition, Fellowships pay full tuition, fees, health insurance, and provide an education budget.

5. Personnel Engaged in Separately Budgeted Research, 5/04–4/05

Professorial faculty	12
Postdoctoral Associates	4
Graduate students	17
Nonteaching Research Personnel	6
Total	39

6. Separately Budgeted Research Expenditures by Source of Support*

	Departmental Research
Federal government	$1,238,923
State and local government	190,299
Private/Industry	93,607
Total	$1,522,829

*For fiscal year Oct. 1, 2003 through Sept. 30, 2004.

Table C—Separately Budgeted Research Expenditures

Research Specialty	No. of Grants	Expenditures ($)*
Astrophysics	6	95,882
Biophysics	1	9,175
Computer Science & Engineering	6	148,250
Condensed Matter Physics	25	890,532
Optics	6	188,691
Physics Education	2	190,299
Total	46	1,522,829

*For fiscal year Oct. 1, 2003 through Sept. 30, 2004.

FACULTY

Professors

Lawson, Chris M., Ph.D., Oklahoma State, 1981. Nonlinear optics; fiber optics; optical sensors; optical coherence imaging and tomography.

Mirov, Sergey B., Ph.D., Lebedev Physical Institute, Moscow, 1983. Experimental quantum electronics; solid state lasers; physics of color centers; laser spectroscopy.

Shealy, David L., Ph.D., Georgia, 1973. Chairman of the Department. Geometrical optics; laser beam shaping optics; radiative transfer; caustic and optical aberration theory.

Vohra, Yogesh K., Ph.D., Bombay, 1980. Materials growth; ma-