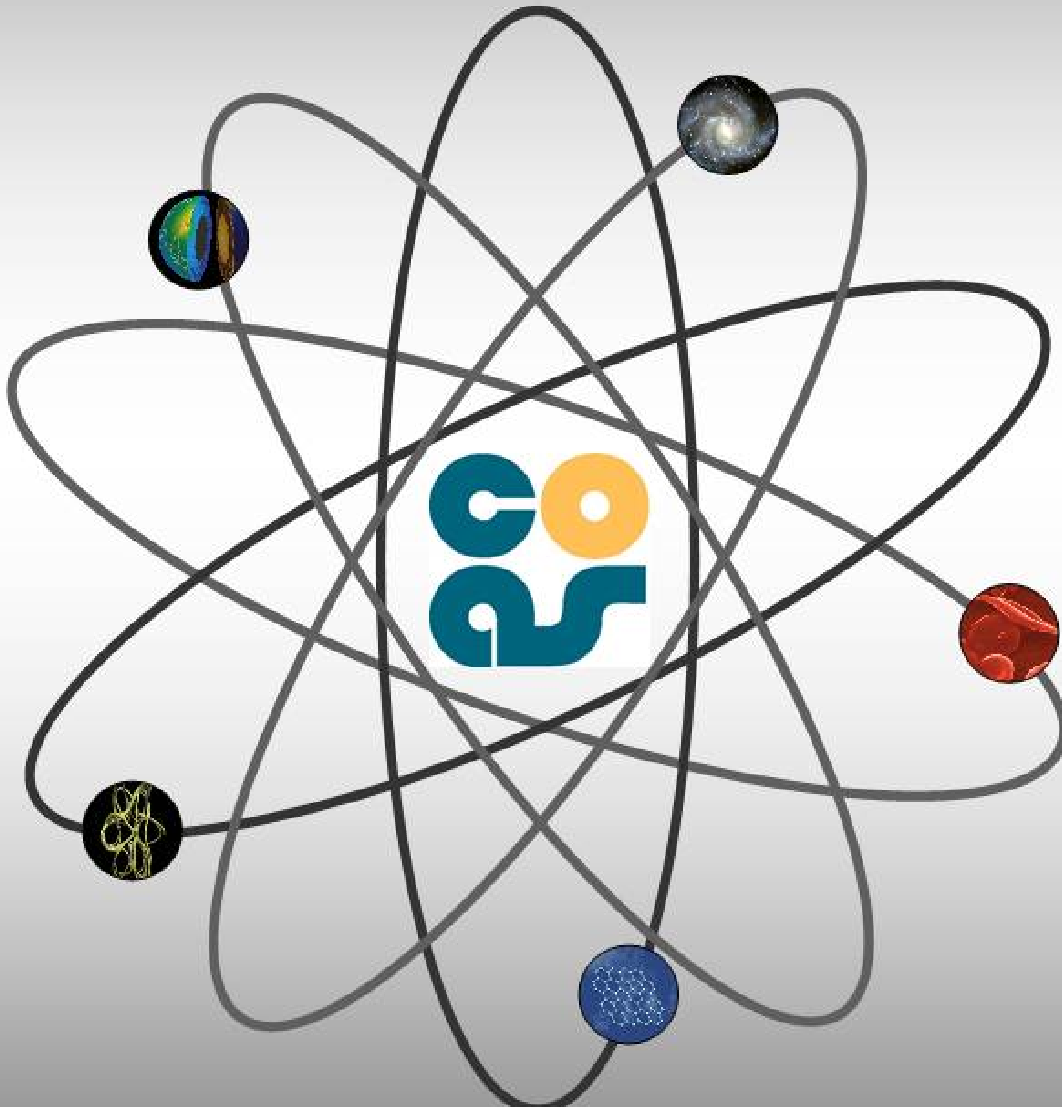
PHYSICS DEPARTMENT

Progress Report

Academic Year 2006 –2007



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Department Head's Foreword

Our mission is to expand our understanding of the physical universe through basic and applied research and prepare students of all disciplines for technical excellence and thoughtful citizenship through innovative instruction and engagement in the process of discovery.

To achieve this mission, we make every effort to continuously enhance the academic stature of our educational programs. Perhaps the most significant initiative this year was the development of our Calculus based Freshman/Sophomore Fundamentals of Physics sequence.

Our graduate program was reorganized. We have strengthened our program by closely monitoring the students' progress, by improving the quality of our graduate students, and by increasing financial support. We seek to attract both high quality domestic and international students.

Our Department continues to contribute to advances in Astrophysics, Biophysics, Condensed Mater and Particle Physics. Most of our faculty are highly recognized in their fields and have received significant external research funding. We offer an educational and research experience in Physics that translates in ample research opportunities for our undergraduate and graduate students.

Our continuing recruitment efforts are paying-off as it is evidenced by the significant increase in undergraduate enrollment. We are proud to stress that the SAT scores of Physics applicants are 100 points higher than the average in other departments at Drexel.

We have organized numerous conferences and workshops. The renowned "12th Annual Kaczmarczik Lecture" was attended by about one thousand participants. The speaker was the 2006 Physics Nobel Laureate John C. Mather. Prior to the lecture, we held an open house. We have also successfully organized and hosted the "Lorenzo Narducci Memorial Symposium". Speakers included four Nobel Laureates and several prominent scientists. The Sloan Digital Sky Survey (SDSS) collaboration meeting was organized and hosted, and counted with internationally recognized participants in the Astrophysics community. We co-organized the "Cosmic Void: Much Ado about Nothing' which was held in Amsterdam, The Netherlands. We have also organized three Modest workshops which brought together a number of experts in astronomy and computational science. Two of these workshops took place at Drexel.

Many exciting events happened in our Department during the past year which all essentially contributed in achieving the Department's mission.

Personnel News

Professor Gordon Richards, received the prestigious 2007 Sloan Research Fellowship Award. This is an extraordinarily competitive award which recognizes outstanding young scientists. The Sloan Research Fellowships are intended to enhance the careers of the very best young faculty members in specified fields of science. Dr. Richard was 1 of only 3 to receive this award in astrophysics; 22 awards were given in Physics.

Professor David Goldberg, was awarded tenure and promoted to Associate Professor.

Dr. Joseph J. Trout, Adjunct Professor in Physics, received the Stanley J Gwiazda Professorship Award from the Goodwin College of Evening and Professional Studies at Honor's Convocation.

Professor Shyamalendu Bose was appointed as Honorary Professor at the Institute of Physics in Bhubaneswar, India.

Dr. Rajesh P. Deo, appointed as Research Post Doctoral Associate, received his PhD from Georgia State University. He is working on multiwavelength studies of AGNs using the Sloan Digital Sky Survey and both the Hubble (optical/UV) and Spitzer (infrared) Space Telescopes.

Dr. Otonyo Mangete, appointed as Research Post-Doctoral Associate, received his PhD in Mathematical Astronomy from the University of Edinburgh. Dr. Mangete's principal area of research is large-scale simulations of astrophysical gas dynamics, and specifically, the origin and evolution of intracluster gas in galaxy clusters. He has expertise in fluid mechanics, high-performance parallel computation, and large-scale structure in the universe. His tasks within the BASIN project are to expand the scope of his simulations to related astrophysical problems on stellar and galactic scales, and to integrate his simulations into the BASIN analysis and visualization framework.

Dr. Daniel Spicer, appointed as Research Professor, received his PhD from the University of Maryland in 1976. He brings expertise in space and solar plasma physics, magneto hydrodynamics, and numerical 3D MHD. Dr. Spicer will participate in a NASA supported project that aims at developing a 3D model of the coronal active region's magnetic field.

Dr. Karim Zbiri, appointed as Research Post-Doctoral Associate, received his PhD from University of Nantes, France. He brings expertise in nuclear physics, heavy ions collisions and Monte Carlo simulation. Dr. Zbiri participates in the Double Chooz experiment. The Double Chooz experiment goal is to search for a non-vanishing value of the θ_{13} neutrino mixing angle. This is the last step to accomplish prior moving towards a new era of precision measurements in the lepton sector. In addition, one of Double Chooz detectors will used to investigate the potential of neutrinos for monitoring the civil nuclear power plants.

Mr. Michael Downes, appointed as Laboratory Services Coordinator, received his BS in Physics with minors in Biology and Computer Science from Drexel University. He is responsible for implementing and administering the new laboratories that accompany the new calculus based introductory Fundamentals of Physics sequence for science and engineering students.

Teaching Program News

Fundamentals of Physics

With the termination of the tDEC program at the end of the 2005 academic year, the Department of Physics took the responsibility of redesigning the Calculus based freshman/sophomore Physics sequence, Fundamentals of Physics I/II/III/IV. Furthermore, for the first time in nearly fifteen years, we assumed the responsibility for teaching the laboratory part of the new **PHYS-101, 102, 201**, and **202** courses. Broadly speaking, in the new Physics sequence, we were aiming at:

1. **Emphasizing the unity of physical concepts**
2. **Introducing modern Physics topics early**
3. **De-emphasizing/dropping some less needed topics**
4. **Introducing new modern Physics experiments early in the Physics sequence**

We requested, and were granted, approval by the College of Arts and Sciences Curriculum Committee and the Senate committee on Academic Affairs (SCAA) to introduce a sequence of four courses to teach Fundamentals of Physics to Freshmen and Sophomore students in Engineering and Sciences. This sequence was to replace the tDEC sequences Physical Foundation for Engineering I, II and III and Energy 1 and 2. The proposed changes in the first year were specific for engineering students with plans to offer these courses for the science students in academic year 2007-2008.

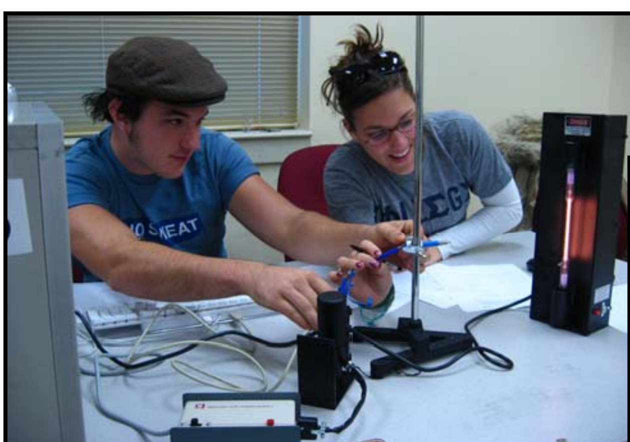
Today's engineering and science students must be prepared to face rapid development in the sciences and the technology of the 21st century. The proficiency needed to adapt to new science concepts and develop new technologies for the benefit of society, can only be achieved if based on a solid foundation in Physics. The Fundamentals of Physics sequence aims at providing the engineering and science students with a robust foundation in Physics via the use of innovative pedagogy, new approaches, and by carefully selecting the topics for the courses to be effective and attractive to the students.

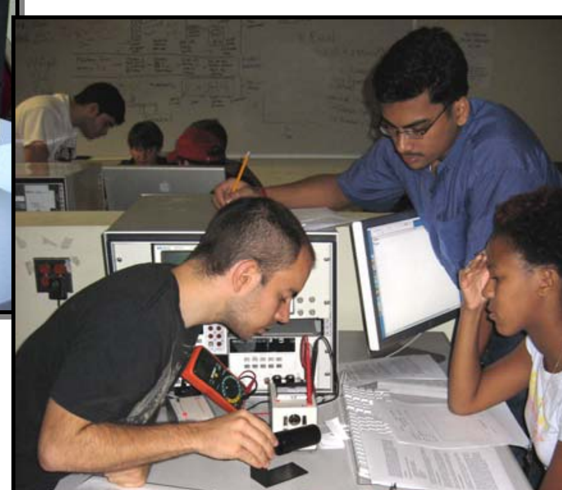
The learning of Physics, like any other 'exact' science, is an exercise in clear, logical thinking. Although Physics is about investigating the behavior of matter, in the most general sense it is about how to formulate and solve problems. Therefore, this course sequence was designed to look at problems that cut across several disciplines. This poses a special challenge, especially at the beginning physics sequence level - the students may not have adequate background to understand and appreciate the "beauty" of Physics as expressed in Modern Physics. However, even in Classical Physics there are many "real world" problems that offer the excitement of discovery, and the joy of being able to understand simple Physics underlying a natural phenomenon. Classical Physics also contains enough elements in it that, with a judicious choice of topics and proper guidance, it allows the student to survey the beautiful landscape of Modern Physics even if one does not fully understand every minute features of its topography. The idea is to get the student excited about and involved in an exploration that goes beyond tedious number crunching to solve problems. Thus, an emphasis is placed on conceptual understanding - how to think through a problem rather than how to quickly get a correct numerical answer. Experience has shown that students who do not do well in their Physics courses and find it an ordeal is not because of their lack of mastery of some mathematical technique, but due to uneasiness with Physics at the conceptual level. The four courses in the Fundamentals of Physics sequence cover in broad sense four topics: mechanics, electromagnetism, classical oscillations and quantum physics, and finally statistical descriptions of gases and complex systems with explicit description of the interactions of light and particles with biological matter.

The choice of topics in the sequence is of primary importance. The chosen topics emphasize the unification of physical concepts, introduce modern physics early on and emphasize applications of Physics in the biological sciences. The emphasis on the unification of physical concepts brings to the students an understanding of the basic principles of the science. Students need to participate in the process of constructing physical model to understand the relationship and differences between concepts. Postponing the exposure to complicated mathematical frameworks to follow the teaching of the basic principle will be a hallmark of the course which corresponds to modern pedagogy.

The introduction of Modern Physics early on is to emphasize the essential need for today's scientists and engineers to understand quantum mechanics well and be proficient at it. Suffice to mention that electrical engineers develop and use photoconductors, quantum wells, semiconductor junctions, etc. Material engineers regularly use quantum dots and sophisticated microscopy techniques based on light and particles among others. Computer engineers are often involved in the development of faster chips. This new course sequence will expose the students to some of the concepts required of the modern engineers and scientists.

The need for an exposure of the uses of physics in the biological world is as evident as the need for an understanding of the quantum world. The importance of Physics in this context stems from the ever more sophisticated instrumentation, from better X-ray techniques to MRI, which are direct applications of Physics. Even more importantly is the importance of Physics as a basic science to serve in the modeling of complex biological systems. A case in point is the fundamental role played by physics concepts in protein folding modeling.





The students performed experiments in the lab sections of the course that are often not done at the undergraduate level at Drexel or anywhere else for that matter. For example, in PHYS-101, students measured the speed of light using fiber optical techniques. Most students have the notion, since the velocity of light is so large ($3*10^8$m/s), that its measurement can be performed only in sophisticated laboratories by experienced scientists. While the notion is true for very exact measurements, the students were surprised and thrilled after having measured the velocity of light within a few percent of the accepted value. Similarly, in PHYS-102, students measured the fundamental electronic charge using the Millikan oil drop experiment – the same experiment for which Millikan was awarded the Nobel Prize in Physics. At most universities, this experiment is often carried out by physics majors in their junior or senior year. In PHYS-201, students carry out experiments on superconductivity, photoelectric effect, interference and diffraction, and emission spectra of gases using the latest equipment in spectral analysis.

For every experiment we also introduced, for the first time, a "Just for Fun" part. In this part students are encouraged to investigate various interesting modern physics phenomena through 'playing' and exploration. All these experiments were new for our engineering majors and the students' response has been uniformly enthusiastic.

Professor Tyagi was responsible for designing, implementing, and teaching these new courses and their new laboratories. He and Professor Vallières co-wrote the proposal that led to the approval of the courses by the Curriculum Committee of the Department, CoAS and the Senate. Professor Ramos worked closely with Professor Tyagi to develop the laboratories for PHYS 101 and PHYS 102 and the teaching of PHYS 101. Professor Ghosh taught with Professor Tyagi PHYS 102. Professors Maricic, Venkataraman, and Tyagi are teaching, this year for the first time, this new Fundamentals of Physics.

Other Multi-disciplinary Developments

Len Finegold persuaded eminent speakers to give presentations on Issues in the PHYS 127/ SOC 137 course "Science and Religion". They were Guy Consolmagno, Vatican Observatory: "Brother Astronomer: Adventures of a Vatican Scientist"; Faye Flam, Philadelphia Inquirer: "Carnal Knowledge: The Clash of Science, Sex and Religion"; Richard Sloan, Columbia University: "Religion and Medicine"; and Eric Rothschild, Esq., Philadelphia: "Law & Creationism. The Dover Case".

Robert Gilmore implemented new teaching innovations in Quantum Mechanics using Transfer Matrices and in Nonlinear Dynamics using our Topological Analysis Methods.

Frederick B. House, continued the online development of two new atmospheric science courses PHEV145 Weather I and PHEV146 Weather II. Both courses are innovative lectures with integrated laboratory investigations. It is expected to implement them totally online in the future. Students are required to write research papers on global warming, climate classification, sunspots and weather. These papers utilize climatology data of temperature and precipitation at stations around the world whose periods of observation are more than 100 years in length. Each student works with his or her own data set.

Charles Lane, renovated the Instrumentation and Advanced/Modern Physics Labs. He set up new computers and installed equipment for the remote environmental monitoring.

Teck-Kah Lim, directed with the assistance of P. Henry, A. Finger and S. Vaidya the creation of EDUC 775 and EDUC 531, two special 1 credit courses for incoming Teaching Assistants in order to prepare them for their responsibilities as instructors.

Teck-Kah Lim and Zenghui Liu, redesigned the website for PHYS 151 introducing links to various resources and incorporating numerous simulations and videos.

Degrees Awarded

Master Degrees:

Travis Hoppe
Katharine Hudson
Steven Jenks
Donna Yosmanovich

PhD Degrees:

Dr. Rui Zhou, “Automated Sensitivity Analysis on Spatio-Temporal Biochemical Systems”. Advisors: Dr. Hun H. Sun, and Dr. Avijit Ghosh, March 19, 2007.

Dr. Ensheng Liu, “Sensitivity, Non-Equilibrium Thermodynamic and Control Analyses of Insulin Metabolic Signaling Pathways”. Advisor: Dr. Jian-Min Yuan, September 12, 2007.

Personnel

Faculty

Shyamalendu Bose
N. John Dinardo
Frank Ferrone
Leonard Finegold
Avijit Ghosh
Robert Gilmore
David Goldberg
Fred House
Charles Lane
Teck-Kah Lim
Jelena Maricic
Steve McMillan
Roberto Ramos
Gordon Richards
Richard Steinberg
Somdev Tyagi
Michel Vallieres
T.S. Venkataraman
Michael Vogeley
Guoliang Yang
Jian-Min Yuan

Faculty Emeritus

Richard Haracz
Paul Kaczmarczik
Donald Larson
James McCray

Research Faculty and Post-Docs

Joel Allred
Alexey Aprelev
Rajesh Deo
Fiona Hoyle
Peter MacNiece
Otonyo Mangete
Kevin Olson
Maria Rotter
Daniel Spicer
Enrico Vesperini
Karim Zbiri

Evening College and Adjunct Faculty

Michael Carchidi
Nicole DiGironimo
William Engle
Saurabh Gayen
Paul Kaczmarczik
Eric Scheidly
Joseph Trout

Staff

Laura D'Angelo
Lisa Ferrara
Janice Murray
Jacqueline Sampson
Michael Downes

Graduate Students

Jeffrey Blomquist
Erica Caden
Benjamin Coy
Daniel J. Cross
Edward Damon
Sanghamitra Deb
Daniel Flynn
Travis Hoppe
Bradley Hubartt
Timothy Jones
Michael Kaczmarczik
Sam Kennerly
William King
Rachel Kratzer
Joseph Lambert
Robert Lawler
Ryan Lee
Hanbing Lin
Runcong Liu
Zenghui Liu
Sean Lynch
Ernest Mamikonyan
Ryan Michaluk
Tatjana Miletic
David J. Miller
Arunasri Nishtala
Danny Pan
John Parejko
Marisa Roman
Nicola Romanazzi
Zechariah Thraikill
Yihua Wang
Weijun Weng
Donna Yosmanovich
Mikhail Zakharov
Di Zhou

Undergraduate Students

Brian Acquaviva
Aida Alibek
Joseph Angelo
George Antonio
Carlos Bahamondes
Kara Blaine
Alexander Bolesta
Jon Brennan
Pablo Calva
Brian Cohen
William Czaja
Andrew Eshelman
Robert Ferrier
Brian Fisher
Meredyth Forbes
Casey Gallagher

William Gallagher
Pubudu Galwaduge
Joseph E Gaston
Eric Gerchberg
Joseph Gombarick
Jason Haaga
Jeffrey Hainsworth
Mike Honie
Andrew Jones
Robert Kaylor
Prativa Kharel
Armir Koka
Warren Kushner
David LaPoint
Flynn Lawrence
Tze Yee Lim
Charles Marine
Daniel McCann
Daniel McGovern
Rory McGurty
Timothy R McJilton
Ryan McKeown
Seth Meiselman
Jerome Mlack
James W Monahan
Charles P Nystrom
William L Peeples
Emily Ann C Peters
Anna Petrone
Max Polun
Jennifer Pillon
Gang Qui
Vede Ramdass
Daniel Rein
Matthew Robinson
Alex Rossi
Matthew Salerno
David S. Serratore
Justin Sochor
Max Soloff
William Stephenson
Anthony Tyler
Stanley Viss
Sarah Wall
Matthew Washick
Casey Watson
Amanda White
Alyssa Wilson

Students Awards

Jerome Mlack, received the Henry S.C. Chen Memorial Award for Physics, presented in memory of Henry S.C. Chen who was a member of the Physics Faculty from 1949 to 1975.

Stacey Jones and Charles Marine, received the Walter R. Coley Award, presented to outstanding freshman and senior Physics majors who have achieved academic excellence.

Casey Gallagher, Vede Ramdass, David Serratore, William Stephenson, and Alyssa Wilson, received the M. Russell Wehr Physics Award, presented to Physics majors who show promise or potential for teaching or for advanced work in the history of science.

Jeffrey Blomquist, Daniel Cross, Danny Pan; and Part-Time Student Employees: **Mani T. Benjamin, Krupa H. Suchak, and Ananth C. Vas,** received the Drexel University Graduate Student Teaching Excellence Award.

The **Society of Physics Students** received the Marsh W. White Outreach Award from the American Institute of Physics "to support projects designed to promote interest in physics among students and the general public."

Memberships and Fellowships

L. Finegold, F. Ferrone, R. Gilmore, Teck-Kah Lim, and **Jian-Min Yuan**, Fellows of the American Physical Society.

S. McMillan, Fellow of the Royal Astronomical Society (U.K.)

F. Ferrone, member of the Franklin Institute Committee on Science and the Arts.

J. Allred, A. Constantin, D. Goldberg, Gordon Richards, S. McMillan, and **M. Vogeley,** members of the American Astronomical Society.

J. Allred and **L. Finegold**, members of the American Geophysical Union.

S. Bose, A. Constantin, N.J. DiNardo, C. Lane, R. Ramos, R. Steinberg, M. Vallières, and **G. Yang**, members of the American Physical Society.

N.J. DiNardo, A. Ghosh and **Jian-Min Yuan**, members of the American Chemical Society.

L. Finegold, and S. McMillan, members of the American Association for the Advancement of Science.

L. Finegold, member of the Committee on Space Exploration.

L. Finegold, member of the Federation of American Scientists.

A. Ghosh, L. Finegold, F. Ferrone, G. Yang, and **Jian-Min Yuan**, members of the American Biophysical Society.

R. Gilmore, member of the American Institute of Physics.

D. Goldberg, member of Phi Beta Kappa.

C. Lane, President, Drexel chapter of Sigma Xi, **A. Ghosh**, Treasurer, **D. Goldberg, F. House, Teck-Kah Lim , J. Maricic,** and **M. Vallières,** members.

S. McMillan, and **G. Richards,** members of the Astronomical Society of the Pacific.

S. McMillan, member of the IEEE Computer Society.

R. Ramos, member American Association of Physics Teachers.

R. Ramos, member, Philippine-American Academy of Scientists and Engineers.

Outreach Activities

Our Department is involved in several outreach activities and offers resources to promote scientific awareness in our local community.

K-12 Outreach Activities

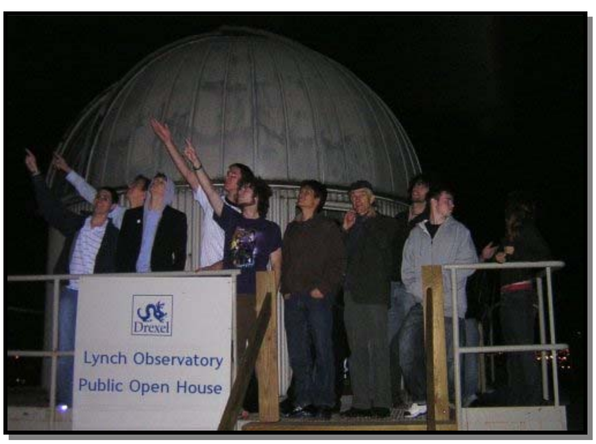
The Kaczmarczik Lecture Series

The Kaczmarczik Lecture Series is a significant event on campus, as numerous Nobel Laureates

have been invited in recent years to address the audience. The goal of this lecture series is to expose a much wider audience, especially high school students, to fascinating concepts at the forefront of Physics research. This year's speaker was Dr. John C. Mather (2006 Physics Nobel Laureate), from NASA Goddard Space Flight Center. Dr. J.C. Mather presented "From the Big Bang to the Nobel Prize" to an audience of about 1000 attendees.

Prior to the lecture, the Department of Physics held an open house. This event has exposed, over the years, thousands of local high school students to recent discoveries in astrophysics and gave them the opportunity to meet with well-known scientists. Our physics researchers gave brief presentations to the students on topics like Biophysics, Astrophysics, Computational Physics, Chaos Theory, and Condensed Mater together with a tour of the department's facilities. As part of the activities, selected Drexel undergraduate students from different areas of science, had breakfast with Dr. Mather and had the great opportunity to have informal discussions with such a prominent scientist. The event was held on March 8, 2007.

Public Observation Nights



On the first Thursday of every month, the Department of Physics invites the public to attend an observing session atop the Main Building at Drexel University. A variety of celestial objects can be viewed from planets, nebulae, star clusters to comets. This program is run by graduate student **John Parejko** under the supervision of **David Goldberg**, Director of the observatory.

http://www.physics.drexel.edu/observatory/index.shtml

Astrophysics Outreach to Philadelphia School District

David Goldberg and graduate student **John Parejko** received a NASA OSS/EPO grant to help the Philadelphia School District with their 6th grade astronomy curriculum. This effort consists in two parts: Student observing nights bringing in 6th grade students from around the district to use our telescope for visual observing and imaging, and Teacher enrichment by offering a free astronomy series for ACT 48 credit to all teachers in the Philadelphia School District.

Low-Temperature Physics in High Schools

Roberto Ramos together with the **Society of Physics Students**, and within the NSF Campaign for Absolute Zero, take low-temperature quantum devices to local high schools and explain superconductivity to the students. This effort includes hands-on demonstrations engaging students in science and low-temperature physics.

High School projects in Quantum Devices

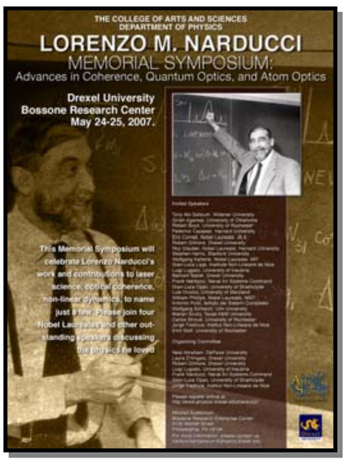
Roberto Ramos brought bright students from Philadelphia High Schools to work ad-honorem in his ultra-low temperature laboratory. They have contributed significantly in designing, building and testing microwave powder filters and measuring quantized conductances. Several students participating in this program have won several awards in Science Fairs including a 3rd prize in the Delaware Valley Tri-State Science Fair. The latter student has been invited to participate in the University of Pennsylvania's Nanoday celebration in October 2007.

Graduate Students Orientation

In order to prepare our incoming graduate students, **Michael Vogeley** in collaboration with **Laura D'Angelo** organized two weeks of orientation. Faculty members and **Ernest Mamikonyan**, gave lectures in advanced computational techniques. Researchers also presented talks on their current research topics. Incoming graduate students received folders containing useful information which were prepared with careful attention to assist them to succeed in their new endeavor.

Organization of Conferences

Lorenzo Narducci Memorial Symposium



Laura D'Angelo co-organized and hosted the Memorial Symposium in honor of the late Professor Lorenzo M. Narducci, held on May 24 and May 25, 2007 at the Edmund D. Bossone Research Enterprise Center. The symposium focused on Advances in Coherence, Quantum Optics, and Atom Optics. Four Nobel Laureates, Eric Cornell, JILA (2001 Nobel Laureate in Physics), Roy Glauber, Harvard University, (2005 Nobel Laureate in Physics), Wolfgang Ketterle, MIT, (2001 Nobel Laureate in Physics), William Phillips, NIST, (1997 Nobel Laureate in Physics), and distinguished speakers gathered to honor and celebrate Professor Narducci's life. He was recognized for his significant contributions to science, his intellect, and his passion for teaching. This event brought to campus over 150 attendees from all over the world.

SDSS Collaboration Meeting

Gordon Richards, organized the Sloan Digital Sky Survey Collaboration Meeting

held at the Bossone Research Enterprise Center from March 29 through 31. The SSDS, a renowned international astrophysics collaboration, consists in three projects. The Legacy Survey, which is completing the original SDSS-I area of sky; a Supernova Survey, aimed at measuring the acceleration of the Universe; and the SEGUE Survey, which is probing the distribution of stars in our own Galaxy.

Royal Netherlands Academy of Arts and Sciences Colloquium on Cosmic Voids

Michael Vogeley, co-organized the Cosmic Void: Much Ado about Nothing. The meeting was under the auspices of the Royal Netherlands Academy of Arts and Sciences and addressed various issues related to the structure, evolution, dynamics and galaxy population of voids in the Megaparsec cosmic matter distribution. The conference took place in the Trippenhuis, the imposing 17th century mansion on the Kloveniersburgwal which forms the headquarters of the Royal Netherlands Academy of Arts and Sciences. December 12-15, 2006.

MODEST-7b Workshop

Steve McMillan, organized and hosted the MODEST-7b workshop on "Multi-scale Multi-physics Simulations". The main themes of the workshop were issues involved in building and maintaining robust software for modeling, analyzing, and visualizing dense stellar systems in astrophysics. A working model is the MUSE project. Much of the meeting was devoted to MUSE, with the goals of adding new modules and functionality to the existing framework and defining the specifications of a more comprehensive environment. Progress on the 1-year "MODEST questions" defined 13 months earlier at MODEST-6a, in Lund was discussed. The meeting was held at Drexel University, January 18-21, 2007.

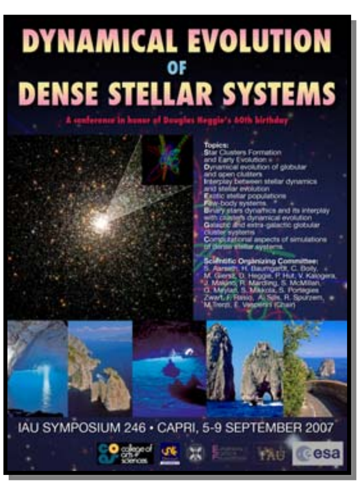
MODEST-7c Workshop

Steve McMillan, organized and hosted the MODEST-7c workshop on Software Frameworks in Astrophysics. During the last year the group have begun to experiment with different methods of tying together modules modeling stellar dynamics, stellar evolution, and stellar collisions within a high-level programming environment. First results of this effort can be found on the MUSE wiki page. However, it is clear that integration of programs written in many different languages, and describing many different complex physical processes, is itself a very complex task, and not unique to our field. The workshop hosted experts with hands-on expertise in building frameworks in different areas of computational science. Their presentations shaped the foundation for a group discussion of constructing frameworks for modeling, analyzing, and visualizing dense stellar systems in astrophysics. The meeting was held at Drexel University, September 15, 2006.

MODEST-7f Workshop

Steve McMillan, co-organized the MODEST-7f workshop. The main objective was to bring together a number of experts in astronomy and computational science to discuss the future developments of the MUSE project. It was held at the University of Amsterdam, the Netherlands, June 10-15, 2007.

International Astronomical Union Symposium 246



Enrico Vesperini, organized and chaired the Scientific Organizing Committee of the International Astronomical Union Symposium 246 on ``Dynamical Evolution of Dense Stellar Systems'' held in Capri, Italy, September 5-9, 2007. **Steve McMillan**, was a member of the Scientific Organizing Committee. The complete study of the formation and evolution of star clusters is a very challenging task which requires the collaboration and the exchange of ideas of astronomers and physicists with observational and theoretical expertise in Galactic and extra-galactic astronomy, stellar dynamics, hydrodynamics and stellar evolution. Expertise on the development of special-purpose hardware and software and, more in general, on many aspects of computational physics also plays a key role in this endeavor. This symposium covered all the aspects of the study of star clusters with particular emphasis on the interplay between them and on the comparison between observations and simulations.

Committees and Professional Activities

Most of our faculty members served as reviewers of renowned scientific journals (Phys. Rev. Lett., Phys. Rev. A, Phys. Rev. E, Phys. Rev. D, Am. J. of Phys., Biophys. J., J. Chem. Phys., J. Phys. Chem., Astrophys. J. Lett., Biochemistry J, Mol. Biol. J. Biophys. Chem., Physics B, Cell Biochemistry and Biophys., Microscopy Research and Technique, Ultrasonics, etc)

Our faculty members also participated as proposal/panel reviewers for the NIH, NSF, NASA E/PO grant program, Petroleum Research Funds, American Chemical Society, Research Corporation, the U.S. Civilian Research and Development Foundation (CRDF) Cooperative Grant Applications.

S. Bose:

- Member of the Senate Committee on Faculty Affairs.
- Chairman of the Review Committee of Sabbatical Applications.
- Chairman, of the Graduate Students Excellence committee.
- Member of the Best Thesis Award committee.
- Judge for the CoAS Research Day.
- Chairman of the Teaching Evaluation Subcommittee of the Departmental Tenure Review Committee.

N. John DiNardo, Vice Provost for Academic Affairs.

F. Ferrone:

- Associate Vice Provost for Research.
- Chair, GRID proposal evaluation committee.
- Chair, Research Day
- Member of the Physics Graduate Admissions Committee.

- Member of the Physics Undergraduate Curriculum.
- Member, representing faculty, University Tenure Review.
- Member Midterm Tenure Review.
- External Examiner for Thesis at Saha Institute of Nuclear Physics, Calcutta, India.

A. Ghosh, co-founder of a new Consortium on Systems Biology of the Dynamic Cell.

R. Gilmore, Standing Committee, International Colloquium for Group Theoretical Methods in Physics.

D. Goldberg:
- Member of the Institutional Review Board – Pennsylvania Hospital.
- Expert consultant for several news broadcasts, including on "Gravity Hills" (ABC; Feb), "Expansion of Gasoline" (Fox 29; June), and "Aerodynamics of Citizen's park (Daily News; June).
- Selection committee for the NASA Education/Public Outreach Program.

L. Finegold:
- Representative, University Senate for the Emeritus Review Committee.
- Administration and Planning Committee for College Poster Day.
- Member of the Editorial Board, Journal of Biological Physics.

F. House
- Member of the University Tenure Appeals Committee.
- Drexel University representative at the University Corporation of Atmospheric Research.
- Organizer of the United Fund Campaign for the Department of Physics.

C. Lane:
- Member of the Radiation Safety Committee and the Chemical Safety Committee.
- Expert consultant to comment on the feasibility "suitcase nukes" and their possible effects. (FOX news affiliate).
- Patron of the Paleontology Society.

Teck-Kah Lim:
- Vice Provost for Graduate Studies.
- Member of the Associate Deans Committee.
- Member of the Postdoctoral Fellows Committee.
- Chair of the Provost Fellowship Committee.

- Chair of the Graduate Advisors Committee.
- Director of the Student Excellence Committee.
- Director of the Club Faculty Advisors Group.
- Directed the Teaching Portfolio Workshop.
- Hosted an Open House in Malaysia.

J. Maricic:

- Elected President of Sigma Xi.
- Judge on Drexel Research Day.

S. McMillan:

- Chair of the University (Provost's) Committee of Research Faculty Appointments.
- Member of the University internal review for IGERT pre-proposals.
- Chair of the CoAS Undergraduate Committee.
- Member of the CoAS Tenure and Promotion Committee.
- Chair of the Physics Department Curriculum Committee.
- Chair of the Physics Department Tenure and Promotion Committee; also member of the Research subcommittee.
- Research Associate, American Museum of Natural History, New York.

R. Ramos:

- Member of the Physics Graduate Admissions Committee.
- Member of the Physics Undergraduate Curriculum Committee.
- Faculty Advisor, Society of Physics Students.
- Served as designated "Local Expert" in NSF-sponsored Campaign for Absolute Zero – a PBS TV documentary.
- Member of the International Scientific Committee of the 27th Annual Symposium of the Philippine-American Academy of Scientists and Engineers.

G. Richards:

- Sloan Digital Sky Survey Quasar Working Group Deputy Co-Chair.
- Builder of the Sloan Digital Sky Survey.
- HEASARC User's Committee (NASA X-ray archive)
- HST Telescope Allocation Committee, AGN Panelist.

S. Tyagi:

- Member of the Math and Physics Workshop Committee.
- Member of the Undergraduate Curriculum Committee.
- Member of the Third Year Tenure Review Committee.

- Member of the Engineering-Physics Coordination Committee.
- Member of the Technical Advisory Committee for Benjamin Franklin Partners.
- Interviewed by a sports correspondent from the Daily News about the physics of the 62 yd. field goal made against the Eagles by the Saint's kicker.
- Interviewed by ABC TV reporter about the role of positive thinking and quantum mechanics as claimed by the author of a recent bestseller, The Gift.

M. Vallières:

- Department Head.
- Administrative Committee of the CoAS Department Heads.
- Member of the University Graduate Student Excellence Committee.

T.S. Venkataraman:

- Member of the University Graduate Student Excellence Committee.
- Member of the University Teaching Assistant Award Committee.
- Member of the College of Engineering Assessment Committee.
- Member of the College of Engineering excellence in teaching TA Award Committee.
- Member Board of Directors: Delaware Valley Science Council
- Participated in the Alliance for Minority Participation Committee.
- Involved in Alcohol and Drug Task Force Committee.

M. Vogeley:

- Advisory Council and Collaboration Council of the Sloan Digital Sky Survey.
- Collaboration Council and Collaboration Council of the Sloan Digital Sky Survey.
- Director of the Graduate Studies of the Department of Physics.
- Member of the Graduate Committee of the College of Arts and Sciences.
- Chair of the Physics Graduate Admissions Committee.
- Member of the Honors College Advisory Committee.

Jian-Min Yuan:

- Judge on University Research Day.
- Judge on College Research Poster Day.
- Advisor for the Taiwanese Undergraduate Student Association.
- Member of the Graduate Admission Committee.
- Member of the Ph.D. Candidacy Examination Committee.
- Ph. D. Candidacy Examination Committee.
- Board Member of the American Association for Ethnic Chinese (AAEC).

G. Yang:

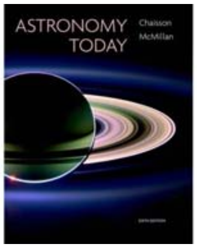
- Judge on University Research Day.
- Judge on College Research Poster Day.

Colloquium Speakers

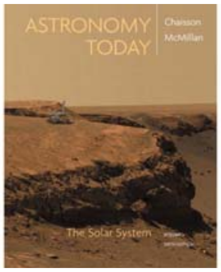
- *"The Latest News in Bananoness - Recent work in Gravitational Lensing and Flexion",* Dr. Dave Goldberg, Drexel University.
- *"Perturbing, Modeling, Imaging, and Evolving Cell Signaling Circuits in Bacteria"*, Dr. Mark Goulian, University of Pennsylvania.
- *"Kinetic Pathways to Phase Separation"*, Dr. Jim Gunton, Lehigh University.
- *"Noise-Dependent Pre-Bifurcational Phenomena and Noisy Unmaskers of Multistability in Cardio (Ventricular) Myocytes"*, Dr. D. Surovyatkina, Space Research Institute of Russian Academy of Science.
- *"The rise and fall of Active Galactic Nuclei"*, Dr. Anca Constantin, Drexel University.
- *"Network Dynamics and Cell Physiology"*, Dr. John J. Tyson Department of Biological Sciences, Virginia Tech.
- "*Warm Dust and Fast Winds: Mid-Infrared Views of Quasar Outflows"*, Dr. Sarah Gallagher, UCLA.
- *"The MINOS experiment"*, Dr. Mark Dierckxsens, Brookhaven National Laboratory.
- *"CP Violation in the B System"*, Dr. Daniel Marlow, Princeton University.
- *"Nonlinear Time Series Analysis of Stellar Light Curves and What We Have Learned Along the Way"*, Dr. Nada Jevtic, Richard Stockton College.
- *"Protein-induced topological changes in DNA"*, Dr. Laura Finzi, Emory University.
- *"AFM and Single Molecule Fluorescence Studies Reveal the Mechanism of Mismatch Recognition"*, Dr. Prof. Dorothy Erie, UNC.
- *"Studying the highest energy cosmic rays with the Pierre Auger Observatory -- prospects for charged particle astronomy"*, Dr. Paul Sommers, Pennsylvania State University.

- *"Colliding 5nm Electron Positron Beams at the International Linear Collider"*, Dr. William Morse, Brookhaven National Lab.
- *"Peeking in Ancient Holes and Seeking the Holy Grail"*, Dr. Amber Miller, Columbia University.
- *"Model-based drug development at the example of the ErbB pathway"*, Dr. Birgit Schoeberl, Merrimack Pharmaceuticals.
- *"New Measurement of the Electron Magnetic Moment and the Fine Structure Constant"*, Dr. Gerry Gabrielse, Harvard University.
- *"Low-Temperature Plasma Physics: Fundamentals and Applications"*, Dr. Alex Fridman, Drexel Plasma Institute.
- *"Protein Interactions: Structure, Energetics, and Kinetics"*, Dr. Huan-Xiang Zhou, Florida State University.

Textbooks and Books

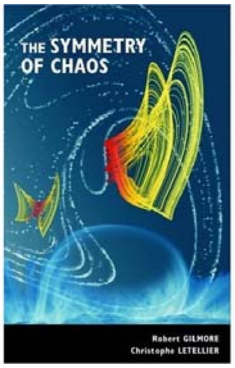


Chaisson, E. and **McMillan, S.** "*Astronomy Today*", 6th edition (Addison Wesley: San Francisco) © 2008.
The sixth edition of this bestselling textbook was significantly expanded and updated as part of the standard three year revision cycle. Chaisson is largely responsible for art program and ancillary material. McMillan has primary responsibility for text, end of chapter material, problems, etc. The new edition contains many revisions (accounts of new discoveries, videos, animations, WWW links, new pedagogical features, planetarium software, etc.) to both the text and the CDROM that accompanies the book, and has significantly improved interactive and online facilities resulting from the move to Addison Wesley.

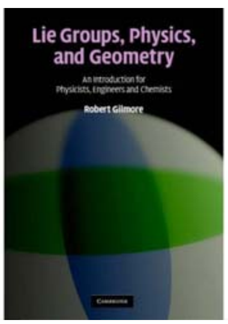


Chaisson, E. and **McMillan, S.** *"Astronomy Today Vol 1: The Solar System"* (6th Edition)
This straightforward volume presents a broad view of astronomy spanning known facts, evolving ideas, and frontier discoveries. The authors combine qualitative reasoning and analogies with familiar objects and phenomena to awaken readers to the excitement of the universe around them. This book incorporates new understanding and emphases in contemporary astronomy, including the latest data on topics ranging from adaptive optics and solar system formation to extrasolar

planets and the recent missions to Mars. Top-notch illustration program exploits the full range of the electromagnetic spectrum, including images taken at radio, infrared, ultraviolet, X-ray, or gamma-ray wavelengths, in addition to visible-light photographs.



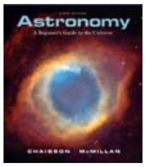
R. Gilmore and C. Letellier. *“The Symmetry of Chaos”* (Oxford University Press: NY) April 18, 2007.
There is a tremendous fascination with chaos and fractals, about which picture books can be found on coffee tables everywhere. Chaos and fractals represent hands-on mathematics that is alive and changing. This graduate textbook in physics, applied mathematics, engineering, fluid dynamics, and chemistry is full of exciting new material, illustrated by hundreds of figures. Nonlinear dynamics and chaos are relatively young fields, and in addition to serving textbook markets, there is a strong interest among researchers in new results in the field. The authors are the foremost experts in this field, and this book should give a definitive account of this branch of dynamical systems theory.



R. Gilmore. *“Lie Groups, Physics, and Geometry”* (Cambridge University Press) 2007.
Describing many of the most important aspects of Lie group theory, this book presents the subject in a 'hands on' way. Rather than concentrating on theorems and proofs, the book shows the applications of the material to physical sciences and applied mathematics. Many examples of Lie groups and Lie algebras are given throughout the text. The relation between Lie group theory and algorithms for solving ordinary differential equations is presented and shown to be analogous to the relation between Galois groups and algorithms for solving polynomial equations. Other chapters are devoted to differential geometry, relativity, electrodynamics, and the hydrogen atom. Problems are given at the end of each chapter so readers can monitor their understanding of the material. This is a fascinating introduction to Lie groups for graduate and undergraduate students in physics, mathematics and electrical engineering, as well as researchers in these fields.

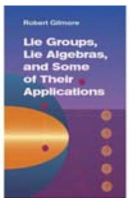
Venkataraman, T.S., Lane, C. and DiNardo, J. *“Undergraduate Physics laboratory Manual”* John Wiley and Sons. 2006.

Recent Books



Chaisson, E. and **McMillan, S.** *"Astronomy: A Beginner's Guide to the Universe Today, 5th edition"*. New York: Prentice Hall, 2006.

Chaisson, E. and **McMillan, S.** *"Astronomy Today"*, 5th edition (Prentice Hall: 2005).



R. Gilmore. "Lie Groups, Lie Algebras, and Some of Their Applications" (Dover Publications January 4, 2006).

Venkataraman, T.S., and Thomas D.H., *"Engineering Applications and Resource Textbook for Physical Foundations of Engineering I, II and III"* Revised and modified Seventh Edition. John Wiley and Sons. September, 2005.

Book Chapters

Goldberg, D.M., ghostwrote for Stephen Hawking in "A Stubbornly Persistent Illusion: The Essential Scientific Works of Albert Einstein" (Running Press: 2007). The book consists of primary source material by Einstein with scientific introductions to each work by Goldberg (writing as Hawking).

Patents

PATENT FILED: Docket # 46528-5029-00-WO, July 11,2007
Methods of Quantitatively Assessing Inflammation with Biosensing Nanoparticles
S. Tyagi, Papazoglou, K. Pourrezaei, A. Karwa, and S. Murthy

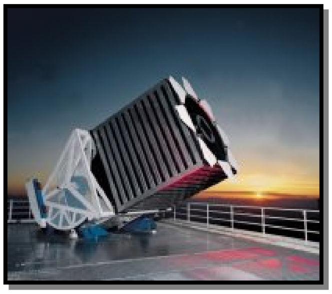
PATENT DISCLOSURE: Fabrication of surface Enhanced Raman Scattering (SERS) Substrates using Nano-particle based Films, S. Tyagi and K. Pourrezaei.

Research Highlights

Astrophysics

- The Astrophysics Group published 35 papers in refereed journals including the Astrophysical Journal, Astronomical Journal, and Monthly Notices of the Royal Astronomical Society.
- Research in astrophysics is funded by 15 active grants with an expected total of $6.4M ($1.6M received this fiscal year) from sources including NSF, NASA, Space Telescope, Sloan Foundation and Jet Propulsion Laboratory.
- Major astrophysics projects include the Sloan Digital Sky Survey, the BASIN parallel computing project, the Starlab Project for simulation and visualization of simulations, MODEST and MUSE.
- Professor Gordon Richards received the prestigious 2007 Sloan Research Fellowship Award.
- Members of the Astrophysics Group organized series of MODEST workshops, SDSS 2007 Collaboration Meeting, the Royal Netherlands Academy of Arts and Sciences Colloquium on Cosmic Voids, and the International Astronomical Union Symposium 246, on Dynamics and Evolution of Dense Stellar Systems, Capri.

Sloan Digital Sky Survey



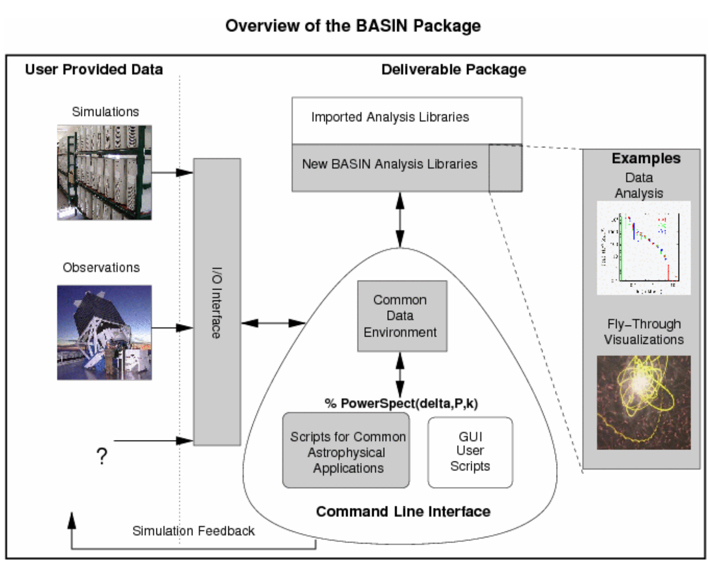
Drexel University continues as a full institutional partner in the Sloan Digital Sky Survey. This project is obtaining detailed optical images covering more than a quarter of the sky, and a 3-dimensional map of about a million galaxies and quasars. The collaboration released new data from the SDSS as Data Release 5 (DR5) and will soon release DR6. Professors Vogeley, Richards, and Goldberg and their students and postdoctoral fellows actively use these data in their research. The SDSS database is also the target of two large interdisciplinary projects: the BASIN parallel computing project (see BASIN below) that includes researchers in both Physics and Computer Science and a NSF-funded collaboration between Vogeley and IST Professor C. Chen and his group.

This IST-Physics collaboration is using data mining techniques to analyze the pattern of publications and citations from the SDSS to quantify the impact of this large survey and its collaboration. Results have been presented in refereed publications and an innovative map illustrating these methods and the SDSS data was selected for an international exhibit on "Places & Space: Mapping Science" that toured in Europe and is installed at the American Museum of Science and Energy at Oak Ridge National Laboratory.

BASIN (Beowulf Analysis Symbolic Interface)

(S. McMillan, D. Goldberg, P. MacNeice, M. Vogeley, C. Chen, E. Vesperini, and O. Mangete)

The BASIN project, funded by the NSF under the ITR program, is a generalization of McMillan's N-body visualization efforts to a broader astrophysical base. The goal is to provide a suite of parallel visualization and analysis tools applicable to a range of data types drawn from many different (astro)physical simulations. The work is being carried out in collaboration with Drexel faculty D. Goldberg, P. MacNeice, and M. Vogeley (Physics) and B. Char (Computer Science). Associate Research Professor E. Vesperini and Postdoctoral Research Associate O. Mangete are also employed by this project. The BASIN kernel and the associated client GUI are now in beta release on the project web site. The collaboration also involves personnel from NCSA (D. Cox, S. Levy, M. Hall, R. Patterson), whose Virtual Director project is integral to this visualization effort. The "VisIt" visualization program, developed at Lawrence Livermore National Laboratory, has been integrated into the BASIN environment. http://www.physics.drexel.edu/BASIN



The Beginning and Evolution of the Universe
(M. Vogeley)

Completed and submitted a major (96 page) commissioned review article on cosmology for the Publications of the Astronomical Society of the Pacific.

Internal Properties of Galaxies
(M. Vogeley, in collaboration C. Park and Y-Y. Choi at the Korean Institute for Advanced Study)

It was precisely characterized the relationships between luminosity, morphology, color, and several other key galaxy parameters, using the largest galaxy data set ever examined. It was convincingly demonstrated that galaxy properties show little variation once morphology and luminosity are fixed.

Environmental Dependence of Galaxy Properties
(M. Vogeley, in collaboration C. Park and Y-Y. Choi at the Korean Institute for Advanced Study)

M. Vogeley and his collaborators found that the morphology and luminosity of galaxies is a strong function of environment, over a range of four orders of magnitude in density. Dependences on environment of other properties are mostly explained by their variation with morphology and luminosity, with a few notable exceptions such as higher star formation rates in void regions.

Topology of Large-Scale Structure
(M. Vogeley in collaboration with J. R. Gott, J. P. Ostriker at Princeton University)

The three-dimensional topology of the distribution of galaxies in the SDSS was measured and found that current physical models and simulations of large-scale structure fail to predict the departure of topology from a Gaussian random field. Thus, these results provide critical tests of models of galaxy formation within the best-fit flat lambda CDM cosmology.

Power Spectrum of Galaxies - Baryon Oscillations and Spectrum Shape

(M. Vogeley in collaboration with the Large-Scale Structure working group of the SDSS)

The signature of baryons were clearly in the spectrum of galaxy density fluctuations, which provided a test of the flat lambda CDM model independent of CMB anisotropy measurements.

Clustering of Active Galactic Nuclei

(M. Vogeley, A. Constantin)

M. Vogeley and A. Constantin discovered strong variation of the spatial clustering of the galactic hosts of different types of active nuclei. This result shows that there is a close relationship between the environment of AGN hosts and the level of activity of accretion onto supermassive black holes in their nuclei.

Cosmic Voids and Void Galaxies

Properties of voids and void galaxies were analyzed in the most recent SDSS data set (DR5). We detected over 400 unique voids in the universe and are in the process of examining their properties (ongoing work with F. Hoyle and D. Pan).

Active Galactic Nuclei in Cosmic Voids

(M. Vogeley, A. Constantin, and F. Hoyle)

A remarkable difference between the frequency and properties of AGN in voids and in denser regions of the universe were found. Together with the clustering results, this group was able to posit a new, complete picture of the co-evolution of supermassive black hole accretion and the galactic hosts of these black holes.

Multi-Wavelength Properties of AGN

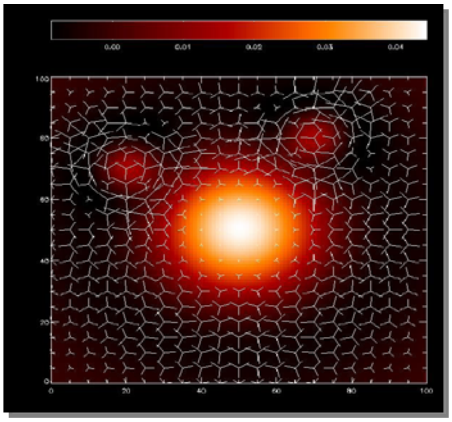
(M. Vogeley, A. Constantin, and J. Parejko)

Data was collected from SDSS and a number of satellite projects to construct spectral energy distributions of active galactic nuclei, which will allow estimation of the accretion rate onto their black holes.

Gravitational Lensing

(D. Goldberg)

Dr. Goldberg is concerned with techniques to extract maximal information from gravitational fields.



His research continues to gain considerable attention within the gravitational lensing community. His group submitted three papers for publication, and has several more in preparation. One paper developed a new technique for measuring Flexion, the "bananeness" of gravitationally lensed images. Along with graduate student Adrienne Leonard, he refined and contrasted existing techniques (developed by Goldberg & Bacon, 2004), with a new fast method called HOLICs.

In Leonard, Goldberg, Haaga and Massey, undergraduate co-op student Jason Haaga helped to reconstruct the mass density of the rich cluster A1689 using both traditional lensing techniques, and the flexion method. It was the first measurement of its kind to be undertaken, and has since inspired similar approaches by other groups.

Finally, in Massey and Goldberg, Goldberg worked with Caltech researcher Richard Massey to show the range of conditions under which traditional lensing techniques may be applied.

His current work in this area is with graduate student Sanghamitra Deb on extracting all the information from Galaxy Cluster lenses in an optimal way. This approach combines traditional weak lensing (shear), flexion, and strong, multiply imaged systems in a new way, including several pieces of the signal which are not utilized in any currently applied reconstructions.

Large-Scale Distortions in Map Projections

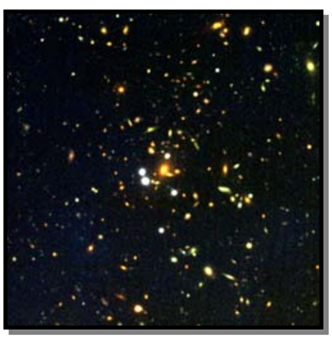
(D. Goldberg)

Tissot indicatrices have provided visual measures of local area and isotropy distortions. Here we show how large scale distortions of flexion (bending) and skewness (lopsidedness) can be measured. Area and isotropy distortions depend on the map projection metric, flexion and skewness, which manifest themselves on continental scales, depend on the first derivatives of the metric. We introduce new indicatrices that show not only area and isotropy distortions but flexion and skewness as well. We present a table showing error measures for area, isotropy, flexion, skewness, distances, and boundary cuts allowing us to compare different map projections. These projections could be used for other planets and for the celestial sphere as well. The mathematical principles used here, including the indicatrices, can in principle be generalized and applied to mapping irregular objects such as asteroids, and hopefully will be helpful in a variety of ways as the search for the best projections for particular applications continues.

Strong Gravitational Lensing

(G. Richards)

In addition to the above projects in weak gravitational lensing, we are involved in searches for examples of strong gravitational lensing. Specifically, quasars that are split into multiple images by the mass of foreground galaxies. Currently an SDSS team (of which Richards is a member) is the record holder for the two most extreme examples (with the largest separation between the images). In fact, such large separations provide independent proof of the existence of dark matter as neither galaxies nor clusters of galaxies alone could produce such large splittings.



The bright white dots in the center of the picture are four images (mirages if you will) of the same quasar, whose actual position is close to the bright yellow/orange galaxy that lies between the four images.

Data Mining for Quasars

(G. Richards)

G. Richards leads the team that is working to create the largest sample of quasars ever. In fact, we already succeeded in that goal with a recent publication of a catalog of 100,000 quasars, but we are now attempting to bring that number to 1,000,000 quasars. The preliminary catalog has been used to measure cosmic magnification, quasar clustering, and the Integrated Sachs-Wolfe effect – allowing us to confirm the currently popular concordance cosmology.

Internal Physics of Quasars

(G. Richards)

G. Richards is actively involved not only in using quasars for statistical purposes, but also in exploring their internal physics. He is one of the proponents of accretion disk-winds as a key ingredient to the physics of quasars and recently gave an invited talk at the AGN Winds in the Caribbean workshop.

Multi-Wavelength Investigations of AGNs

(G. Richards)

In addition to optical studies of AGNs, they are interested in understanding their properties in the infrared and X-ray wavelength regimes. For example, Richards led a team that recently provided the best yet characterization of the infrared properties of quasars. Richards is also the chair of the High-z Science Team for the upcoming Constellation-X mission, which is the next generation of X-ray satellites after the extremely successful Chandra mission.

The Starlab Project

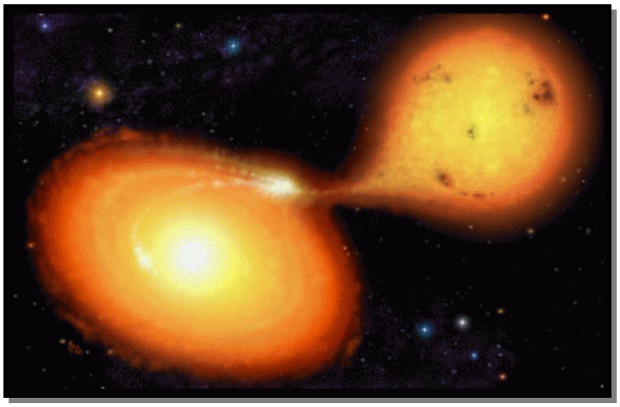
(S. McMillan in collaboration with S. Portegies Zwart)

In collaboration with S. Portegies Zwart (U. Amsterdam), McMillan is the principal developer of the Starlab software environment, a public-domain package of libraries and tools for the simulation of dense stellar systems, and the reduction, analysis, and visualization of the resulting data. The tools share a common data structure and can be combined in arbitrarily complex ways to study the dynamics of star clusters and galactic nuclei. McMillan specializes in writing interface software and parallel front-end applications for the GRAPE-6 special-purpose computer. The centerpiece of Starlab is the GRAPE-based kira N-body integrator, which has now been parallelized for use on Beowulf clusters. McMillan also maintains and oversees the Starlab Web site, http://www.ids.ias.edu/~starlab.

The MODEST Consortium

(S. McMillan)

MODEST (MOdeling DEnse STellar systems) is a loosely knit international collaboration between various groups working in stellar dynamics, stellar evolution, and stellar hydrodynamics. The group's aim is to provide a software framework for



large-scale simulations of dense stellar systems, within which existing codes for dynamics, stellar evolution, and hydrodynamics can be easily coupled. Along with P. Hut (Institute for Advanced Study), McMillan is a founding member of the consortium, which organizes semiannual workshops and whose mailing list now contains more than 100 researchers around the world. McMillan is webmaster for the main MODEST Web site (http://manybody.org/modest), and coordinates the activities of the project's 10 working groups. These activities have now expanded into an ambitious international collaboration with researchers in Rochester, Amsterdam, and Heidelberg to perform large-scale numerical simulations of the central regions of our Galaxy. This collaboration, which combines expertise in many different numerical techniques, represents the first coherent attempt to understand theoretically the physics of this complex region of space.

MUSE (MUlti-scale Multi-physics Software Environment)
(S. McMillan)

MUSE (http://muse.li) is a rapidly developing offshoot of the MODEST consortium. It is a collaborative programming project with the goal of developing a robust software framework to allow modern and legacy programs and packages written in different languages to interoperate in simulations of dense stellar systems. Over the past year MUSE has developed into a sophisticated package combining multiple modules written in C, C++, and Fortran within a unifying python framework, providing tools for the simulation of large-scale stellar dynamics, stellar and binary evolution, stellar collisions, and the dynamics of small systems of stars. At least two independent versions of each module have been included, allowing experimentation and direct comparison of different implementations of each method.

Analysis and Visualization of Complex Datasets
(S. McMillan)

McMillan has a long-standing interest in the development of robust, standalone analysis tools and graphical environments for the visualization of datasets relating to particle simulations. Key projects within this context are Partiview and Basin.

Partiview: (http://www.manybody.org/manybody/partiview.html), an advanced 4D-visualization tool originally developed by S. Levy (National Center for Supercomputer Applications) for use with 3D data, and subsequently extended by McMillan to include the 4D tdyn Starlab data format. A new interface between partiview and the BASIN and VisIt projects is currently under development.

A Next Generation Coronal Active Region Model
(K. Olson, P. MacNeice, J. Allred, D. Spicer)

A grant to model the coronal region of the sun using modern computational techniques was recently awarded to members of the Physics Department at Drexel. One person in this effort has left Drexel to join NASA (P. MacNeice) and one new person has joined the physics department to work on this project (D. Spicer). P. MacNeice remains the overall leader of this project.

Coronal active regions are the original sources of much of the most severe space weather events. Understanding the structure and evolution of these active regions represents a critical step toward a comprehensive space weather forecasting capability.

Recent advances in modeling and an imminent explosion in data sources, particularly vector magnetogram data, have brought us to a point where we can now expect to develop high resolution models of the slow evolution of the magnetic field of chosen active regions.

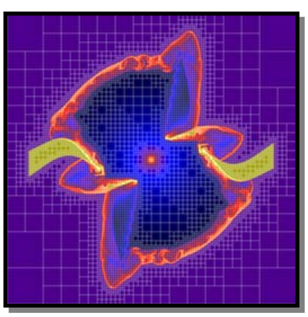
Key model advances have been made because of improvements in both algorithms and in the hardware on which the models run. Adaptive mesh technology has been added to MHD codes enabling high resolution with computational efficiency. New non-linear force free algorithms have been developed in the last few years. Techniques have been developed for constructing surface flow fields by tracking features in magnetogram time series. At the same time, processor and memory performance and cost have all improved significantly.

Because of new data sources, these models must now enter a new phase in which they will routinely be driven by real observational data. This project will seek to develop a next generation active region model which takes advantage of all these recent and imminent developments. The model will include both MHD and non-linear force-free field (NLFFF) representations of the magnetic field. It will stress efficient execution and will include a user friendly graphical interface. D. Spicer and K. Olson will be primarily responsible for the development of the MHD model.

Almost all the key components for a comprehensive active region model already exist in the community. The most challenging aspect of this project therefore will be to achieve the quick run turn-around times demanded in the NRA, particularly for the MHD codes. Our strategy tackles this in two ways – first through the use of an implicit algorithm, and secondly by using the solutions from a NLFFF code to pre-condition the MHD code. This second task must recognize that the photospheric boundary conditions for the two vector field models are inconsistent. The NLFFF solution must be adjusted to allow for non-force-free behavior driven by any cross-field photospheric flows before it is passed to the MHD code.

PARAMESH: A Grid Tool for the Space Sciences

(K. Olson)



K. Olson works on the day to day maintenance and development of PARAMESH. He supervises the addition of new features to PARAMESH including parallel I/O using HDF5 and MPIIO, I/O routine for output into a format which can be read in by the graphics package 'ChomboVis', addition of multigrid and elliptic solver support, writing a C interface to PARAMESH, and improving and generalizing the interpolation schemes used in PARAMESH. He will also work on constructing and maintaining the PARAMESH source code repository, defining coding standards for PARAMESH and regularly testing the software. Finally, he will work with the FLASH code group at the University of Chicago to ensure that PARAMESH continues to support their needs.

Over the past year, one of the largest Astrophysical calculations to date has been performed using the FLASH code. The simulation was of the processes which could lead to a Type Ia Supernova. This simulation made efficient use of some of the largest supercomputers on the planet. All this is made possible by the work on PARAMESH that K. Olson is doing.

Publications (refereed journals):

Adelman-McCarthy, et al. *"The Fifth Data Release of the Sloan Digital Sky Survey"* Astrophysical Journal Supplement Series, v 172, (2007): 634.

Anderson, S.F., Margon, B., Voges, W., Plotkin, R.M., Syphers, D., Haggard, D., Collinge, M.J., Meyer, J., Strauss, M.A., Agueros, M.A., Hall, P.B., Homer, L., Ivezic, Z., **Richards, G.T.**, Richmond, M.W., Schneider, D.P., Stinson, G., Vanden Berk, D.E., York, D.G.*"A Large, Uniform Sample of X-Ray-emitting Active Galactic Nuclei from the ROSAT All Sky and Sloan Digital Sky Surveys: The Data Release 5 Sample"*, Astronomical J, 133, n 1, 313.

Chen, C., Zhang, J., Zhu, W., **Vogeley, M.S.** *"Delineating the Citation Impact of Scientific Discoveries"*. IEEE/ACM Joint Conference on Digital Libraries (JCDL2007). June 17-22, 2007. Vancouver, British Columbia, Canada. ACM. (2007): 19-28.

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McMillan S.L.W. *"Dynamics of Young Star Clusters"* colloquium presented to the Astronomy Department of the California Institute of Technology, May 2, 2007.

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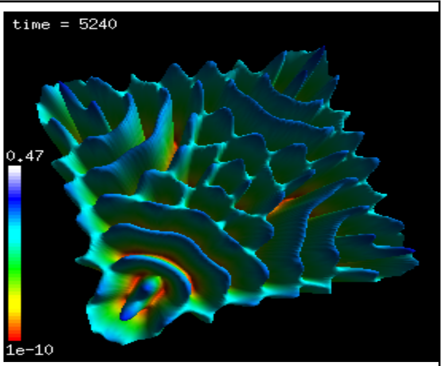
Biophysics

Computational

(A. Ghosh)

CellSim – A High Performance Cellular Simulator for Systems Biology

None of our biological efforts would be possible without the development of high performance computational Systems Biology tools for quantifying, modeling and visualization. Our efforts have been grouped together as a freely available software package called CellSim, (Cellular Simulator). This package is highly optimized for high performance distributed computing platforms using the Message Passing Interface (MPI) parallel programming library. In addition, the cross-platform development tools have allowed us to port our software to small desktop workstations such as standard windows and Macintosh computers for wide distribution and usability.



Snapshot of Fast Adaptive Time Step Integration of Gray Scott Model in CellSim using periodic boundary conditions. This model is a mathematical Model of the glycolysis process and illustrates the complexity of coupled reaction diffusion equations in simple models

The MPI distributed computing platform is particularly efficient for transport-coupled kinetics. The chemical reaction terms are essentially communication independent as they depend only on the local concentrations of each species. Furthermore, as the computational cost of transport has been designed to be much less than the kinetic components, the system is essentially immune to communication overhead and may therefore be parallelized with near linear efficiency.

Oncogene Explorer Module

The research efforts on the MAPK kinase cascade have lead to the development of an automated oncogene detection module that may be used within CellSim. This software module, takes as input a series of chemical pathways (temporally and optionally, spatially) and, in an automated manner, generates a set of predictive rankings of putative oncogenes using both direct simulation and sensitivity analysis.

The Extracellular signal Regulated Kinase (ERK) pathway is one of the most well studied signaling pathways in cell cycle regulation. Disruptions in the normal functioning of this pathway are linked to many forms of cancer. In a previous study, this group had developed a novel approach to predict single point mutations that are likely to cause cellular transformation in signaling transduction networks. This method was extended to study disparate pair mutations in enzyme/protein interactions and in expression levels in signal transduction pathways and it was applied it to the MAPK signaling pathway to study how synergistic or cooperative mutations within signaling networks act in unison to cause malignant transformation. The method provides a quantitative ranking of the modifier pairs of ERK activation. It is seen that the highest ranking single point mutations comprise the highest ranking pair mutations. We validate some of our results with experimental literature on multiple mutations. A second order sensitivity analysis scheme is additionally used to determine the effect of correlations among mutations at different sites in the pathways.

Drug Targeting Module

In silico models of signal transduction pathways have been highly successful in describing, quantitatively, how complex protein networks govern overall cell function. By analyzing a recently developed model of oncogenesis in the Mitogen Activated Protein Kinase (MAPK) signal transduction pathway, a quantitative ranking of putative targets that inhibit the transformation process has been developed. The inhibitor, a virtual drug, is constructed by specifying its parameters: initial concentration and binding affinity kd. Many of the targets found by this analysis have inhibitors that are currently under investigation. In addition, several novel targets not previously investigated have been found. Of the thirteen targets, Ras, Guanine Exchange Factor (GEF), and Raf, show the highest potential. In addition, the analysis finds that certain calcium blockers may have much potential as anti-tumor agents, functioning at much lower concentrations but requiring higher specificity.

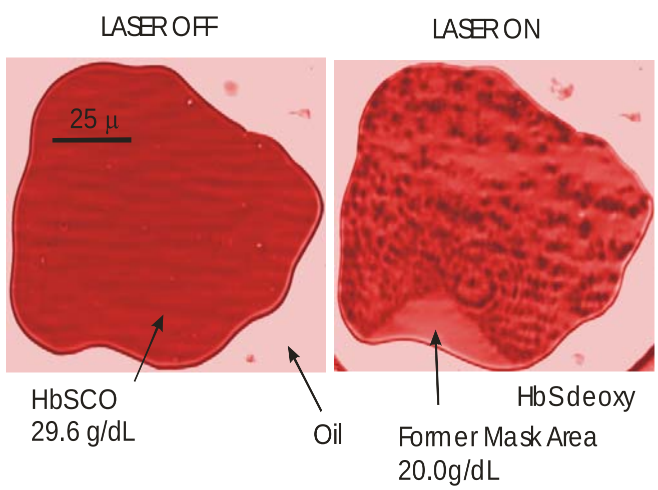
Experimental

Protein Assembly

(F. Ferrone)

Our work focuses on how proteins form large assemblies, many of which are pathological. Primarily we have investigated sickle hemoglobin, but assembly of β amyloid fibers (Alzheimer's disease), prions (Mad Cow disease), or poly-glutamate repeat proteins (Huntington's disease) all have similar features, and the fundamental work done in our laboratory is being adapted by researchers of these other communities as paradigms for other assembly diseases.

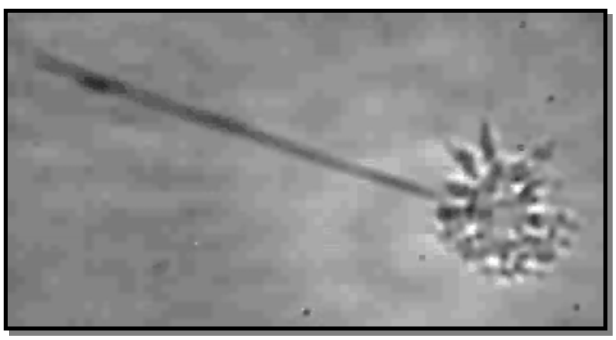
A major discovery this year has been that the polymerization of sickle hemoglobin does not proceed to equilibrium, but is frustrated by the occlusion of polymer ends. It had been previously assumed that the endpoint represented equilibrium. This has profound importance for the pathology of the disease. Red cells must deform in order to fit through the narrowest part of the circulation. It had been assumed that sickling in those capillaries would create an incompressible mass, which thereby created the problems in downstream circulation. What our finding suggests is that the red cells will actively wedge themselves against the capillary walls by virtue of the outward pressure the polymers exert as they attempt futilely to grow further. This also would lead to membrane damage, and might cause adhesion that is also observed.



This discovery arose from the work of Dr. Alexey Aprelev, a postdoctoral research associate in our group. Dr. Aprelev suggested that we use droplets of hemoglobin suspended in oil, and photolyze (thereby allowing polymerization in) most but not all of a drop. The unphotolyzed area acts as a reservoir, and will be drawn down as polymerization proceeds. In our experiments under usual conditions, the reservoir did not fall to the expected solubility limit.

The droplet methodology has proved fertile. In the presence of dextran, hemoglobin will polymerize at much lower concentrations, and there the droplet experiment replicates more usual results, as shown by Mr. Zhengui Liu, a graduate student. We have also shown how to account for crowding by using scaled particle theory with a variable volume, which is a novel theoretical approach. With this method we can reliably determine the free energy of assembly of hemoglobin mutants (provided by our collaborators) using only a few microliters of the protein.

The droplet method is also being explored by another graduate student, Mr. Weijun Weng, whose work is relating the droplet measurements to measurements in undispersed solutions. He has shown that in those solutions as well equilibrium is not reached. In that case, a method developed previously in our lab is used, called modulated excitation. A trace of CO is added to a deoxygenated sample of hemoglobin which is allowed to gel. When photolyzed, the rate at which CO rebinds depends on the concentration of free hemoglobin, thus measuring in situ the unpolymerized hemoglobin, i.e. the solubility. To understand this experiment Mr. Weng has shown also that, in droplets, the final concentration at a given temperature depends on the initial temperature of gelation. That is, polymerization at 35°C, followed by a move to 20 °C is not equivalent to direct polymerization at 20°C. For the undispersed modulation experiment, the sample gels but once, and thus its properties are frozen by that temperature. Mr. Weng's work shows that the droplet result is universal.



Another thrust of our work is microrheology, since sickle cell disease is fundamentally a rheological . Again we are using the droplets. Another graduate student, Mr. Mikhail Zakharov, and Dr. Aprelev, have developed a unique microrheological capability. To drive the system, we have placed small electromagnets around a sample, which can be observed by a state of the art video system, capable of 12 bit framing at 1000 frames per second. Through a high speed processor, we can process images rapidly enough for active feedback to the electromagnets. With our droplets, we compress microscope slides by using the electromagnets to pull on a nickel washer sinusoidally. The expansion of the droplet's perimeter as it compresses provides *one angstrom* resolution of sample thickness.

In another approach we are using nickel nanowires trapped within polymer domains. These are rotated by phasing the magnets, twisting the nanowire as the polymer domain is melted. Feedback allows the nanowire displacement to be kept constant by varying the force exerted.

With Dr. Maria Rotter, a Research Assistant Professor in our group, and Dr. Kazuhiko Adachi of Chidren's Hospital, we have published a description in Journal of Molecular Biology of the first artificially created hemoglobin to exceed Fetal Hemoglobin as an inhibitor for polymerization. Our kinetic measurements and model analysis provided the data to propose the novel mechanism that a kinetic cap forms, slowing polymerization and changing the morphology of the resulting polymer domains.

In collaboration with the University of Palermo we are completing work on the theory of liquid-liquid demixing in hemoglobin. This will be the first case of hard-sphere exclusion and demixing to be described successfully, and may explain the scaling behavior that connects demixing and polymerization.

Experimental

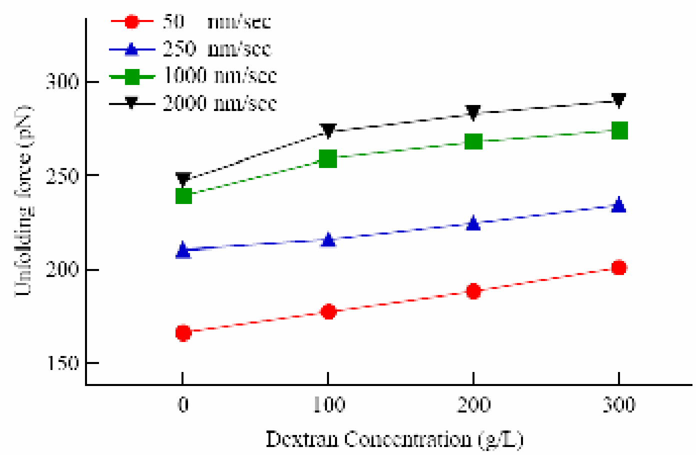
(G. Yang)

Our lab investigates the property, function and processes of biological macromolecules and macromolecular assemblies at the nanometer scale. Current research projects include the study of protein folding mechanisms, the investigation of macromolecular crowding effect on protein folding, the application of solid state nanopores to characterize nucleic acids, the characterization of polymer properties after modifications, and the elucidation of the viscosity effect on the AFM measurements of forces. In the past year, we have made progress on all of these projects, as described below.

Macromolecular crowding effects on the mechanical stability of proteins

Macromolecular crowding, a common phenomenon in the cellular environments, can significantly affect the thermodynamic and kinetic properties of proteins. We have investigated the effects of macromolecular crowding on mechanical stability of proteins using a single molecule technique. It was found that the forces required to unfold a protein molecule was enhanced by macromolecular crowding from added dextran molecules, as shown in the Figure obtained from ubiquitin. To our knowledge, there is no report for such experiments. Since the generation and transformation of mechanical forces are involved in many biological processes, our findings suggest that macromolecular crowding might serve as a means to fine tune the protein function and regulate the biomolecular processes that involve mechanical forces. In collaboration with Dr. Yuan of our Department and Dr. H-X

Zhou of Florida State University, we are developing theoretical models to account for the observed effects of macromolecular crowding. A manuscript is to be submitted on this work in the near future. A graduate student, Marisa Roman, is currently working on the project to elucidate how the size and type of the crowding agents affect the macromolecular crowding induced resistance of proteins to mechanical stresses.

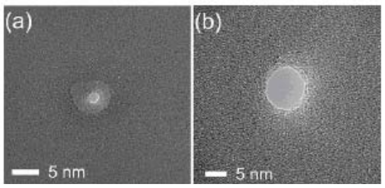


Experimental measurement of the free energy landscape roughness of proteins

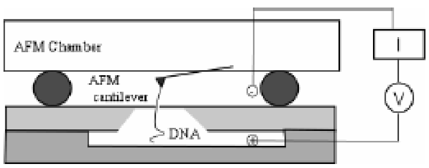
Most protein molecules need to fold into their native structures in order to function properly. Studies of protein folding using experimental, computational and theoretical approaches have shown that there are certain common features in protein folding, and a few parameters can be used to characterize the important aspects of protein folding process. One of these common features is that foldable proteins have a funnel-shaped energy landscape with a gradient toward the native state structure. The energy landscape of real proteins is rough because attractive non-native contacts as well as the steric hindrance on the protein configuration changes during the folding process. Knowing the energy landscape roughness will be crucial in understanding protein folding mechanism. According to a recently developed theory, the energy landscape roughness of protein molecules can be measured from the unfolding forces of protein molecules, if the experiments are performed at different temperatures. We have carried out single molecule mechanical unfolding experiments within a wide temperature range, and obtained a direct assessment of the energy landscape roughness of the protein ubiquitin. A manuscript is in preparation. Mr. Trevor King, a graduate student, is working on the experiments of temperature dependent mechanical unfolding of another protein, the immunoglobulin like domain 27 (I27). In addition to the roughness of the free energy landscape of this protein, these experiments might also provide information on the molecular mechanism for the change of muscle flexibility with temperature.

Characterization of nucleic acids using solid state nanopores

Nucleic acids are polymers with highly charged phosphate groups. Two types of nucleic acids, i.e., DNA and RNA are found in living organisms, while only one type, DNA or RNA, is found in viruses. Nucleic acids perform the vital functions of storing, replicating and transmitting the genetic information. In addition, DNA and RNA also have enzymatic, structural and other important biological functions. Furthermore, DNA and RNA molecules can be used to fabricate artificial



nanostructures and nanomachines, as well as serve as handles for nanomanipulations of other molecules. As a result of these important functions of nucleic acids, novel technologies are always in high demand in order



to accurately and efficiently determine the sequence, structure and other properties of DNA and RNA. At present, the speed and cost of currently available methods for nucleic acids characterization are still insufficient to provide the sequence and structural information of individualized genomes for routine biomedical applications. In collaboration with Dr. Kim and Dr. Zhou in the Department of Mechanical Engineering and Mechanics, we are developing a technique based on using nanopores to acquire the sequence, mechanical and structural properties of individual DNA and RNA molecules at very high speeds and low costs. The nanometer-sized pores are fabricated on free-standing solid state thin films using electron beam and focused ion beam, as shown in the figure. Individual DNA and RNA molecules will be mechanically pulled through the nanopore with an AFM cantilever. The local rigidity, secondary structures and sequence of the molecules will be determined from the force signal.

Measurement of the viscosity effect on the AFM force measurements

In the experiments of using the AFM to study protein folding/unfolding and to measure the mechanical properties of macromolecules, the forces are measured from the deflection of the AFM cantilever, which is submerged in the buffer solution. When the cantilever moves relative to the surrounding liquid, the viscous drag force cause errors in the measurements, especially when the cantilever moves at a high speed and/or the buffer solution has a high viscosity. The small dimensions and irregular shapes of the cantilever and the AFM liquid chamber make it difficult to calculate or measure the viscosity effects on force measurements. A graduate student, Runcong Liu, conducted experiments to determine the viscous drag force on the AFM cantilever by measuring deflections of the cantilever under controlled displacement of the sample surface. These measurements are essential for the interpretation of our experimental data of the macromolecular crowding effect on the mechanical stability of protein molecules, where the measurements were performed in solutions with high viscosities.

Determination of spring constant of AFM cantilevers using biological molecules

One of the major challenges in single molecule measurements of mechanical forces in biological systems is the calibration of the force sensors at the scale of tens of pico newtons. In the atomic force microscope (AFM), the force sensor is a micro cantilever, with a spring constant in the range of 1 to 1000 pN/nm. Currently, the most commonly used method for the determination of the spring constant utilizes the equipartition theorem by modeling the cantilever as a one-dimensional oscillator and measuring the amplitudes of the thermally driven oscillations. This method is convenient, but inaccurate. Mr. Flynn Lawrence, an undergraduate student, is working on developing an alternative method to determine the spring constant of AFM cantilevers for his senior research project. The approach utilizes the unique signature generated by DNA molecules during the force induced structural transformation from the double helix conformation to a linear ladder, i.e., the so called B-S transition, which occurs at a force of 65 pN. Using previously established procedures, individual molecules of double-stranded (ds) DNA is stretched with the AFM cantilever to be calibrated, and deflection is measured at the point of the B-S transition. The spring constant of the cantilever is equal to the force (65 pN) divided by the deflection. Computer programs will be also developed for the identification of the B-S transition in the large number of data curves, and the calculation of the spring constant of the cantilever.

An ordinary image of a thermally damaged chicken skin tissue sample taken with an ordinary CCD camera (left) and a dielectric contrast image (right) recorded using our technique

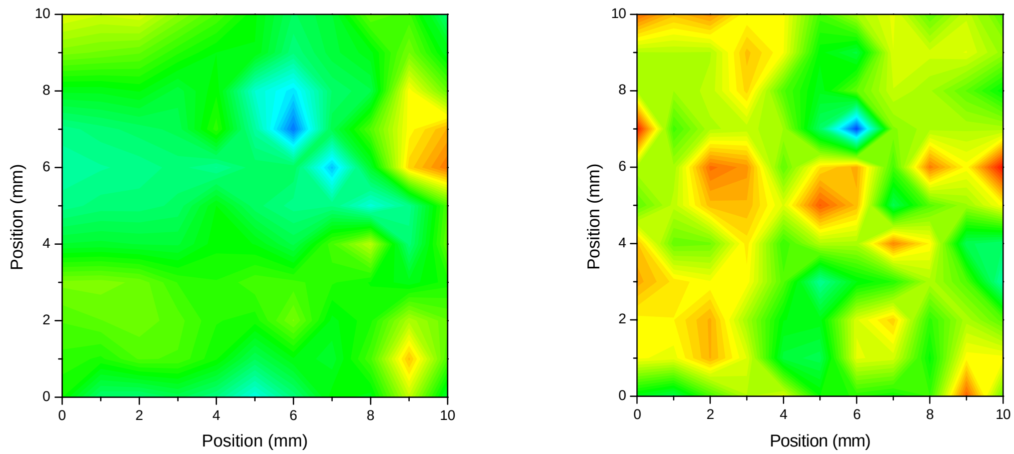
Experimental

(S. Tyagi)

Scanning Near-Field Microwave Microscopy

A non-propagating, evanescent *em*-field exists near an aperture in a resonant cavity if the dimension of such an aperture is much smaller than the microwave wavelength. In our case the radius of the circular aperture is $r = 10\text{- } 100\ \mu m$ for $\lambda = 10 - 30cm$. The technique provides variable depth imaging of samples in terms of their dielectric properties.

At 1.0- 10.0 GHz, we have used this technique to image the free-water content and other dielectric properties of skin tissue. Water retention capacity of skin is one of the most important parameters that measures the state of health of skin tissue and the wound healing capacity in particular.

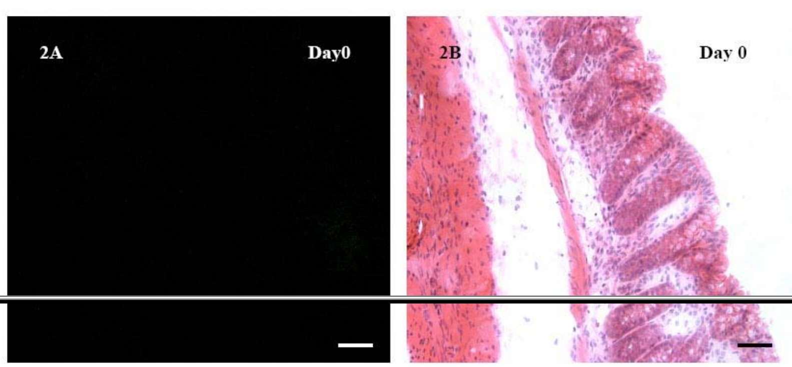


Scanning of the same skin sample at 0.9 and 10.0 GHz showing frequency-dependent response and the inhomogeneous nature of skin tissue.

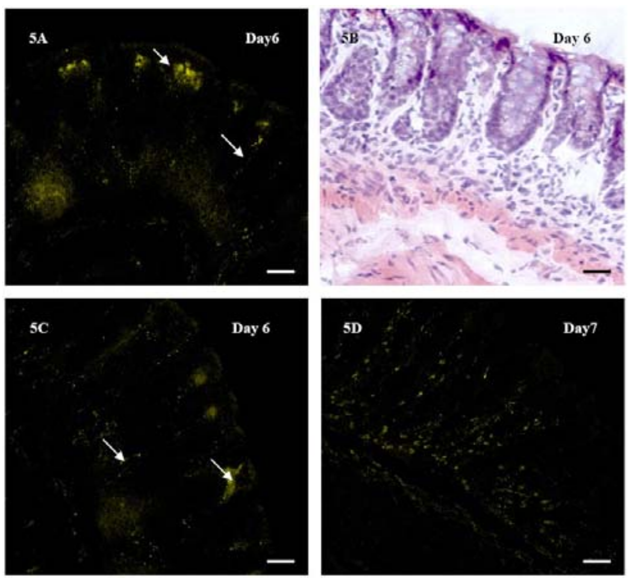
Imaging Biomakers of Inflammation in situ with Functionalized Quantum Dots

Inflammation is a complex systemic and local response by the host immune system to harmful stimuli such as infection and noxious chemicals interacting with the local immune system. Animal model used: dextran sodium sulphate (DSS) model of mouse colitis. Inflammation is induced in the mouse colon by feeding it DSS

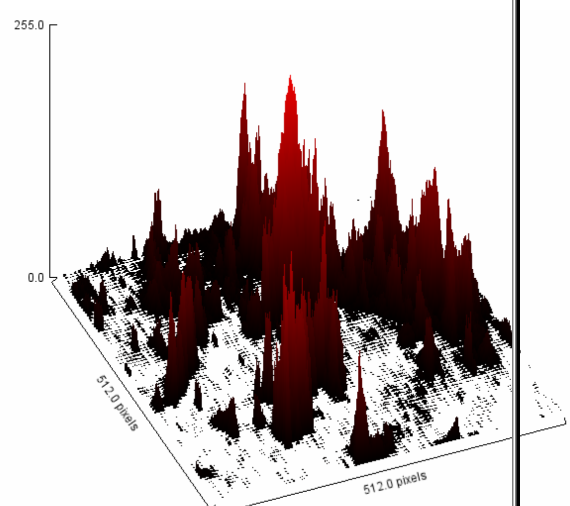
Quantum dots (QDs) are nanometer-sized (a few thousand atoms) fluorescent particles which are used to measure the degree of inflammation in the tissue.



Degree of inflammation has been quantified for the first time using myeloperoxidase (MPO) as an inflammation biomarker. Images from experiment 2, DSS model of colitis on Day 0 of DSS feed (control), with 565 QD-MPO antibody conjugates. Confocal maximum projection is shown as Figure 2A and H&E stained section as Figure 2B. Figure 2A shows absence of binding of QD-MPO antibody conjugate corresponding with lack of histologic inflammation (2B). Minimal inflammation is seen and QDs do not attach to colon due to absence of MPO expression. Scale bar = 75μ in confocal image and 48μ in H&E.



These Figures represent images from experiment 2 from animals exposed to DSS for six and seven days. Figures 5A, 5C and 5D show the binding of QD-MPO conjugate on days six and seven. Figure 5B represents the corresponding histological picture on day six with shortening of crypts and increased infiltration of inflammatory cells. Scale bar = 75[illegible] in confocal image and 48[illegible] in H&E stained image.



This Figure shows the surface plot for day5 image. The plot shows the localization of QD in the tissue at the site of inflammation. Peak heights indicate degree to of inflammation.

Theoretical

(J.-M. Yuan)

Applications of non-equilibrium thermodynamics to cellular signaling pathways

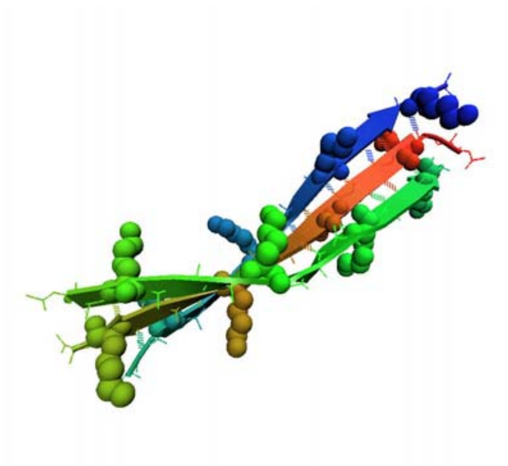
Several interesting articles on MAP kinase cascade appeared since 1999 in Science and Nature, where computer simulations of the interacting networks of signaling pathways were presented. In these articles the kinetic equations for proteins and effectors are considered. An important set of questions about pathways that we are investigating are: how regulation of signaling pathways is achieved through cross-talks and feedbacks among component (MAPK, PI3K, and RalGDS) pathways, what are the topological structures of these protein networks, and what are the design principles underlying these pathways. Our interest in the network of the Ras pathways is stimulated by the potential in identifying drug targets for cancers. While we are investigating fundamental issues about pathways, we keep this goal in perspective.

We have successfully achieved our goal in developing computer codes for the dynamic studies and sensitivity analysis of the Ras and PI3K signaling pathways. We are not satisfied in just obtaining numerical results and want to achieve deeper understanding of the biological and physical origins of the cascade amplification and feedbacks in the Ras network. For this purpose, we have developed powerful tools of non-equilibrium thermodynamics and have applied them to the Ras and insulin pathways. These tools help us to understand the dynamical and topological behaviors of the Ras and insulin networks and unravel some of the design principles of these biological systems.

Structural analysis of early state of self-aggregation of peptides - beta-amyloid peptide (Aβ) and $(AAKA)_n$

In collaboration with Professors Hai-Lung Dai (Chemistry Department), Hank Kung, and Mei-Ping Kung (Radiology Department) of the University of Pennsylvania, we are studying chemical kinetics of the formation of dimers and small oligomers of Aβ using single pair fluorescence resonance energy transfer (spFRET), a single-molecule technique. Oligomers of Aβ are now believed to be the most neurotoxic substance and the cause of Alzheimer's disease (AD). However, the most toxic forms of the oligomers are so far still unknown. Our joint experimental and computational efforts aim at revealing the structures of dimers, trimers and other small oligomers of Aβ, which will certainly shed lights on the early stage of the amyloidosis of AD.

In another project, we are collaborating with Reinhard Schweitzer-Stenner to work on the self-aggregation properties of the peptides, $(AAKA)_n$, n=3,4. Reinhard has observed hydrogel formation of this type of peptides with antiparallel β-sheet structure. But it is well-known that alanine peptides tend to form α-helical structure, thus it becomes important to understand how the α-helix to β-sheet structure transformation takes place. Since the peptides are small, they serve as a good model for the study of the α-helix to β-sheet transformation, known to take place for the prion proteins.



The most stable conformation of $(AAKA)_4$ trimer with clear beta-strand structure obtained in our molecular dynamics calculation.

In collaboration with Drs. Feng-Yin Li (National Chung-Hsin University, Taichung, Taiwan) and Soonmin Jang (Seoul National University, Seoul, Korea) , we have carried out molecular dynamics calculations on such systems. We have recently received support from the Pittsburgh Supercomputing Center to continue our dynamical and structure studies on both Aβ and AAKA systems.

Results have already been obtained using spFRET on Aβ. We have made some progress in analyzing the large amount of data accumulated. On the other hand, extensive molecular dynamics (MD) calculations on $(AAKA)_4$ have been carried out. Our results show that although monomers and dimers of (AAKA)4 form mainly random coil structures with minor α-helix and PPII contents, the most stable conformations of trimers assume anti-parallel β-strand structures (see figure). Furthermore, this phenomenon of peptide aggregation to form trimer is sensitive to temperature and concentration, consistent with recent experimental results obtained in Schweitzer-Stenner's laboratory. A manuscript has recently submitted for publication based on these results.

Effects of confinement and crowding on protein stability and forced-induced unfolding/refolding of proteins

To measure directly the forces inside bio-molecules, tools developed in nanotechnology, such as atomic force microscopy, have been used to pull molecules apart or to force proteins to unfold. We have carried out simulations of such force-induced processes, which lead to better understanding of forces in bio-molecules in general. Specifically, we have worked on mechanical unfolding of ubiquitin in collaboration with Dr. Guoliang Yang.

Furthermore, we are investigating the effects on protein stability and protein dynamics due to the presence of confinement. This is important for the developments of biosensors or bio-catalysts using encapsulated protein molecules. This part of the work is done in collaborating with Dr. Yen Wei's group. Associated with our interests in excluded volume effects, we are studying the effects of macromolecular crowding on rates of protein folding/unfolding. New techniques, such as multi-histogram and Monte Carlo methods are used in our computer simulations.

We have been working on developing a unified theory for the macromolecular crowing and confinement effects on protein folding based on the depletion force theory from colloidal physics and soft-matter physics. This formulation unifies approaches from several different fields, including concepts of chemical potential from chemical thermodynamics, depletion force, semi-grand canonical ensemble approach from statistical mechanics, scaled particle theory from the theories of fluids, and computer simulations. We are collaborating with Dr. Guoliang Yang to interpret the enhancement of unfolding forces observed in their AFM experiments on ubiquitin in dextran solutions.

Publications (refereed journals):

Aprelev, A., Weng W., Zakharov M., Rotter M., Yosmanovich D., Kwong S., Briehl R.W., **Ferrone F.A.** *"Metastable Polymerization of Sickle Hemoglobin in Droplets"*. J Mol Biol. (2007):369:1170-4.

Li, L.Y., Li B., **Yang, G.L.**, Li C.Y. *"Polymer Decoration on Carbon Nanotubes via Physical Vapor Deposition"*. LANGMUIR 23 16 (2007): 8522-8525.

Lofland, S.E., Mazzatenta, J.D., Croman, J., and **Tyagi, S.** *"Multimode Near-field Microwave Monitoring of Free Water Content of Skin and Imaging of Tissue"*. Phys. Med. Biol 52. (2007):1295-1301.

Lofland, S.E., **Tyagi, S**., Hettinger, J.D., McCarroll, W.H., Ramanujachary, K.V., Gall, P., and Gougeon, P. *"Metal-Insulator Transitions in Reduced Molybdenum Oxides Sm4Mo18O32 and Nd4Mo18O32*. Materials Research Bulletin 42, (2007):1230-41.

Papazoglou, E.S., Weingarten, M.S., Zubkov, L., Zhu, L., **Tyagi, S**., Pourrezaei, K. *"Near Infrared Diffuse Optical Tomography: Improving the Quality of Care in Chronic Wounds of Patients with Disease"*. Biomedical Instrumentation and Technology 41, (2007): 83-97.

Ong, K.K., Cheng, T.C., Yin, R., Dong, H., **Yuan, J.M.**, Wei, Y. *"Nanoencapsulation of Organophosphorus Acid Anhydrolase (OPAA) with Mesoporous Materials for Chemical Agent Decontamination in Organic Solvents"* in Polymers and Materials for Anti-Terrorism and Homeland Defense. Ed. J. G. Reynolds and G. Lawson, American Chemical Society Symposium Series, ACS-Oxford University Press, Washington DC; ISBN: 0841239649, 2007.

Karwa, E., Papazoglou, E., Pourrezaei, K., **Tyagi, S**., and Murthy, S. *"Imaging Biomarkers of Inflammation in situ with Functionalized Quantum Dots in the Dextran Sodium Sulfate (DSS) Model of Mouse Colitis"*. Accepted for publication in Inflammation.

Liu, Z., Weng, W., Bookchin, R.M., Lew, V.L., and **Ferrone, F.A.** *"Free Energy of Sickle Hemoglobin Polymerization: A Scaled-particle Treatment for Use with Dextran as a Crowding Agent"*. Accepted for publication in Biophys. J.

Zhou, J., **Yang, G.** *"Nanohole Fabrication Using FIB, EB and AFM for Biomedical Applications"*. Int. J. Precision Eng. Manufacturing, 7, (2006): 18-22.

Other Presentations (conferences, seminars, workshops):

Aprelev, A., Rotter, M., Yasmonovich, D., Ferrone, F.A. *"Polymerization of Sickle Hemoglobin Emulsions: Premature Termination of Polymerization"*, Biophysical Society Annual Meeting, Baltimore, MD, March 2007.

Ferrone, F.A. *"Nonideal Behavior in Protein Aggregation: Equilibria and Kinetics"*, invited talk, Colorado Protein Stability Conference, June 2007.

Ferrone, F.A. *"Physical Principles in Protein Assembly: Lessons from Sickle Hemoglobin Polymerization"*, invited talk, Workshop on Protein Aggregation, October 2006.

Ferrone, F.A., Palma, M.U., Vittorelli-Palma, M.B. *"A Unified Approach to Sickle Hemoglobin Gelation and Phase Separation"*, Biophysical Society Annual Meeting, Baltimore, MD, March 2007.

Finegold, L., Flamm, B., S. Bogh. *"Therapy by Static Magnets"*. Biophysical Society Annual Meeting, Baltimore, MD, March 2007.

Finegold, L. *"Therapy by Static Magnets"*. College of Arts and Sciences Poster Day, Drexel University, April 5, 2007.

Ghosh, A. *"From Simulation to Therapy: A Systems Biology Approach to Oncogene Detection"*, invited speaker Seventh International Conference on Systems Biology ICSB-2006, Yokohama, Japan, October 9-13, 2006.

Karwa, A., Papazoglou, E., Pourrezaei, K., **Tyagi, S.**, and Murthy, S. *"Targeting in situ and Imaging Multiple Inflammatory Biomarkers with Quantum Dots in DSS Model of Colitis"*, Drexel University Research Day, April 17, 2007.

Liu, Z., **Ferrone, F.A.** *"Resolution of Multiple Absorption Spectra at High Peak OD"*, Biophysical Society Annual Meeting, Baltimore, MD, March 2007.

Liu, Z., Weng, W., Bookchin, R.M., **Ferrone, F.A.** *"Dextran Acts as a Spherical Crowder with Concentration Dependent Volume"*, Biophysical Society Annual Meeting, Baltimore, MD, March 2007.

Measey, T.J., **Yang, G.L., Yuan J.M.,** Schweitzer-Stenner. R. *"Aggregation of the Amphipathic Peptides AAKAn into Antiparallel Beta-sheets"*, Biophysical Society Annual Meeting, Baltimore, MD, March 2007.

Su, M.H., Yang, G.L. *"Mechanical Unfolding of Protein Molecules: Results Analysis and Interpretation"* Biophysical Society Annual Meeting, Baltimore, MD, March 2007.

Weingarten, M., Papazoglou, E., Zubkov, L., Zhu, L., Pourrezaei, K., and **Tyagi, S.** *"Biomedical Technology Showcase Optical Properties of animal Tissue as Diabetes progresses"*. Nov. 3, 2006, Drexel University, Philadelphia, 19104.

Weng, W., Aprelev, A., Ferrone, F.A. *"Sickle Hemoglobin Solutions Terminate Polymerization Without Reaching Solubilit"*, Biophysical Society Annual Meeting, Baltimore, MD, March 2007.

Yang, G.L. *"The Effects of Macromolecular Crowding on the Mechanical Stability of Proteins"*, Invited talk. Department of Physics, Rice University, March 23, 2007.

Yang, G.L., Yuan, J.M., Chyan, C.L. *"Macromolecular Crowding Enhances the Mechanical Stability of Protein Molecules"*, Biophysical Society Annual Meeting, Baltimore, MD, March 2007.

Yuan, J.M., *"Sensitivity, Thermodynamic, and Control Analyses of Signaling Pathways: Cancer- and Diabetes-related Networks"*, invited talk, Mini-Workshop on Systems Biology Department of Physics, Chung-Yuan Christian University, Chungli, Taiwan, June 28, 2007.

Yuan, J.M., *"A Systems Biology Approach to MAPK/PI3K and Insulin Pathways"*, colloquium, Genomics Research Center, Academia Sinica, Nankang, Taipei, Taiwan, June 27, 2007.

Yuan, J.M., *"The Effect of Macromolecular Crowding on Protein Stability, Dynamics, and Aggregation"*, colloquium, Research Center for Applied Science, Academia Sinica, Nakang, Taipei, Taiwan, July 3, 2007.

Yuan, J.M., gave three seminars on macromolecular crowding, protein folding and stability, protein aggregation, and signaling pathways at the Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei, Taiwan, June-July, 2007.

Yasmonovich, D., Rotter, M., Aprelev, A., Ferrone, F.A., *"Tertiary Inhibition of Sickle Hemoglobin Polymerization by NO"*, Biophysical Society Annual Meeting, Baltimore, MD, March 2007.

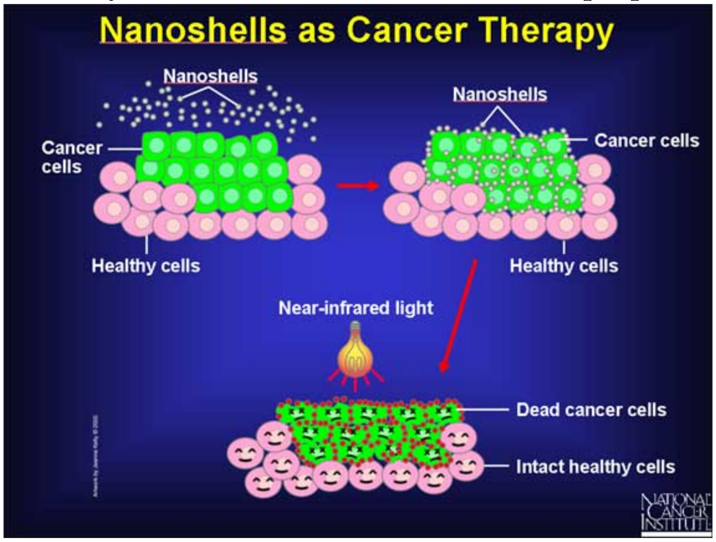
Zakharov, M., Aprelev, A., Ferrone, F.A. *"Rheology of Sickle Hemoglobin Probed by Compression of Thin Slides"*, Biophysical Society Annual Meeting, Baltimore, MD, March 2007.

Condensed Matter Physics

Electronic and Optical Properties of Metallic Nanoshells

(S.M. Bose)

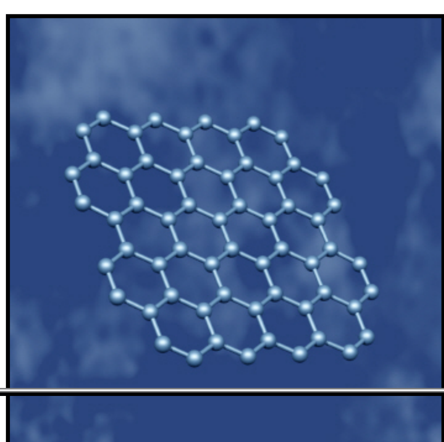
Recently discovered metallic nanoshells prepared by depositing metals like gold on a silica nanosphere have found important applications in cancer treatment and other medical fields. For example, when nanoshells are deposited on the cancer tumor of mice and radiated with near infrared (IR) electromagnetic waves, it is found that the IR energy is absorbed by the nanoshells in the form of surface plasmon excitation. The plasmon then decays by depositing its energy in the form of heat on the tumor and the tumor gets ablated by the heat produced. With an objective to understand the process quantitatively, we are calculating (a) plasmon frequencies of a single metallic nanoshell and also of concentric nanoshells. (b) Using many body techniques we are also calculating infrared absorption and radiative and nonradiative decay of metallic shells. When these processes are fully understood, the medical community will be able to apply the processes with great deal of precision to early detection and treatment of cancer, fast whole blood immunoassays, precision drug delivery, sensors of tiny molecular systems, *etc*.



Electronic Properties of Graphene

(S.M. Bose)

Graphene – two-dimensional sheets of carbon that are just one atom thick - have recently been isolated from graphite, the form of carbon that is found in pencil tips. Graphene has been found to have many exotic properties. For example, unlike graphite, graphene is an excellent conductor. Furthermore, the electrons in graphene behave like relativistic particles with no rest mass, travel with a speed of 10^6 m/s and hence are being called massless Dirac

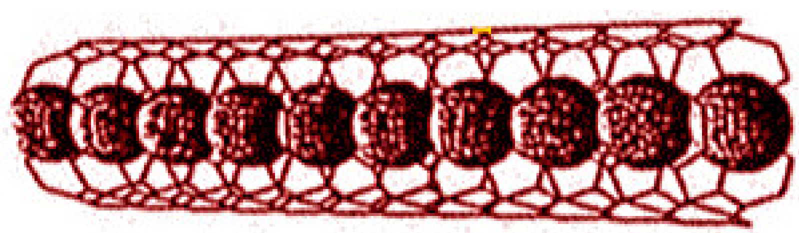


Fermions. We are embarking on a many-body study of the electronic properties of graphene such as excitation of plasmons and their contribution to angle resolved photoemission, electron energy loss spectra, *etc*. The fact that single particle energies in this system is linearly proportional to the momentum rather than the usual quadratic dependence of an ordinary electron gas, will make the results different and exciting. These properties are not only of scientific interest, but it is expected that they will have many practical applications.

Properties of Carbon Nanotubes

(S. M. Bose)

Ever since the discovery of carbon nanotubes in the early 1990's, it was realized that the nanotubes have such unusual properties that they will find many commercial and industrial applications. For example, their strong field emission properties have already been used to produce more efficient electron guns and field emission lamps. The possibility of storing hydrogen and lithium leading to super batteries is being pursued. Nanosize p-n junctions, field-effect transistor, etc. are being produced using nanotubes. We have calculated collective excitations in single wall and multiwall carbon nanotubes and their applications in electron energy loss spectra and Raman spectra of metallic nanotubes. We have also studied the superconducting properties of the nanotubes, mediated by electron plasmon interaction.



Nanotube filled with atoms

Properties of thermoelectric materials

(S. M. Bose)

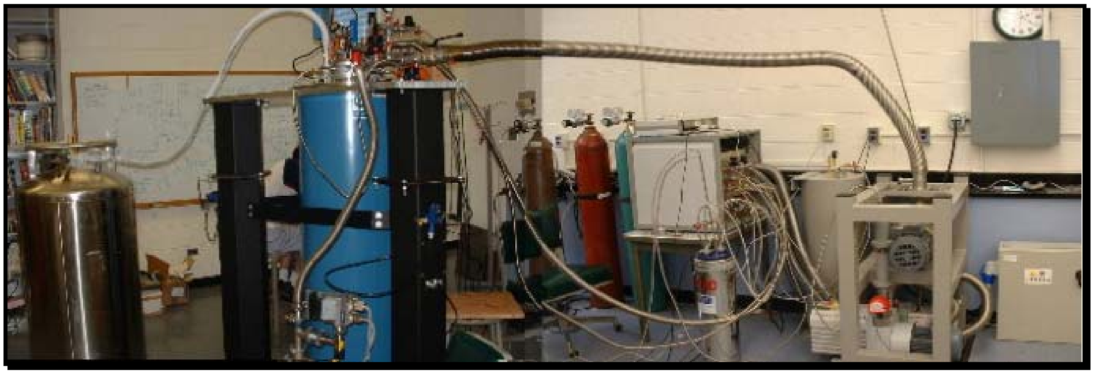
Recently there has been a lot of interest in studying thermoelectric properties of solids because of discovery of new materials which have the promise of having a large thermoelectric figure of merit such as clathrates and skutterudites because they have large electrical conductivity and low thermal conductivity. It is well known that a material with a figure of merit as large as 3 or 4 will lead to solid state refrigeration avoiding the use polluting hydrocarbons. We are involved in calculating the figure of merit of these substances with particular attention to how the figure of merit can be enhanced in these and other caged materials.

U Ultra-Low Temperature Physics

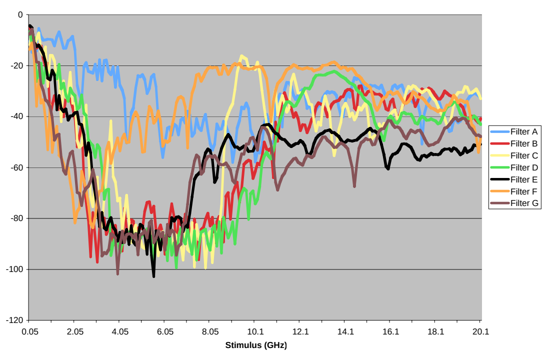
(R. Ramos)

Dr. Roberto Ramos and graduate student Zechariah Thrailkill have designed and built ultra-low noise detection electronics, RF coaxial assemblies, and thermal anchors mounted on a low temperature cryostat for experiments with superconducting devices. The devices are known to behave like artificial atoms, exhibiting macroscopic quantum phenomena such as distinct energy levels and a phenomenon known as entanglement that is responsible for the exponential speed-up in quantum information technology. To isolate the device from its electrical environment during quantum state measurements, microwave filters were especially constructed and their attenuation properties tested at liquid Nitrogen (LN) temperatures using a vector network analyzer up to 20Ghz. Results showed acceptable attenuations of around 80 dB in the relevant operating frequencies (3-8 Ghz) of the junctions. Based on these tested design parameters, new filters are being installed on the experimental platform. A breakout box connecting them was also built and leak-tested down to a sensitivity of 10^{-9} atm-std/sec. During the Summer, new graduate student Zechariah Thrailkill attended the Int'l Superconducting Electronics Conference at Washington, DC.

We continued our research collaboration with colleagues at the University of Maryland. Measurements of three DC SQUID phase qubits have shown that the time constant for the decay of Rabi Oscillations for the aluminum-based qubits ranged from 20-30ns. These experiments have also shown that random magnetic flux noise is not the primary source of decoherence in this class of qubits.



The workhorse in our lab is the dilution refrigerator cryostat which goes down to 0.009 degrees Kelvin. Near Absolute Zero, quantum energy levels in artificial atoms such as Josephson junctions and quantum dots are not washed out by ambient temperature and can be used for applications in quantum information technology and tests of quantum mechanics.



The attenuation (electrical isolation) provided by home-made microwave filters were measured using a vector network analyzer over a 20 Ghz range. Acceptable attenuations of about 80 dB were obtained for the frequency range 2-8 Ghz for certain designs; these results narrowed down filter designs. Unlike commercial filters, copper powder filters do not freeze out at low temperatures.

Low-noise circuits for detecting junction states were built and tested.

Publications (refereed journals):

S.M. Bose and S. Gayen, *"Plasmon Exchange Model for Superconductivity in Carbon Nanotubes"*, Nano-Scale Materials: From Science to Technology edited by S.N. Sahu, R.K. Choudhury, and P. Jena, pp 155-161 (Nova Science Publishers, Inc., 2006)

Behera, S.N.; **Gayen, S.**; Ravi Prasad, G.V.; and **Bose**, **S.M.** *"Electronic Properties of Ordered and Disordered Linear Cclusters of Atoms and Molecules"*, Physica B v390, (2007): 124-133.

Paik, Hanhee; Cooper, B.K.; Dutta, S.K.; Lewis, **R.M.; Ramos**, R.C.; Palomaki, T.A.; Przybysz, A.J.; Dragt, A.J.; Anderson, J.R.; Lobb, C.J.; Wellstood, F.C. *"Measurements*

of Decoherence in Three dc SQUID Phase Qubits". IEEE Transactions on Applied Superconductivity, v 17, n 2 (June, 2007): 120-123.

Gayen, S.; Behera, S.N.; and **Bose**, **S.M.** *"Raman Spectra of Unfilled and Filled Carbon Nanotubes: Theory"*, Phys. Rev. B 76, (2007) 165433.

Other Presentations (conferences, seminars, workshops):

Bose, S.M., attended two one-day conferences at the Institute of Materials Science in Bhubaneswar, India and F.M. Autonomous College in Balasore, India during February 2007 as chief guest and delivered keynote talks on Nanomaterials and Raman Effect in Nanotubes.

Ramos, R.C., presented a contributed talk entitled *"Applications of Nanotechnology using Superconducting Quantum Devices"*, Drexel Nanotechnology Discovery Workshop, Philadelphia, PA, February 2007.

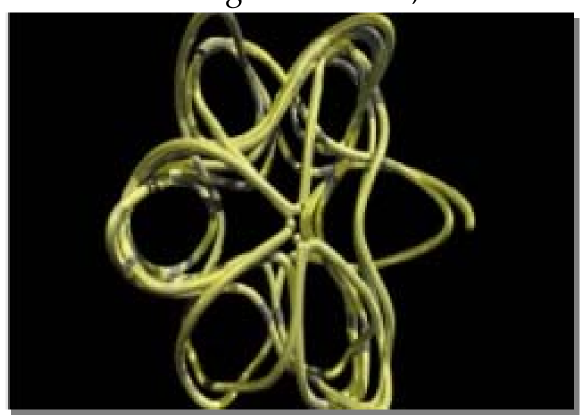
Nonlinear Dynamics

(R. Gilmore)

Theory of strange attractors

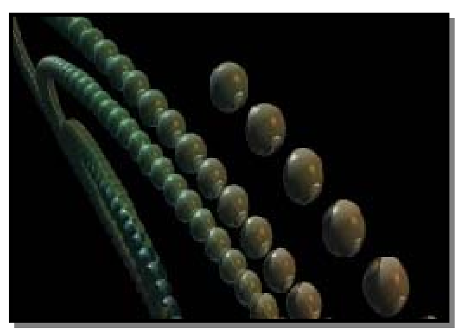
The Nonlinear Dynamics Group continues to work on the cutting edge of research into the application of topology to the analysis of chaotic systems.

R. Gilmore and his colleagues have created the analog of Fourier analysis for nonlinear dynamical systems in three dimensions. Strange attractors, or their caricature, branched manifolds/bounding tori, are built up Lego-style from two basic building blocks, one containing splitting singularities, the other joining singularities, in a way that is systematic yet with sufficient degrees of freedom to allow an even richer variety of behavior in physical systems than has yet been seen.



Field Theory

R. Gilmore and J. Ramos Medina investigated the use of group theory to derive free field Maxwell and Einstein field equations.



Reflection analog of Ramsauer effect

Structure in a 100% reflecting potential can be determined by measuring the phase shift of the reflection amplitude. The phase shift is related to a Lorentzian that describes the location of a resonance and its half life. An interference experiment is proposed to measure reflection phase shifts in washboard potentials.

Publications (refereed journals):

Letellier, C.; **Gilmore, R**. *"Symmetry Groups for 3D Dynamical Systems"*. Journal of Physics A: Mathematical and Theoretical, v 40, n 21 (May 2007): p 5597-620.

Gilmore, R. *"Two-parameter Families of Strange Attractors"*. Chaos, v 17, n 1 (March 2007): p 13104-1-4.

Moroz, I.M.; Letellier, C.; **Gilmore, R.** *"When are Projections also Embeddings?"* Phys. Rev. E 75, n 4 (April 2007): p 46201-1-11.

Romanazzi, N.; Lefranc, M.; **Gilmore, R.** *"Embeddings of Low-dimensional Strange Attractors: Topological Invariants and Degrees of Freedom"*. Phys. Rev. E 75, 066214 (2007)

Gilmore, R.; Letellier, C.; **Romanazzi, N.** *"Global Topology from and Embedding"*. J. Phys. A: Math. Theo. 40 (2007) in press.

Other Presentations (conferences, seminars, workshops):

Gilmore, R. invited presentation entitled: *"The Four Levels of Structure in Topological Analysis"*, Dynamics Days, Paris, France, March 16, 2007.

Gilmore, R. invited presentation entitled: "*Topological Analysis of Chaotic Data*", Narducci Memorial Symposium, Philadelphia, PA, May 24-25, 2007.

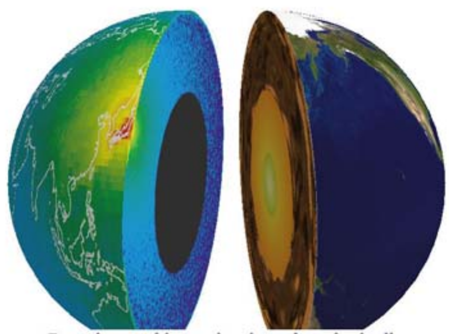
Gilmore, R. invited presentation in Topological Analysis minisymposium entitled *"Embeddings: Invariants and Degrees of Freedom"*. Snowbird Conference on Nonlinear Dynamics, (presented by N. Romanazzi for reasons of availability).

Nuclear and Particle Physics

(C. Lane and J. Maricic)

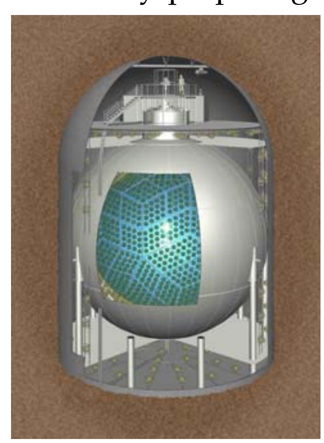
The experimental particle physics effort in the Department has been primarily focused on neutrino physics, which has been a very fruitful area of research over the past several years. We are primarily involved with two neutrino experiments:

The KamLAND experiment is a large (~1000 tons) underground neutrino detector located in the Kamioka mine in central Japan. We have been involved in the KamLAND experiment from the beginning, contributing data-acquisition electronics to the effort.



Experimental investigation of geologically produced antineutrinos with KamLAND

KamLAND has been in operation for several years now, resulting in the first definitive measurement of neutrino oscillation, a limit on the flux of anti-neutrinos from the Sun, and the first detection of neutrinos from the radioactive decays that provide the Earth's internal heat. KamLAND is currently preparing to enter a second phase of operation, where backgrounds are greatly reduced to allow direct measurement of solar neutrinos in a hitherto unexplored region of the solar neutrino spectrum. KamLAND is in the process of preparing for the search of the solar neutrinos. However, that requires purification of the target material (scintillator) and this process will continue for at least several months. In meantime, the group continues collecting data and reactor phase which allows them to see reactor anti-neutrinos, geoneutrinos and we have a supernova watch.



Freshman Physics major James Monahan was in the STAR program during the Summer of 2007. He worked with the group doing Photo Multiplier Tubes (PMT) testing and electronics development for the Double Chooz (France) and KamLAND (Japan) experiments. As part of this program, J. Monahan traveled to Japan from 14 Aug to 28 Aug 2007. He assisted with general detector checks and maintenance, and more significantly with a reconfiguration of the US electronics systems on KamLAND. Professor Lane's DOE grant provided funding to complement the STAR scholarship.

The Double Chooz experiment is a new project, with an international collaboration (France, US, Germany, Italy, Spain, Russia, Japan, Brazil) working to build a pair of neutrino detectors at a nuclear reactor site in northern France. The goal of Double Chooz is to pin down one of the remaining unknowns in neutrino properties: the `generation skipping' mixing angle θ_{13}.

The value of θ_{13} is almost entirely unconstrained by theory, and is critical for evaluating future experiments in neutrino properties, including understanding the mass spectrum of neutrinos, and whether neutrinos violate CP symmetry. Violation of CP is a necessary ingredient for a matter-dominated universe (as opposed to anti-matter, or a mix of matter and anti-matter), but current observed or theorized sources of CP violation are insufficient to explain how matter came to completely dominate our universe.

Overview of the experiment site

The current limit on the values of θ_{13} was set by the Chooz experiment, at the same site and with the same collaborators (including Prof Lane). Double Chooz will reduce systematic errors by using a pair of identical detectors at different distances to hopefully measure θ_{13}, or at least set a substantially lower limit on its value.

Prof. Lane is co-chair of the electronics working group of the Double Chooz experiment, and active in developing front-end electronics for the experiment. The Double Chooz experiment has been given partial (manpower, travel) support for some NSF groups, with DOE and NSF equipment proposals under review. Professor Maricic is pursuing the calibration of the Photo Multiplier Tubes (PMT) and of the detector as a whole.

Erica Caden, a graduate student under Professor Lane's direction, attended Double Chooz collaboration meetings in Madrid Spain (5-11 March 2007) and Aachen Germany (13-18 October 2006). She presented results from her studies of source calibration techniques. She also presented her results as a poster at the Drexel Research Day in the Spring 2007.

Other Presentations (conferences, seminars, workshops):

Maricic, J., presented a contributed talk on "The Quest with Theta13 with the Double Chooz", proceedings of Colliders to Cosmic Rays 2007 Conference, Lake Tahoe, California, February 26-March 1, 2007.

Maricic, J., presented two contributed talks entitled: "Exploring the Geo-reactor Hypothesis with Neutrinos" and "The Quest for θ13 with the Double Chooz Detector" at the Deep Ocean Anti-Neutrino Observatory Workshop, Honolulu, Hawaii, March 23-25, 2007.

Maricic, J., presented an invited talk entitled "Surveying the Earth with Neutrinos" at Stockton College, April 16, 2007

Facilities

Astrophysics Survey Facility

The facility duplicates the Sloan Digital Sky Survey data locally. Facilities include SGI and Linux workstations and a multi-TB database server, with latest object-oriented database management and query software.

Numerical Astrophysics Facility

Emphasis is on cosmology, matter distribution in the universe, gravitational lensing, and globular cluster modeling. Sloan Digital Sky Survey data are analyzed locally on a compute/data center with a large-RAID-array disk farm. The group also uses the 96-CPU Beowulf system as described below. The globular cluster modeling is performed on GRAPE board (the fastest computer in the world) connected to a dual AMD front-end server harboring a large-RAID-array disk farm. Facilities also include a variety of Linux workstations, with fast access to National Supercomputer Clusters.

The Joseph R. Lynch Observatory

The observatory at Drexel University houses a 16" Meade Schmidt-Cassegrain, the largest in Philadelphia. Students use the observatory for coursework, independent observation projects, and hardware development.

Protein Self-Assembly Laboratories

Four fully computer interfaced optical tables are available with argon-ion lasers and microscope optics to study the dynamics of protein self assembly. One apparatus uses multiple images to study stochastic nucleation. A second apparatus uses a spatial light modulator to produce complex images and test the adaptability and flexibility of fibers, as well as providing multiple optical tweezers. A third apparatus uses high speed, high resolution particle-tracking to determine the viscoelastic properties of domains of polymers. A fourth apparatus uses amplitude modulated light to measure the rates of rebinding of ligands to hemoglobin. Supporting equipment includes thin-film reflectivity and absorbance measurements for sample characterization.

Protein Dynamics Laboratory

This laboratory is dedicated to the study of the structure and mechanical properties of proteins. An Atomic Force Microscope (AFM) is used to mechanically stretch individual proteins and measure the force and ensuing changes in conformations. The laboratory is fully equipped with ancillary equipment to prepare and manipulate samples.

Preparative Facilities for Biophysical Experiments

This general-use facility includes a cold chamber, Beckman centrifuge, Mettler balance, fume hood, large nitrogen glove box, phase-contrast microscope, digital pH meter, and a Hewlett-Packard diode spectrophotometer interfaced to a personal computer.

Nano-bio-optics

Fiber-optical nanoprobes are being developed for intracellular measurements of biochemical processes. These probes are based on silver or gold-coated conically tapered optical fibers with typical distal end diometers of 20-30 nm. The biomolecules are identified by their characteristic surface enhanced Raman (SER) spectra. Facilities include two Raman (785nm, 680nm) spectrometers.

Computational Biophysics Laboratory

A 2 processor, 2 gigabyte Sun Blade 2000 running Solaris for both numerical work and for 3D visualization, and a Sun V880, a 4 processor, 8 gigabyte SMP machine with a terabyte of fiber based storage are available for biophysics simulations and visualization. In addition, a Linux-based Beowulf Cluster which currently consists of 44 dual processor nodes, each of which are dual Xeon 2.66 GHz chips, connected with a gigabit ethernet. The master node as about a 1/2 terabyte of storage space and 2 gigs of ram, while each of the client nodes have an 80 gigabyte drive and 1 gigabyte of RAM.

Magnetic Materials

Research is being conducted on amorphous magnetic thin films, and fiber optical sensors. Facilities include a Varian X-band ESR spectrometer, vibrating sample magnetometer, Kerr-effect magnetometer, Mössbauer spectrometer, AC-susceptometer, and a variety of thin-film deposition apparatus using techniques including thermal evaporation, E-beam evaporation, and RF- and DC-triode magnetron sputtering.

Ultra-Low Temperature Physics and Nanoscience Laboratory

Research is conducted on the behavior of matter in the micro- to nano scale length scales and at low to ultra-low (near absolute zero) temperatures. This facility includes a helium dilution refrigerator (with a base temperature of 10mK), helium-3 and helium-4 cryostats and two RF SQUIDS.

Particle Physics Detector Development Laboratory

This facility provides experimental support for a research program in non-accelerator particle and nuclear physics, performing tests of invariance principles and conservation laws and searches for neutrino oscillation and high-energy neutrinos. Facilities include modern data acquisition electronics, including numerous CAMAC and NIM modules, various photomultiplier tubes, oscilloscopes, pulse height analyzers, a pulsed tunable dye-laser, a high-sensitivity long-path spectro-photometer, and a 600-liter liquid scintillation test tank.

Laboratory for High-Performance Computational Physics

This undergraduate and graduate teaching facility also provides support for various numerically intensive research projects. Facilities include a dual Xeon server and 15 independent Pentium workstations all running Linux, configured in a subnet and having full network access.

Drexel Beowulf Parallel Computers

The three clusters of off-the-shelf computers act as parallel computers. The first cluster is a server to support astrophysics research. It consists of 48 dual AMD CPUs, with 48 gigabytes of RAM and large local disks. The cluster is linked via two switched fast-Ethernet networks working in parallel.

The second cluster is the 88 Xeon processor system described above in the Computational Biophysics Laboratory.

The third is the ABAX system. It harbors 9 dual Intel Xeon processors configured in a rack mount. It is used to support biophysics research and as a teaching platform.

Undergraduate Students Lounge

Our department is providing undergraduates with a study area and relaxation area where they can socialize between classes, organize meetings, and conduct study groups. The lounge is decorated with comfortable furniture and it is located on the 7th floor of Disque Hall, Room 708.