Physics Department

Progress Report

Fiscal Year 2005 –2006

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The Department has seen a very productive year. A particular highlight of the year was the hiring of two faculty members: Dr. Maricic, bringing expertise in Geo-Neutrino Physics and Dr. Richards being an expert in Quasar Astrophysics. We were also fortunate to hire three Research Faculty/Post-Docs.

Our continuing efforts to provide a first-rate educational environment for our students, the high quality of our programs, and our Faculty reputation, translated in a significant increase of the undergraduate enrollment. Our Department teaches Physics to most students on campus, from COMAD, to Business, Engineering and Science students. Dr. Goldberg received the Allan Rothwarf Award for Teaching Excellence.

Our Faculty and Staff keep working to develop a structure that promotes and supports funding and research activities. Our Department strives to be a leading and innovative enterprise, a center for learning that provides excellence in teaching and research. Our Researchers continue to pursue basic research in many fundamental areas, from Cosmology at the scale of the universe, to protein science, nano-scale, low temperature, and Neutrino Physics. Our researchers published 44 papers in the last year. We were awarded 2.6 millions in sponsored grants.

Next year promises to be a busy and an especially exciting year. We are organizing a series of events with an expectation of more than a thousand attendees altogether. The speaker for our very successful *Kazcmarzik Lecture* will be Dr. J. Mather, 2006 Nobel Prize in Physics. The *Lorenzo Narducci Memorial Symposium* will be honored with the presence of Dr. W. Phillips (1997 Nobel Prize in Physics) and Dr. E. Cornell (2001 Nobel Prize in Physics). The *Sloan Digital Sky Survey (SDSS) collaboration meeting* will include prominent participants in the Astrophysics community, including two MacArthur Fellows and a Crafoord Prize winner. The organization of the prestigious symposium "*Dynamical Evolution of Dense Stellar Systems, International Astronomical Union Symposium 246"* will be sponsored by the International Astronomical Union.

I invite you to see for yourself our Department's accomplishments for the past year.

Michel Vallieres
Department Head

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Professor N. John DiNardo, appointed Vice Provost for Academic Affairs.

Professor Frank Ferrone, appointed Associate Vice Provost for Research.

Professor Teck-Kah Lim, appointed Associate Vice Provost for Graduate Studies.

Professor Lorenzo M. Narducci. It is with great regret that we report the lost of one of our most prestigious colleagues and beloved teacher. He passed away on July 21 and he is deeply missed.

Dr. David Goldberg, was the recipient of the Allan Rothwarf Award for Teaching Excellence, 2005.

Dr. Jelena Maricic, recently appointed as Assistant Professor, received her PhD from the University of Hawaii in 2005. She participated in the KamLAND experiment in Japan where she was part of the calibration effort and single-handedly performed the analysis that lead to the discovery of the geo-neutrino. The latter constitutes the first evidence for radio active decay in the crust of the earth which explains the energy source to warm up the interior of the earth. This work was featured in Nature with a front cover display (2005). She will participate in the Double CHOOZ experiment in France.

Dr. Gordon Richards, appointed as Assistant Professor, received his PhD from the University of Chicago in 2000. He is one of the world's experts on the astrophysics of quasars. His research on quasars defines the state of the art in the field and his papers (83 refereed papers to date) are widely referenced. His research goals are to understand the formation and evolution of supermassive black holes in the nuclei of galaxies, the evolution of the galaxies themselves, and the role that these objects play in the formation of structure in the universe since the big bang. These are among the forefront questions in cosmology today and he is a recognized leader in this field. He serves as the Co-Chair of the SDSS Quasar Working Group, and recently led a team that published the initial results on the SDSS key project to determine the quasar luminosity function.

Dr. Michael Vogeley, was on sabbatical leave at the Department of Astrophysical Sciences at Princeton University as Visiting Faculty Fellow.

Dr. Joel Allred, appointed as Research Post-Doctoral Associate, received his PhD from the University of Washington in 2005. He brings his expertise on simulations of solar and stellar flares.

Dr. Kevin Olson, appointed as Research Professor, received his PhD from the University of Massachusetts. He mainly works on the development of parallel,

numerical algorithms for Astrophysics applications. He is a major developer of the parallel, adaptive mesh refinement software package known as PARAMESH. This research was originally conducted at NASA, Goddard Space Flight Center, but has now been moved to Drexel University. Numerous other researchers are currently using PARAMESH and Olson continues to provide technical support and collaborates with other researchers using PARAMESH in their scientific research. PARAMESH has been incorporated into several, large computer codes and is being used as their main parallelization tool. The FLASH Astrophysics code developed at the University of Chicago under the Department of Energy's ASC project is a notable example. PARAMESH is currently being used in a wide array applications such as simulating cometary interaction with the solar wind, solar coronal mass ejections, supernova explosions, and the propagation of gravitational waves resulting from the collision of two black holes. Olson also is using the FLASH code to study the collisions of stars and collisions of giant molecular clouds.

Dr. Meihong Su, appointed as Research Post-Doctoral Associate, received her PhD Chinese Academy of Sciences, Beijing, China, she is working in the protein unfolding/refolding with single molecule manipulation methods.

Mrs. Laura D'Angelo, former Assistant Editor of Optics Communications, changed her position and joined our Department as Research Coordinator. Her role is to provide support on funding opportunities, offer assistance in our graduate program, the production of departmental reports, and outreach activities.

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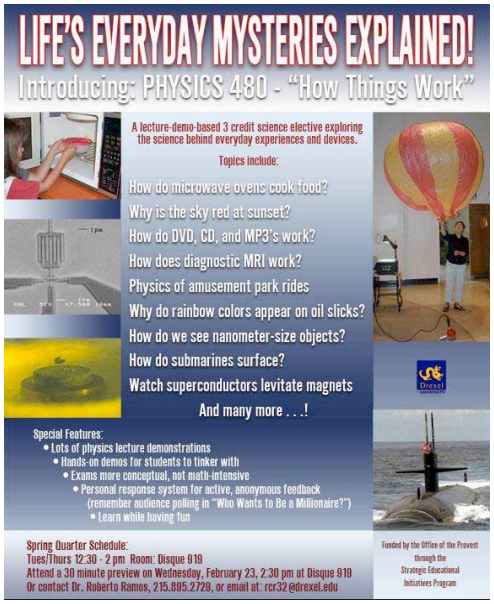
Som Tyagi, Roberto Ramos, **Avijit Ghosh, and Michel Vallières** are developing novel and innovative lecture sets and laboratories to replace the TDEC Physics series and its infrastructure. They planned new pedagogical approaches, fundamental modifications in course curricula, changes in the infrastructure, purchasing of equipment, personnel hiring, development of lab experiments and demonstrations and purchase of equipment which aims to impact 700 Engineering freshmen.

Roberto Ramos ***pioneered*** the use of Personal Response Systems or **"clickers"** for its utilization in classrooms at Drexel. Clickers were first introduced by R. Ramos in his class "How Things Work" in the Spring of 2005. The clickers provide active feedback during lectures and are instrumental in holding students attention.



Following our successful use of clickers, Chemistry and Math adopted their use in some of their courses. In the Winter Quarter of 2006-2007, the Physics Department will implement this teaching innovation in the large (700-800) engineering freshman introductory physics courses.

The success of ***How Things Work*** – a novel course that uses everyday devices and experience to convey physics concepts, inspired a new Chemistry course: "Why Things Work which followed the following year.
http://www.pages.drexel.edu/~rcr32/htw/phys480_AnnounceS06.htm

Frank Ferrone, developed a new graduate/senior Biophysics course based on a new textbook. He utilizes a laptop and camera to allow discussion with textbook and figures.

David Goldberg and John Parejko, offered a course on "Astronomy for Teachers".

David Goldberg, taught a new Honors seminar "Playing Dice with the Universe" on the nature of probability in life, science, the stock market, and the news.

Somdev Tyagi, designed and taught the first TDEC-111,113,115 –PFE Honors sequence with an enrollment of 102 students. In addition to the standard subjects, many other Modern Physics topics were included as "The Special Theory of

Relativity", "Heisenberg's Uncertainty Principle, the Fundamental Forces, the radioactive decay and enrichment of Uranium".

Frederick B. House, developed two new atmospheric science courses PHEV145-Weather I and PHEV146-Weather II. Both courses are innovative lectures with integrated laboratory investigations. Students are introduced to the Earth's atmosphere and the dynamic world of weather as it happens by working with current meteorological data. The students study recent archived real-world weather data in the laboratory component of each course. In addition, they are required to write research papers utilizing 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.

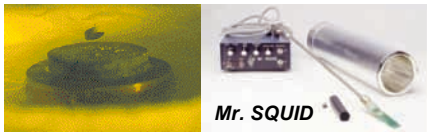
Charles Lane, developed new Phys106 (HiFi) multimedia lecture set with approximately 27 lectures entirely in PowerPoint, including online java demonstration CGIs, audio displays, music and video clips, etc. The lectures were made available to the students in the form of PDF in lieu of a textbook, since no appropriate textbooks are currently in print, or are seriously out of date.

Stephen McMillan, reworked the content of PHYS 431 Galactic Dynamics to better reflect current research priorities in the department and in the field.

Robert Gilmore, implemented a novel-unconventional-modern additions to the Quantum Mechanics Course.

Roberto Ramos, added new lecture demonstrations for general physics use including demonstration of ion propulsion (magneto-hydrodynamic propulsion), and metal detection.

Roberto Ramos, developed a new series of superconductivity experiments using Mr. SQUID for the Physics Advanced Lab Series (Physics 328).



Roberto Ramos, proposed a new Physics course for Business that was well-received by the Dean of College of Business, Dr. George Tsetsekos and the Associate Dean for Undergraduate Studies Dr. Frank Linnehan. Ramos is currently developing this new course that Lebow has agreed to adopt.

T.S. Venkataraman, modified the TDEC199 Preparation for Engineering Studies - Web Based Course for under-prepared engineering students. Students are taking this course before starting at Drexel and, based on their performance, they are placed in the appropriate curriculum. It is currently used by incoming freshman.

T.S. Venkataraman, TDEC 111, TDEC 113, and TDEC 115, more Engineering Applications were added to the textbook and Lecture demonstrations. A number of Biomedical and Biological applications of Physics were introduced in the lectures and recitations.

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Master Degrees:

Ari B. Silver
Akhilesh Kumar Singh
Lin Li
Zenghui Liu
Wenli Bi
Adrienne Leonard
Yuanxin Sun
Yihua Wang

PhD Degrees:

Dr. Tony Aby-Salloum, "Interference Between Competing Pathways in the Interaction of Three-Level Atoms and Radiation". Dr. Lorenzo Narducci, advisor, June 2006.

Dr. Jimin Gao, "A Numerical Study of an Asymmetric Breakout Model for CME Initiation". Advisor: Dr. Peter McNiece, November 2005.

Dr. Dawei Hu, "Unraveling Design Principles of Signaling Pathways and Controlling Output Signals Using Non-Equilibrium Thermodynamics and Sensitivity Analysis". Advisor: Dr. Jian-Min Yuan, June 2006.

Dr. Jairzinho Ramos Medina, "Gravito Electromagnetism (GEM): A Group Theoretical Approach". Advisor: Dr. Roberto Gilmore, July 2006.

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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
Anca Constantin
Fiona Hoyle
Peter MacNiece
Kevin Olson
Maria Rotter
Meihong Su
Enrico Vesperini
Dana Woerdeman

Evening College and Adjunct Faculty

Michael Carchidi
Nicole DiGironimo
William Engle
Saurabh Gayen
Paul Kaczmarczik
Robert Lawler
Milincic Radovan
Nicola Romanazzi
Eric Scheidly
Joseph Trout

Staff

Laura D'Angelo
Lisa Ferrara
Maryann Fitzpatrick
Janice Murray
Wolfgang Nadler
Jacqueline Sampson

Graduate Students

Wenli Bi
Jeffrey Blomquist
Erica Caden
Benjamin Coy
Daniel J. Cross
Sanghamitra Deb
Michael French
Steven Jenks
Travis Hoppe
Timothy Jones
Michael Kaczmarczik
Sam Kennerly
William King
Robert Lawler
Lin Li
Hanbing Lin
Ensheng Liu
Kewei Liu
Runcong Liu
Zenghui Liu
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
Yao Yang
Yi Yang
Donna Yosmanovich
Mikhail Zakharov
Jinhan Zhu
Rui Zou

Undergraduate Students

Carlos Bahamondes
Kara Blaine
Alexander Bolesta
Tyler Butler
Pablo Calva
Marion H Cavanaugh
Alexander Chambers
Conn, Lindsay A
David Corbett
William Czaja
Edward DiNola
Anthony Dyszel
Perry Edelson
John Fazio
Robert Ferrier
Wynne R Fisher
Casey Gallagher
William Gallagher
Joseph E Gaston
Eric Gerchberg
Jason Haaga
Jeffrey Hainsworth
Mike Honie
Andrew Jones
Stacy Jones
Joseph M Keil
Christopher Kim
Alex Lair
David LaPoint
Flynn Lawrence
Eleazer Lieberman
Jason Lindsay
Michael Lynch
Charles Marine
Cijy Mathai
Bailey McCreery
Rory McGurty
Timothy R McJilton
Ryan McKeown
Seth Meiselman
Jerome Mlack
James W Monahan
Charles P Nystrom
William L Peeples
Christopher Perez
Emily Ann C Peters
Max Polun
Vede Ramdass
Chantia Robinson
Alex Rossi
David S. Serratore
Thomas Shortell

Max Soloff
William Stephenson
Randall Trzaska
Anthony Tyler
William Varenas
Stanley Viss
Sarah Wall
Matthew Washick
Glenn Winship
Alyssa Wilson

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

L.M. Narducci, Fellow of the Optical Society of America.

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

L.M. Narducci, Emeritus member of the Franklin Institute Committee on Science and the Arts.

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

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

S. Bose, A. Constantin, F. Ferrone, C. Lane, R. Ramos, R. Steimberg, M. Vallières, and **G. Yang**, members of the American Physical Society.

A. Ghosh and **Jian-Min Yuan**, member of the American Chemical Society.

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

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

R. Gordon, S. McMillan, and **M. Vogeley**, members of the Astronomical Society of the Pacific.

D. Goldberg, member of Phi Beta Kappa.

C. Lane, President, Drexel chapter of Sigma Xi, **A. Ghosh**, Treasurer, **Teck-Kah Lim**, and **M. Vallieres,** members.

L. Feingold, S. McMillan and **L.M. Narducci**, members of the American Association for the Advancement of Science.

S. McMillan, member of the IEEE Computer Society.

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

R. Ramos, member American Association of Physics Teachers.

Astrophysics

The Astrophysics Group continues to gain recognition as evidenced by invitations to speak at international conferences and successfully obtaining several grants. They published 12 refereed papers this year.

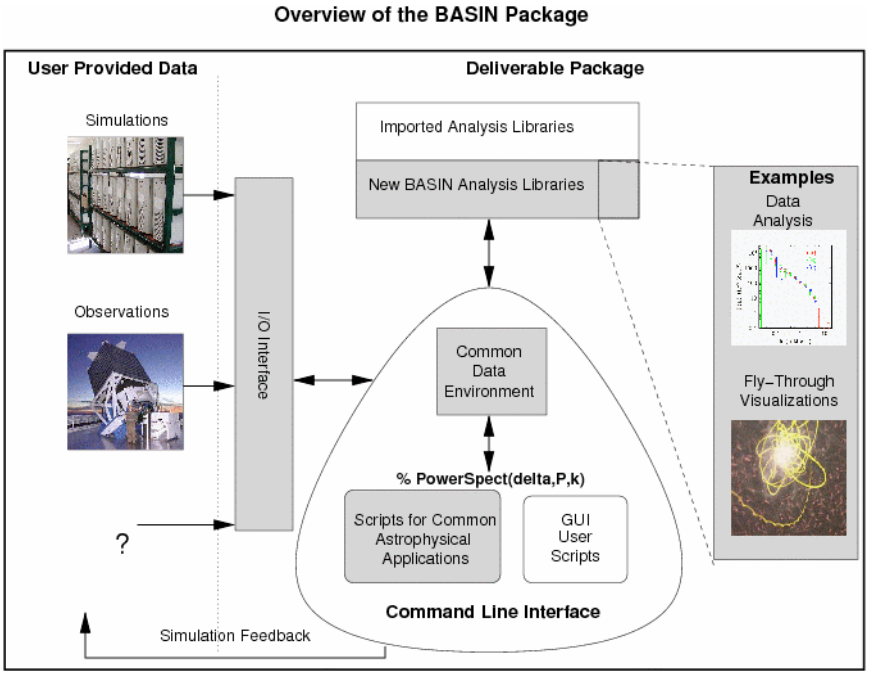
Drexel University Joins the Sloan Digital Sky Survey

M. Vogeley led negotiations that allowed Drexel University to become a partner in the SDSS and its three-year continuation, SDSS-II, effective late December 2005. He serves as Lead Scientist for Drexel in this project and he is responsible for overseeing and facilitating the participation of our faculty and students.

We released new data from the SDSS as Data Release 4 (DR4) and will soon release DR5, which includes all data from the initial phase of the SDSS.

BASIN (Beowulf Analysis Symbolic Interface)
(S. McMillan, D. Goldberg, P. MacNiece and M. Vogeley)

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. Starlab and Starcluster are small-scale prototypes of this larger effort, which is being carried out in collaboration with Drexel faculty D. Goldberg, P. MacNeice, and M. Vogeley (Physics) and B. Char (Computer Science). The BASIN kernel is now in alpha 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 our visualization effort. BASIN personnel are also exploring collaborations with the developers of the "Spiegel" system at the Rochester Institute of Technology and the "VisIt" visualization group at Lawrence Livermore National Laboratory. http://www.physics.drexel.edu/BASIN

Properties and Spatial Distribution of Galaxies and Active Galactic Nuclei

(M. Vogeley)

Internal Properties of Galaxies:

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

Environmental Dependence of Galaxy Properties:

We 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:

We measured the three-dimensional topology of the distribution of galaxies in the SDSS and found that (1) the variation of topology with scale and luminosity indicates a non-trivial relationship between mass and galaxy density and (2) 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:

We clearly detected the signature of baryons in the spectrum of galaxy density fluctuations, which provided a test of the flat lambda CDM model independent of CMB anisotropy measurements. On the other hand, we found evidence in the overall shape of the spectrum that indicates a complicated dependence of galaxy clustering on galaxy type, which is not well-fit by current galaxy formation models.

Power Spectrum of Galaxies - Cosmological Constraints:

We obtained the most accurate-to-date measurement of the galaxy power spectrum and combine this result with the three-year WMAP results to sharpen constraints on cosmological parameters. The SDSS power spectrum significantly improves our constraints on the cosmic baryon fraction, neutrino density, and tensor/scale fluctuation ratio.

Clustering of Active Galactic Nuclei:

We 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:

We initiated analysis of voids and properties of void galaxies 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 Hoyle and Pan). Submitted observing proposals to study the baryonic content of void galaxies. Proposals were approved and will be scheduled for observation using the Westerbork Radio Synthesis Telescope in the Netherlands, and using the Arecibo radio telescope in Puerto Rico.

Active Galactic Nuclei in Cosmic Voids:

We found a remarkable difference between the frequency and properties of AGN in voids and in denser regions of the universe. Together with the

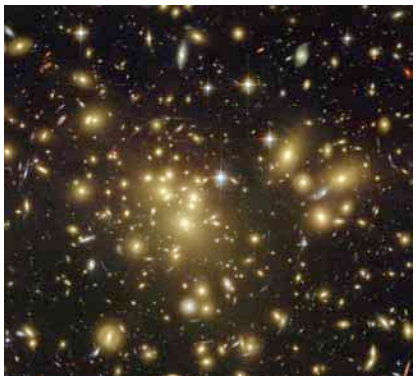
clustering results, we are able to posit a new, complete picture of the co-evolution of supermassive black hole accretion and the galactic hosts of these black holes.

Multi-Wavelength Properties of AGN:

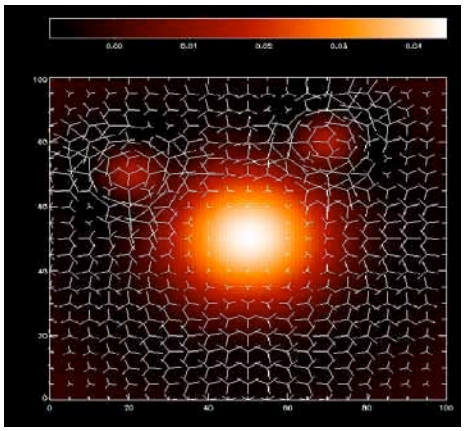
We collected data from SDSS and a number of satellite projects to construct spectral energy distributions of active galactic nuclei, which will allow estimation of the accretion rate onto their black holes (ongoing work with Constantin and Parejko).

Gravitational Lensing
(D. Goldberg)

This is a new technique for measuring 2nd order gravitational lensing signals in background galaxies and radio lobes. Our research continues to gain considerable attention within the gravitational lensing community. This year, Dr. Goldberg presented contributed talks at a lensing workshop at the Lorentz Institute in Leiden and the Aspen Center for Physics, and an invited talk at a gravitational waves workshop in Tennessee as well as at the Institute for Advanced study. His group submitted two papers for publication, and has several more in preparation. One of the submitted papers concerns an entirely new topic of large-scale distortions in map projections.



Weak Gravitational flexion: Flexion is the significant third-order weak gravitational lensing effect responsible for the weakly skewed and arc-like appearance of lensed galaxies. We demonstrated how flexion measurements can be used to measure galaxy halo density profiles and large-scale structure on nonlinear scales, via galaxy–galaxy lensing, dark matter mapping and cosmic flexion correlation functions. We have seen from these applications of flexion that this quantity is a highly useful tool for a variety of methods of measuring mass fluctuations in the Universe. Flexion constitutes a valuable complement to shear, as it is sensitive where shear is not, and vice versa. With upcoming surveys from ground and space, flexion will provide a useful addition to the armory of those who seek to understand mass in the Universe.



Measuring Flexion: We found practical approaches to measuring flexion in observed galaxies. In particular, we looked at the issues involved in using the

Shapelets and HOLICs techniques as means of extracting 2nd order lensing information. We also developed an extension of HOLICs to estimate flexion in the presence of noise, and with a nearly isotropic PSF. We tested both approaches in simple simulated lenses as well as a sample of possible background sources from ACS observations of A1689. We found that because noise is weighted differently in shapelets and HOLICs approaches, that the correlation between measurements of the same object is somewhat diminished, but produce similar scatter due to measurement noise.

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)

We are actively involved not only in using quasars for statistical purposes, but also in exploring their internal physics. Richards 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.

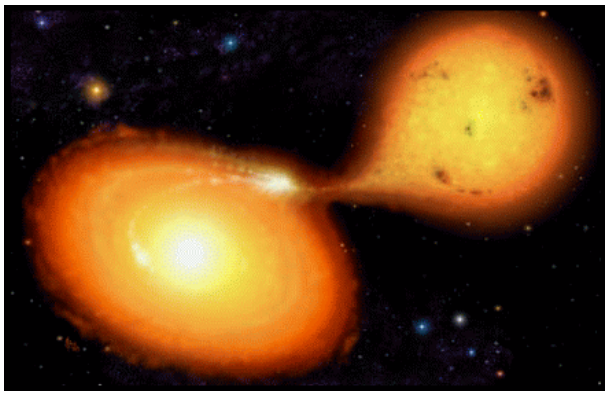
Multiwavelength Investigations of AGNs In addition to optical studies of AGNs, they are interested in understanding their properties in the infrared and X-ray wavelength regimes. For example, Richards led a team that recently provided the best yet characterization of the infrared properties of quasars. 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 M
(S. McMillan)

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. Our 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
(S. McMillan)

The most recent development in the MODEST arena is the MUSE (MUlti-scale MUlti-physics Software Environment) project. Born during the MODEST-6d meeting in Amsterdam in March 2006, MUSE is a collaborative effort 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 (http://london.science.uva.nl:8000/muse).

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: (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 5 format. A new interface between partiview and the BASIN and VisIt projects (see below) is currently under development.

Starcluster: (http://starcluster.org), is a collection of sophisticated data-analysis and display tools for N-body systems, based on the Starlab libraries, but using a simplified data format allowing immediate use by other simulation packages. It is maintained by McMillan and Drexel Physics graduate student E. Mamikonyan. The entire package is available on the Starcluster web site, where numerous interactive demonstrations may also be found.

Atmospheric Science
(F. House)

In collaboration with Dr. R.J. Hamilton (College of Medicine, Drexel University), Dr. Frederick House, worked on a research project concerning workplace carbon monoxide deaths and their relationship to weather factors such as regional temperatures and seasons of the year. In May 2006, our joint paper on "Relationship between Accidental Workplace Carbon Monoxide Deaths, Season, and Temperature" was accepted for presentation at the American Academy of Clinical toxicology, INC. in San Francisco.

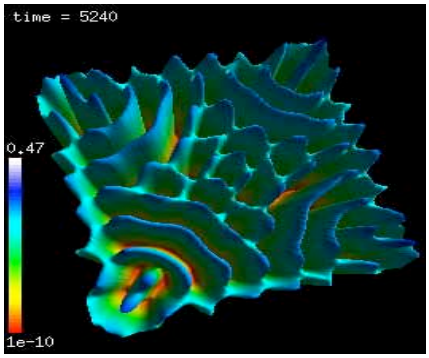
Biophysics

Computational
(Dr. Avijit Ghosh)

This year, our work has received major worldwide attention as measured by a series of invited talks. We have now published our major research work on cancer as well as on sensitivity analysis, and submitted our first contribution on the numerical algorithm design for systems biology. We just submitted a manuscript on drug targeting. This year we have published two articles, a book chapter and two conference proceedings on our work. We have given three invited talks at various conferences and workshops in the US, Germany and in Japan. An overview of our research follows:

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. While the tools that are being developed are still "a work in progress" since the inception of CellSim (within the last year and a half), the following features have been implemented by our group:

Oncogene Explorer Module

Our 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, we had developed a novel approach to predict single point mutations that are likely to cause cellular transformation in signaling transduction networks. We have extended this method to study disparate pair mutations in enzyme/protein interactions and in expression levels in signal transduction pathways and have 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.

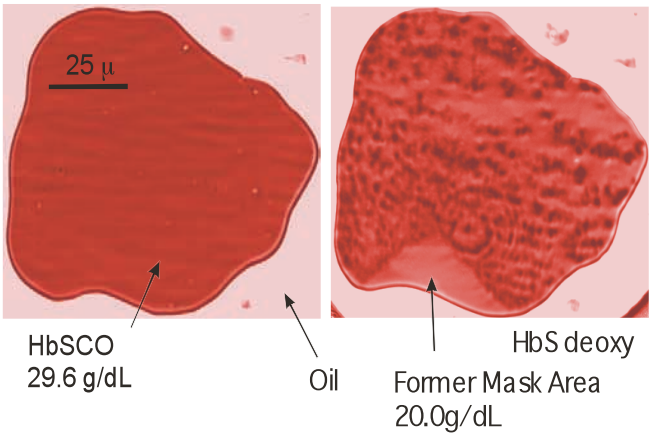
This work has piqued the interest of Martha Head at GSK (where I will present this work) and has started a preliminary collaboration with Merrimack Pharmaceuticals and the biosimulation group at Mathworks (the creators of Matlab).

Experimental
(Dr. Frank Ferrone)

Protein Assembly

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.

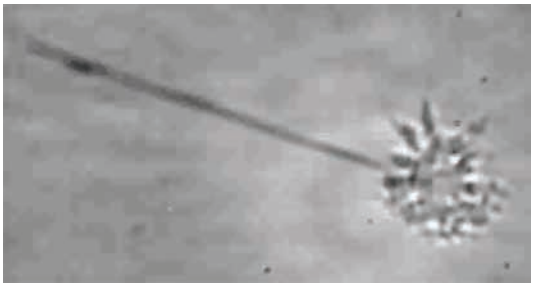
The droplet methodology has proved fertile. In the presence of dextran, hemoglobin will polymerize at much lower concentrations, and there the droplet experiment replicates more usual results, as shown by Mr. Zhengui Liu, a graduate student. We have also shown how to account for crowding by using scaled 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.



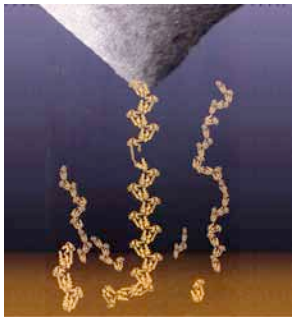
With Dr. Maria Rotter, a Research Assistant Professor in our group, and Dr. Kazuhiko Adachi of Chidren's Hospital, we have published a description in Journal of Molecular Biology of the first artificially created hemoglobin to exceed Fetal Hemoglobin as an inhibitor for polymerization. Our kinetic measurements 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
(Dr. Guoliang Yang)

Single Molecule Manipulation and Atomic Force microscopy

Our lab is interested in studying the molecular mechanisms of protein folding using Atomic Force Microscopy based single molecule method. In the last ten years, single molecule techniques have developed into powerful tools for several branches for physical and biological sciences.



In the past year we carried out experiments to elucidate the effects of macromolecular crowding on the folding and stability of individual protein molecules, which has not been done before. The results will be published in the Journal of Molecular Biology.

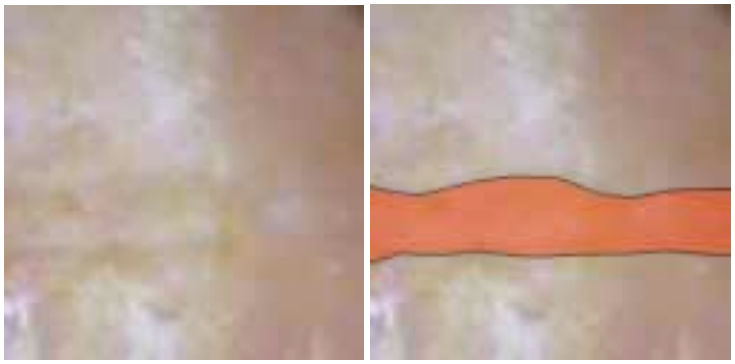
We published five papers with one more accepted for publication. In addition to the continued funding from NIH, we obtained a supplement to the NIH grant, and a NSF-NER grant (in collaboration with R. Lec).

We are in the process of developing new types of protein polymers for novel singlemolecule studies. The project is carried out by Dr. Meihong Su in collaboration with Prof. Oelkers in the Department of Bioscience & Biotechnology.

Experimental
(Som Tyagi)

Scanning Near-Field Microwave Microscopy
(in collaboration with S. Lofland, Rowan Univ.)

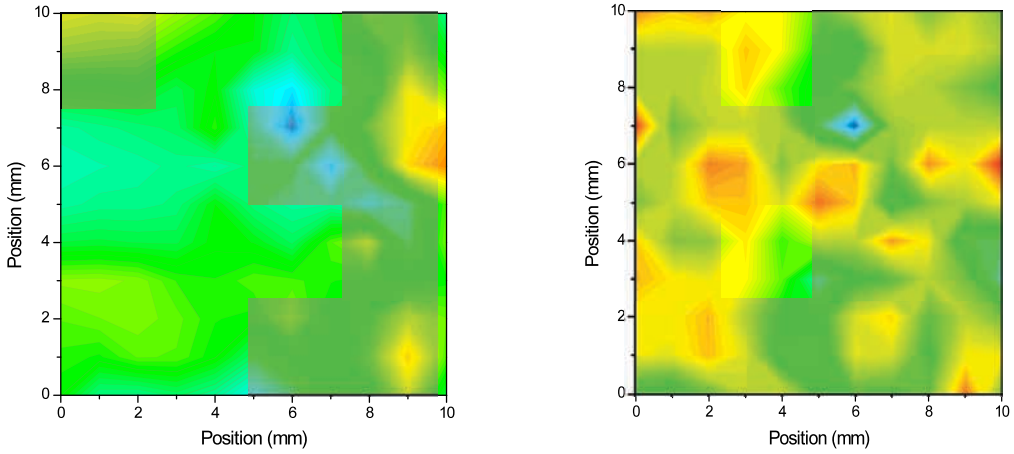
A non-propagating, evanascent *em*-field exists near an aperture in a resonant cavity if the dimension of such an aperture is much smaller than the microwave wavelength. In our case the radius of the circular aperture is $r = 10\text{-}100\ \mu m$ for $\lambda = 10 - 30cm$. The technique provides variable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



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

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 Funcionalized Quantum Dots

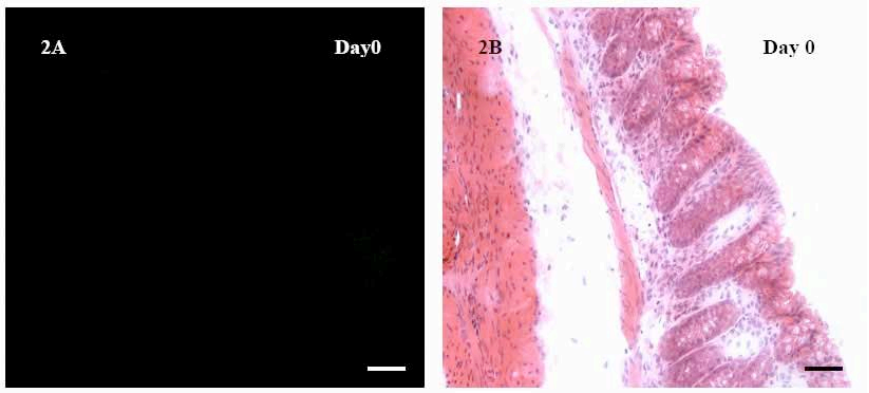
(in collaboration with S. Murthy, E. Papazoglou, and K. Pourrezaei)

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.

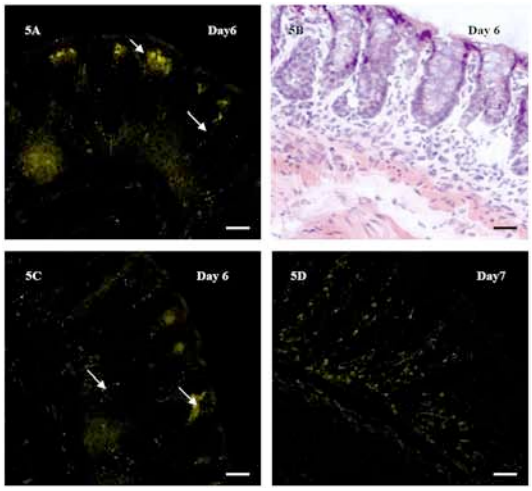
Quantum dots (QDs) are nanometer-sized (a few thousand atoms) fluorescent particles.

Animal model used: dextran sodium sulphate (DSS) model of mouse colitis. Inflammation is induced in the mouse colon by feeding it DSS.

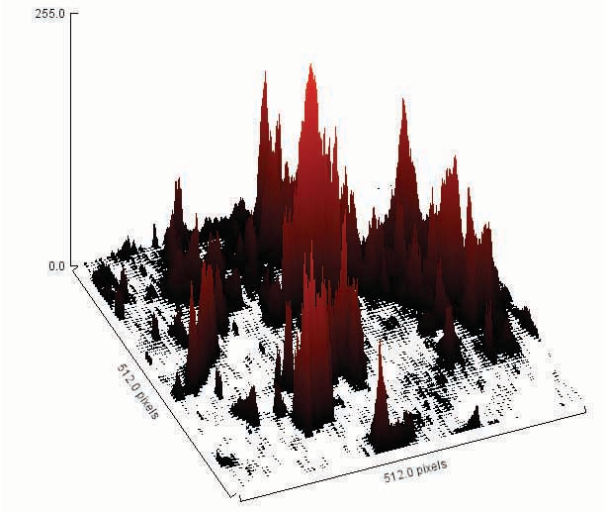
Degree of inflammation has been quantified for the first time using myeloperoxidase (MPO) as an inflammation biomarker.
Images from experiment 2, DSS model of colitis on Day 0 of DSS feed (control), with 565 QD-MPO antibody conjugates. Confocal maximum projection is shown as Figure 2A and H&E stained 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 = 75μ in confocal image and 48μ 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
(Dr. Jian-Min 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 will 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 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.

With the 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.

Specific target: Preliminary results have already been obtained using MD and spFRET on Aβ. MD simulations on it will be carried out shortly. Preliminary molecular dynamics results on AAKA obtained reveal mainly α-helix structure. Perhaps longer calculations will reveal structure transformations. But it may also

require the simulations being carried out at higher peptides concentration or/and at lower pH values.

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 leads 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 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.

Condensed Matter Physics

Electronic and optical properties of metallic nanoshells
(S. Bose)

Recently discovered metallic nanoshells prepared by depositing metals like gold on a silica nanosphere has 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 process to various applications with great deal of precision.

Properties of carbon Nanotubes
(S. Bose)

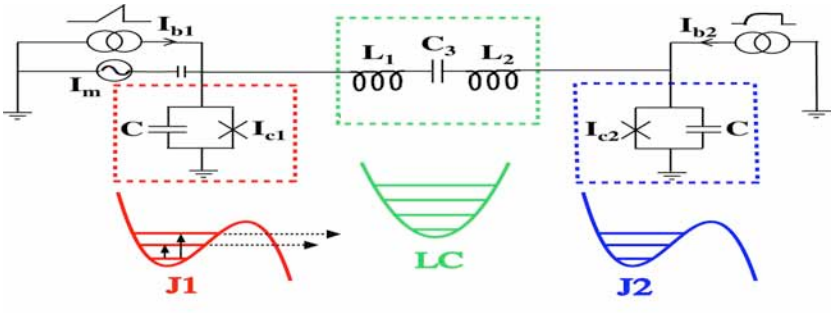
Ever since the discovery of carbon nanotubes in the early 1990's, it was realized that the nanotubes have such unusual properties that they will find many commercial and industrial applications. For example, their strong field emission properties have already been used to produce more efficient electron 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.

Properties of thermoelectric materials
(S. 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 a particular attention to how the figure of merit can be enhanced in these and other caged materials.

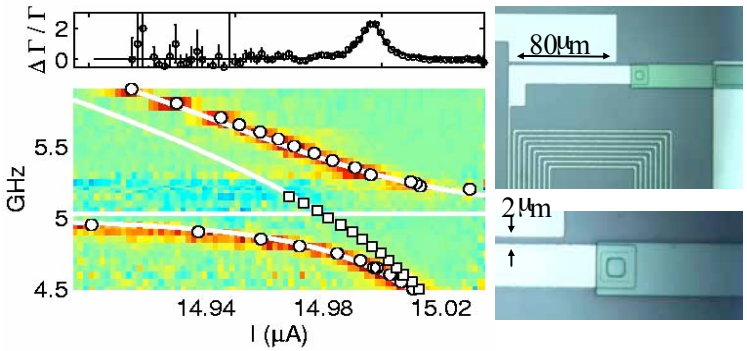
Ultra-Low Temperature Physics
(R. Ramos)

Dr. Roberto Ramos, and in collaboration with U of Maryland colleagues, contributed to observing the first evidence of quantum entanglement between 3 macroscopic superconducting objects in a circuit cooled to 30 milliKelvin, close to Absolute Zero Temperature. This is a major advance in the field because all other researchers have focused only on two qubits/devices.



Qubit 1 **Harmonic Oscillator** **Qubit 2**

Quantum entanglement, a necessary feature for quantum computing, was observed between 2 Josephson junction qubits and a linear harmonic oscillator consisting of the intrinsic capacitance and inductance of a wire. The Josephson junctions, 10□m x 10□m across, were deposited on a Silicon wafer.



Microwave spectroscopy reveals quantum energy levels in a macroscopic chip

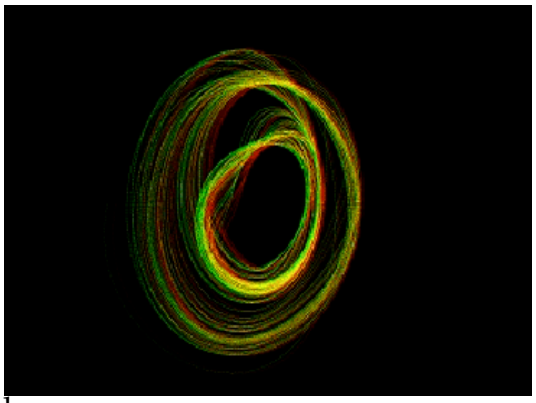
Dr. Ramos is currently building an Ultra-low Temperature Laboratory at Drexel University. He is studying quantum computing, quantum properties of artificial atoms made by superconductors, quantum fluids and carbon Nanotubes.

The workhorse in his lab is the dilution refrigerator cryostat (right) which goes down to 0.007 degrees Kelvin.

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

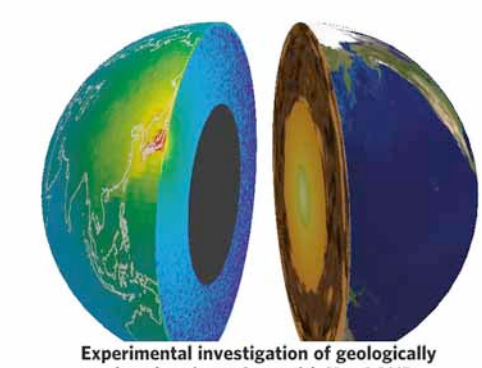
Structure in 100% reflecting potential can be determined by measuring the phase shift of the reflection amplitude. The phase shift is related to a Lorentzian that describes the location of a resonance and its half life. An interference experiment is proposed to measure reflection phase shifts in washboard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

Nuclear and Particle Physics

(C. Lane and J. Maricic)

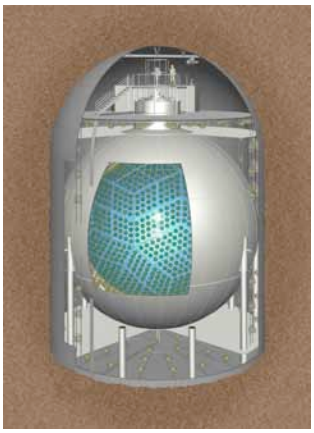
The experimental particle physics effort in the Department has been primarily focused on neutrino physics, which has been a very fruitful area of research over the past several years. We are primarily involved with two neutrino experiments:

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.

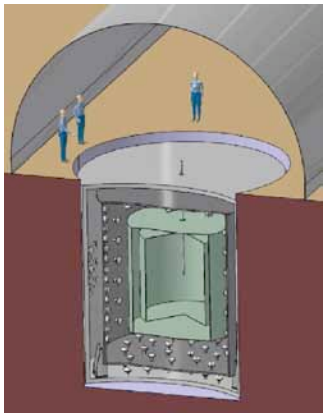


Drexel members of KamLAND include Prof. Lane, Prof. Maricic (who recently joined the Department), and graduate student Tanya Miletic who is writing her Ph.D. thesis on a nucleon-decay search using KamLAND data. Prof. Maricic will be continuing to work on the next phase of KamLAND geo-neutrino analysis.

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.



The current limit on the values of θ_{13} was set by the Chooz experiment, at the same site and with a number of 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.

Quantum Optics

(L. Narducci)

When light interacts with atoms, it can induce transitions by way of distinct but indistinguishable pathways and yield unexpected results. Lorenzo Narducci and Tony Abi-Salloum studied the physical origin of the transparency induced in two different Cascade configurations by the simultaneous interplay of the coupling and probe fields. The two studied configurations differ by the different strengths of the applied fields. Probe and coupling fields are switched between configurations. They demonstrated, in the inhomogeneous limit, the existence of quantum interference in one configuration which is associated with Electromagnetically Induced Transparency. They also elucidated the absence of interference in the other configuration which is related to the Autler-Townes effect. They used techniques borrowed from quantum scattering theory. The transition amplitude between selected initial and final states offers what they believed was convincing evidence for the appearance, or for the absence, of quantum interference effects.

Portfolio Report for Projects

Date		Title	Principal Investigator	Funding Agency	Funded Amount	
Start	End				Awarded	Received this FY
4/1/2006	3/30/2011	Heterogenoeous Nucleation in Sickle Cell Disease	**F. Ferrone**	NIH	1,312,500	262,500
7/1/2000	6/30/2006	Sickle Hemoglobin Structure	**F. Ferrone**	NIH	1,281,489	262,552
8/15/2005	8/15/2008	Galaxy Flexion-Gravitational Lensing	**D. Goldberg**	NASA/EPO	45,000	15,000
6/1/2005	5/31/2007	Galaxy Flexion-Gravitational Lensing	**D. Goldberg**	NASA	274,127	87,000
7/1/2005	6/30/2007	Measuring Gravitation Flexion in AC	**D. Goldberg**	Space Telescope Science Inst.	68,555	68,555
7/1/2000	6/30/2007	Neutrino Physics at KamLAND	**C. Lane**	US Dept. of Energy	448,620	98,598
8/1/2004	7/31/2006	Solar and Heliospheric Modeling	**P. MacNeice**	NASA	398,221	173,976
6/15/2004	6/14/2007	Coronal Mass Ejections	**P. MacNeice**	NASA	371,448	70,514
5/1/2001	4/30/2006	Magnetic Sun Eruptions	**P. MacNeice**	Univ. of California, Berkeley	490,149	112,074
1/1/2005	12/31/2007	Westerlund I	**S. McMillan**	Space Telescope Science Inst.	50,000	25,000
9/15/2003	8/31/2007	ITR: Beowulf Analysis (BASIN)	**S. McMillan**	NSF	1,400,000	325,000
6/1/2004	5/31/2007	Young Dense Star Clusters	**S. McMillan**	NASA	345,000	118,971
1/15/2006	9/30/2007	PARAMESH Parallel Tool	**K. Olson**	NASA	334,640	160,467
6/30/2005	6/30/2006	Colloid-coated Nano-probes for Intracellular SERS spectroscopy	**S. Tyagi***	Nano-Tech Initiative of Southeastern Pennsylvania	107,000	107,000
8/1/2005	7/31/2007	Empirical Tests of Galactic Black Hole Formation	**M. Vogeley**	NSF	292,715	199,863
9/1/2005	8/31/2006	Voids as Laboratories for Galaxy	**M. Vogeley**	NSF	79,970	79,970
6/15/2002	6/142007	AGN Clustering Evolution (LTSA 2001)	**M. Vogeley**	NASA	563,505	147,424
8/1/2004	7/31/2007	Single Molecule Studies	**G. Yang**	NIH	785,446	185,446
8/1/2003	7/31/2006	Acoustic Tweezer for Nanoparticle	**G. Yang***	NSF	100,000	32,270
7/15/2005	6/30/2006	Acoustic Nanoparticle Analizer	**G. Yang***	NSF	100,000	100,000
TOTAL					**8,848,385**	**2,632,180**

*Co-PI (PI in another Drexel Departments)

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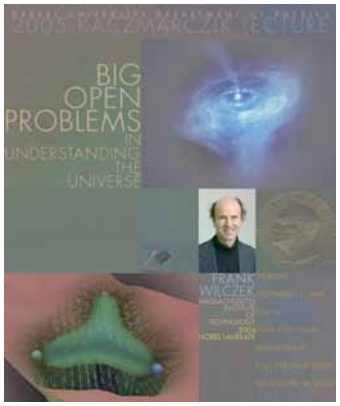
Our Department is involved in several outreach activities and offers resources to promote scientific awareness in our local community. Several Faculty served as judges in the Research Day event.

The Kaczmarczik Lecture Series



The 2005 Kaczmarczik lecturer was Frank Wilczek, MIT (2004 Nobel Laureate). As part of the activities, the Department of Physics held an open house with an attendance that exceeded 400 high school students. This annual event exposed thousands of local high school students to recent discoveries in astrophysics and gave them the opportunity to meet with scientists. Our researchers give brief presentations to the students on topics like biophysics, astrophysics, computational physics, solid-state physics, chaos theory, and others, together with a tour to the department's facilities.

Public Observation Nights

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

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

Computational Boot Camp and Graduate Student Orientation

In order to prepare our incoming graduate students for research, D. Goldberg, A. Ghosh, S. McMillan, M. Vallières, and M. Vogeley gave lectures in advanced computational techniques. Researchers also gave orientation lectures in their research topics.

Committees, Community Services, and Other Activities

- **S. Bose,** member of the Senate Committee on Faculty Affairs.
- **S. Bose**, Chairman of the Review Committee of Sabbatical Applications.
- **S. Bose**, Chairman, Drexel IGERT Fellowship proposal screening committee.
- **S. Bose**, Chairman, of the Graduate Students Excellence committee.
- **S. Bose**, member of the Best Thesis Award committee.
- **F. Ferrone**, Chair, Search Committee for Chemistry Department Head.
- **F. Ferrone**, Chair, Faculty Committee to revise research awards.
- **F. Ferrone**, Chair, GRID proposal evaluation committee.
- **F. Ferrone**, member, representing faculty, University Tenure Review.
- **Avijit Ghosh**, M. Lechner and A. Kriete founded a new Consortium on Systems Biology of the Dynamic Cell: An Interdisciplinary Consortium for Drexel University and the Philadelphia Region. The expectation is to bring together faculty members from biology, engineering and the mathematical sciences as well as from the medical school to study the spatio-temporal aspects of living cells. (http://silicon.physics.drexel.edu/systemsBiology)
- **R. Gilmore**, Standing Committee, International Colloquium for Group Theoretical Methods in Physics.
- **D. Goldberg**, member of the Institutional Review Board – Pennsylvania Hospital.
- **R. Gordon,** Sloan Digital Sky Survey Quasar Working Group Deputy Co-Chair.
- **L. Feingold,** served in the Faculty Senate.
- **F. House and L. Feingold** served in the Tenure Appeals Committee.
- **C. Lane,** member of the Radiation Safety Committee and the Chemical Safety Committee.
- **C. Lane**, member of the Double Chooz collaboration, including co-chair of electronics working group and member of finance committee.
- **Teck-Kah Lim**, Recording Secretary, Faculty Senate.

- **Teck-Kah Lim**, Co-Chair, Undergraduate Programs and Academic Quality (UPAQ) Committee of Provost's Strategic Plan Implementation

- **Teck-Kah Lim**, directed the Teaching Portfolio Workshop (with the attendance of 16 faculty) at the Bridge to the Doctorate Retreat for Drexel and Delaware State Students.

- **Steve McMillan,** Chair, CoAS Undergraduate Committee.

- **Steve McMillan,** member of the CoAS Tenure and Promotion Committee.

- **Steve McMillan,** Research Associate, American Museum of Natural History, New York. McMillan works with Museum personnel to develop visualization techniques to display astrophysical particle simulations in the Hayden planetarium dome and elsewhere.

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

- **Roberto Ramos** performed physics demonstrations for Drexel's "Inspire-a-Child-to-Dream" event. April 27, 2006.

- **T.S. Venkataraman,** member of the College of Engineering Assessment Committee.

- **T.S. Venkataraman,** member of the College of Engineering excellence in teaching TA award committee.

- **T.S. Venkataraman,** member Board of Directors: Delaware Valley Science Council to promote interest in Science among students in area high schools.

- **T.S. Venkataraman,** participated in the Alliance for Minority Participation committee.

- **T.S. Venkataraman,** involved in Alcohol and Drug Task Force committee.

- **T.S. Venkataraman,** Founder Member SRUTI- India Music and Dance Society of Greater Delaware Valley.

- **M. Vogeley,** Advisory Council and Collaboration Council of the Sloan Digital Sky Survey.

- **Jian-Min Yuan**, served as President and Board Member of the American Association for Ethnic Chinese (AAEC).

Colloquium Speakers

- "Double Chooz: Searching for the next neutrino mixing angle, a theta_13 measurement", Dr. Steven Dazeley, Louisiana State University.
- "Hemoglobin: Nitric Oxide Destroyer, Preserver or Creator?", Prof. Daniel. B. Kim-Shapiro, Wake Forest University.
- "From protein unfolding to stem cell biophysics - the key role of elasticity in biology", Prof. Dennis Discher, University of Pennsylvania.
- "Pattern formation in epithelial layers", Dr. Stanislav Shvartsman, Princeton University.
- "Composition and Processing of Circumstellar Disks and Clues for Planet Formation", Dr. Alycia Weinberger, Carnegie Institution of Washington.
- "Quantifying Specificity of Biomolecular Recognition", Prof. Jin Wang, SUNY Stony Brook.
- "Quasars and Cosmology: Accretion Related Feedback and the Growth of Galaxies", Dr. Gordon Richards, Johns Hopkins University.
- "Physics Songs for Fun and Teaching", Walter Smith, University of Haverford
- "First Steps Toward Constraining Supermassive Black-Hole Growth: Mass Estimates of Black Holes in Distant Quasars", Dr. Marianne Vestergaard.
- "Physics is underground", Dr. Steven Dazeley, Louisiana State University
- "Probing the Earth's Interior with Neutrinos and Other Neutrino Applications", Dr. Jelena Maricic University of Hawaii.
- "The MUSYC Census of Protogalaxies at z=3" Dr. Eric Gawiser, Yale University.
- "The Angra Neutrino Project", Dr. David Reyna, Argonne National Laboratory.
- "Investigation of Hadronic Resonances and Pentaquarks in STAR", Dr. Sevil Salur, Yale University.
- "Fault Detection using Scanning SQUID Microscopy", Dr. John Matthews, Center for Superconductivity Research, University of Maryland.
- "The Viscoelastic Properties of Single Fibrin Fibers" Dr. M. Guthold, Wake Forest University.

- "Mapping the routes towards a catastrophic systems failure: The Biology of Aging", Prof. Andres Kriete, School of Biomedical Engineering, Drexel University.

- "WW domain-containing oxidoreductase (WOX1): A candidate tumor suppressor", Dr. Nan-Shan Chang, Guthrie Research Institute.

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1. Paik, H. Strauch, F.W., Ramos, R.C., Berkley, A.J., Xu, H., Dutta, S.K. Johnson, P.R., Dragt, A.J., Anderson, J.R., and Lobb, C.J. *"Cooper-pair Box as a Variable Capacitor"* IEEE Trans. Appl. Supercond. vol. 15(2), (2005): p. 884.

2. Pant, D., and Ghosh, A. "*Automated oncogene detection in complex protein networks with applications to the MAPK signal transduction pathway*" Biophys Chem. 113(3), (2005): p. 275-88.

3. Park, C., Choi, Y.Y., Vogeley, M.S., Gott, J.R., Kim, Juhan. Hikage, C., Matsubara,T., Park, M.G., Suto, Y., and Weinberg, D.H. *"Topology Analysis of the Sloan Digital Sky Survey: I. Scale and Luminosity Dependences"* Astrophysical Journal (2005): 633, 11.

4. Portegies Zwart, S. and McMillan, S. *"Planets in Triple Star Systems-the Case of HD188753"*. Astrophysical Journal (Letters), 633 (2005): 141.

5. Rotter, M., Kwong, S., Briehl, R.W., and Ferrone, F.A. *"Heterogeneous Nucleation in Sickle Hemoglobin: Experimental Validation of a Structural Mechanism "* Biophys. J 89 (2005): 2677-84.

6. Yu, M., Hattrick-Simpers, J., Takeuchi, I., Li, J., Wang, Z.L., Liu, J.P., Lofland, S.E., Tyagi, S., Freeland, J.W., Giubertoni, D., Bersani, M., and Anderle, M. *"Interphase exchange coupling in Fe/Sm-Co bilayers with gradient Fe thicknes"* J. Appl. Phys. 98 (2005): 1-4.

7. Zehavi I., Zheng Z., Weinberg D.H., Frieman J.A., Berlind A.A., Blanton M.R., Scoccimarro R., Sheth R.K., Strauss M.A., Kayo I., Suto Y., Fukugita M., Nakamura O., Bahcall N.A., Brinkmann J., Gunn J.E., Hennessy G.S., Ivezic E., Knapp G.R., Loveday J., Meiksin A., Schlegel D.J., Schneider D.P., Szapudi I., Tegmark M., Vogeley M.S., York D.G. *"The luminosity and color dependence of the galaxy correlation function"* Astrophysical Journal , 630 (2005): 1-27.

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9. Adelman-McCarthy, J.K. et al. *"The Fourth Data Release of the Sloan Digital Sky Survey"* Astrophysical Journal Supplements 162 (2006):38.

10. Araki, T. et al. *"Search for the Invisible Decay of Neutrons with KamLAND"* Phys. Rev. Lett. 96 (2006): 101802.

11. Aravindhan, K., Webb, C.L., Jaye, M., Ghosh, A., Willette, R.N, DiNardo, N.J., Jucker, B.M. *"Assessing the effects of LXR agonists on cellular cholesterol handling: a stable isotope tracer study"*, Lipid Press 47(6): (2006): 1250-60.

12. Bacon, D.J. , Goldberg, D.M., Rowe B.T.P., and Taylor A.N. *"Weak Gravitational Flexion"*. Mon. Not. of the Royal Astron. Soc. 365 (2006): 414.

13. Bose, S.M., Gayen, S. and Behera, S.N. "Theory of the Tangential G-band Feature in the *Raman Spectra of Metallic Carbon Nanotubes"* Phys. Rev. B 72, (2005): 153402-1-4.

14. Constantin, A., and Vogeley, M. S. *"The Clustering of Low Luminosity AGN"* Astrophysical Journal, (2006): 650, 727.

15. Finegold, L. and Flamm,B.L. *"Magnet Therapy"* British Medical Journal 332, (2006): 4.

16. Gilmore, R. *"Lie Groups, General Theory"* Encyclopedia of Mathematical Physics, J.-P Francoise, G. L. Naber, and S. T. Tsou (eds.), Amsterdam: Elsevier, pp. 286-304 (2006).

17. Gilmore, R. *"Chaos and attractors"*, Encyclopedia of Mathematical Physics, J.-P. Francoise, G. L. Naber, and S. T. Tsou (eds.), Amsterdam: Elsevier, pp. 477-488 (2006).

18. Grindlay, J., Portegies Zwart, S., and McMillan, S. *"Short gamma-ray bursts from binary neutron star mergers in globular clusters"* Nature Physics (2006): 2, 116.

19. Hu, Dawein, and Yuan, J.M. *"Time-dependent sensitivity analyses of biological networks: The coupled MAPK and PI3K pathways"* J. Phys. Chem. 110 (2006): 5361-5370.

20. Kundu, A., Zepf, S.E., Hempel, M., Morton, D., Ashman, K.M., Maccarone, T.J., Kissler-Patig, M., Puzia, T.H., Vesperini, E. *"The Ages of Globular Clusters in NGC 4365 Revisited with Deep HST Observations"* Astrophys.J. 634 (2005): L41-L44.

21. Letellier, C. Aguirre, L.A., Maquet, J., and Gilmore, R. *"Evidence for low-dimensional chaos in sunspot data "* Astronomy and Astrophysics 449, (2006): 379-387.

22. Li, Lingyu, Yang, Yao, Yang, G., Chen, Xuming, Hsiao, B.S., Chu, B., Spanier, J.E., and Li, C.Y.*"Patterning polyethylene oligomers on carbon nanotubes using physical vapor deposition"* Nano Lett. 6 (2006): 1007-1012.

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24. Li Y.F., Goldwasser S.M., Herczfeld P.R., Narducci L.M., *"Dynamics of an electrooptically tunable microchip laser"* IEEE J. of Quantum Electronics 42 (1-2) (2006): 208-217.

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26. Palomaki, T.A., Dutta, S.K., Hanhee Paik, Xu, H., Matthews J., Lewis, R.M., Ramos, R.C., Mitra, K., Johnson, P.R., Strauch, F.W., Dragt, A.J., Lobb, C.J., Anderson, J.R., and Wellstood, F.C. *"Initializing the flux state of multiwell inductively isolated Josephson junction qubits"* Phys. Rev. B 73, (2006): 014520.

27. Pant, D.K., and Ghosh "*A systems biology approach for the study of cumulative oncogenes with applications to the MAPK signal transduction pathway*"A. Biophys Chem. 119(1), (2006): p. 49-60.

28. Papazoglou, E., Zubkov, L., Weingarten, M., Zhu, L., Tyagi,S., Pourrezaei, K. *"Optical Properties of Wound Tissue in Diabetic and Healthy Animals*" *IEEE Trans. Biomed. Eng*. 53(6), (2006):1047-1055.

29. Patel, A.C., Li, Shuxi , Yuan, Jian-Min, and Wei, Yen. *"In-Situ Encapsulation of Horseradish Peroxidase in Electrospum Porous Silica Fibers for Potential Biosensor Applications"* Nano Lett. 6, (2006): 1042-1046.

30. Ping, Guanghui, Yang, Guoliang, and Yuan, Jian-Min. *"Depletion force from macromolecular crowding enhances mechanical stability of protein molecules"* Polymer 47, (2006): 2564-2570.

31. Portegies Zwart, S., Baumgardt, H., McMillan, S., Makino, J., Hut, P., and Ebisuzaki, T. *"The Ecology of Star Clusters and Intermediate-Mass Black Holes in the Galactic Center"* Astrophysical Journal 641 (2006): 319.

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34. Turner, M.S, Briehl, R.W., Wang, J.C., Ferrone, F.A., and Josephs, R. *"Anisotropy in sickle hemoglobin fibers from variations in bending and twist"* J Mol Biol. 357 (2006): 1422-7.

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36. Yao Yang, Fan-Chi Lin, and Guoliang Yang *"A temperature control device for single molecule measurements using the AFM"* Rev. Sci. Instrum. 77 (2006): 063701(1-5)

37. Zou, R., and Ghosh, A. *"Automated Sensitivity Analysis of Stiff Biochemical Systems using a 4th Order Adaptive Step Size Rosenbrock Method"* IEE Proc. Systems Biology, 153(2), (2006): p. 79-90.

38. Behera, S.N. , Gayen, S., Ravi Prasad, G.V., and Bose, S.M. *"Electronic properties of ordered and disordered linear clusters of atoms and molecules"*, accepted for publication in Physica B.

39. Lofland, S., Croman, J. , and Tyagi, S. *"Multimode near-field microwave monitoring of free-water content of the skin and imaging of tissue"* accepted for publication, Physics in Medicine and Biology.

40. Portegies Zwart, S., McMillan, S., and Makino, J. *"Star Cluster Ecology: VII The evolution of young dense star clusters containing primordial binaries"*. To appear in Monthly Notices of the Royal Astronomical Society.

41. van den Berk, J., S. Portegies Zwart, and McMillan, S. "The formation of higher--order hierarchical systems in star clusters". To appear in Monthly Notices of the Royal Astronomical Society.

42. Ferrone, F.A. *"Nucleation: the connections between equilibrium and kinetic behavior Methods in Enzymol"* (2006) In press.

43. Goldberg, D.M., and Leonard, A. *"Measuring Flexion"*, accepted for publication, Astrophys. J.

44. M Tegmark, et al. *"Cosmological Constraints from the SDSS Luminous Red Galaxies"* accepted for publication, Phys. Rev. D.

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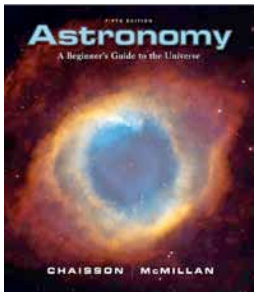

Chaisson, E. and **McMillan, S.** *"Astronomy: A Beginner's Guide to the Universe Today, 5th edition"*. New York: Prentice Hall, 2006.

R. Gilmore and C. Letellier. *"The Symmetry of Chaos" Oxford: Oxford University Press (in press)*

R. Gilmore, *Geometry and Lie Groups (in process, estimate 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.

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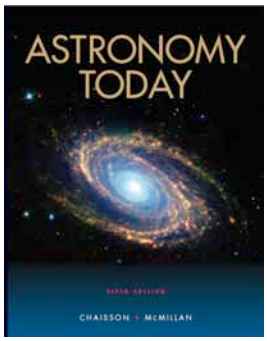


In collaboration with E. Chaisson and the Prentice Hall staff, **McMillan** develops and provides ongoing support for the CD-ROMs and World-Wide Web sites associated with the Astronomy Today and Astronomy: A Beginner's Guide to the Universe projects. The combined Web site may be found at http://www.prenhall.com/chaisson.

Book Chapters

1. Ghosh, A., Miller, D., Zou, R., Pais, H., Sokhansanj, B., Kriete, A. *"Integrated Spatio-temporal Model of Cell Signaling"*. Proc. FOSBE 2005, Santa Barbara, CA. 2005.

2. Scheraga, H.A., et al., "*The Protein Folding Problem"*, Proc. Conf. Algorithms for Macromolecular Modeling. 2005: Leicester, U.K.

3. Ghosh, A., Miller, D. Zou, R, Sokhansanj, B. and Kriete, A. *"Spatio-Temporal Systems Biology"*. Computational Systems Biology. Ed. A. Kriete and R. Eils. 2006, San Diego: Elsevier. pp. 327-382.

4. Ghosh, A., Pant, D. Kumar, A., Zou, R., and Miller, D. *"From Simulation to Therapy: A Systems Biology Approach to Oncogene Detection"*. A Systems Biology Approach to Oncogene Detection. in From Computational Biophysics to Systems Biology. Ed. Jan Meinke, Olav Zimmermann, Sandipan Mohanty, and Ulrich H.E. Hansmann Juelich, Germany, 2006 pp. 7-14

5. Lim, Teck-Kah. *"Evaluating Faculty Research"*. Evaluating Faculty Performance, ed. Peter Seldin. Massachussets: Anker Publishing Company, 2006. pp. 131-149.

6. Olson, Kevin, *"PARAMESH: A parallel adaptive grid tool"*, A. Deane, G. Brenner, A. Ecer, D. Emerson, J. McDonough, J. Periaux, N. Satofuka, & D. Tromeur-Dervout (Eds.), Parallel Computational Fluid Dynamics: Theory and Applications, Proceedings of the 2005 International Conference on Parallel Computational Fluid Dynamics, May 24-27, College Park, MD, Elsevier 2006.

7. Ong, K.K., Cheng, T.C., Yin, R., Dong, H., Yuan, J.M., and Wei, Y. Nanoencapsulation of Organophosphorus Acid Anhydrolase (OPAA) with Mesoporous Materials for Chemical Agent Decontamination in Organic Solvents. Polymers and Materials for Anti-Terrorism and Homeland Defense. Ed. J. G. Reynolds and G. Lawson, ACS publication, accepted, 2006.

[illegible]

1. Bose, S.M., Gayen, S., and Behera, S.N. *"Theory of the tangential G-band feature in the Raman spectra of metallic single-wall carbon nanotubes"*. Conference on Nano E/GDR-E-05: Science and Applications of Nanotubes, Houffalize, Belgium October 10-12, 2005.

2. Constantin, A. and Vogeley, M.S. *"AGN Activity and Galaxy Clustering"*, B.A.A.S., 37 1408, 2005.

3. Constantin, A. *"Linking the Power Sources of Emission-Line Galaxy Nuclei from the Highest to the Lowest Redshifts"*, Publications of the Astronomical Society of the Pacific, 116, 1153, 2005.

4. Gosh, A. *"Computational Studies on Proteins"*. Invited seminar, Medical Center, University of Cincinati, September 8, 2005.

5. Gosh, A. *"A systems biology approach to Oncogene Detection"*. Invited Seminar, NYU Courant Institute, December 3, 2005.

6. Goldberg, D.M. *"Weak Lensing and Flexion"*. Invited talk in "Probing the distant universe with gravitational waves", TN, November 2005.

7. McMillan, S. *"Stellar Collisions and Black Hole Formation in Dense Star Clusters."* Department of Astronomy, University of Delaware, October 2005

8. McMillan, S. *"Intermediate Mass Black Holes in the Galactic Center."* Department of Physics, Rochester Institute of Technology, November 2005.

9. McMillan, S. Moderator and discussion leader, MODEST-6a workshop on Dynamics of Dense Stellar Systems, Lund, Sweden, December 2005.

10. Yang, Guoliang, *"The effects of macromolecular crowding on the mechanical stability of proteins"* Department of Physics, Wake Forest University, November 17, 2005.

11. Abi-Salloum, T., and L.M. Narducci, *"Interference between competing pathways in the interaction of three-level atoms and radiation"* (Contributed talk) 2006 American Physical Society March Meeting, Baltimore, MD. March 13, 2006.

12. Aprelev, A., Zakharov, M., Korneva, G., Gogotsi, Y., Bradley, J.-C., Rotter, M.A., Ferrone, F.A. *"Microrheology of Sickle Hemoglobin Polymer Domains Using Nanotube Levers"* (Poster Presentation). Biophysical Society Annual Meeting, Salt Lake City, Utah, February 18-22, 2006.

13. Bi, W., and Ramos, R.C. *"How Things Work: Using Clickers and Lecture Demonstrations together for Active Feedback"* (Poster), Drexel Research Day, April 25, 2006.

14. Bose, S.M., and Zale, E. *"Collective excitations in concentric metallic nanoshells"* Bull. Am. Phys. Soc. 51, 122 (2006).

15. Feingold, L., and B. Flamm. *"Magnet Therapy"* (Poster), Drexel Research Day, April 25, 2006.

16. Ferrone, F.A., *"Molecular Crowding and Sickle Hemoglobin Assembly"* (Invited Seminar). Department of Physics, University of Palermo, Palermo, Italy, June 9, 2006.

17. Gayen, S., Behera, S.N., and Bose, S.M. *"Effects of collective excitations in the G-band and RBM modes in the Raman spectra of metallic unfilled and filled carbon nanotubes"*, Bull. Am. Phys. Soc. 51, 1421 (2006).

18. Gayen, S., Behera, S.N., and Bose, S.M. *"Effects of collective excitations on the G-band and RBM modes in the Raman spectra of metallic unfilled and filled carbon nanotubes"* (Poster Presentation). 2006 American Physical Society March Meeting, Baltimore, MD. March 13, 2006.

19. Gilmore, R. *"The Topology of Chaos"* (Colloquium) Math department, Drexel University.

20. Gilmore, R. *"The Topology of Chaos"* (Colloquium), Physics Department, University of Missouri, St. Louis.

21. Gilmore, R. *"The Topology of Chaos"* (Colloquium), Applied Math, Oxford University.

22. Ferrone, F.A., Palma, M.U. , Palma-Vittorelli, M.B. *"A Unified Approach to Sickle Hemoglobin Gelation and Phase Separation"* 2006 American Physical Society March Meeting, Baltimore, MD, March 13, 2006.

23. Ferrone, F.A., (Chair Session) *"Proteins Structure and Function"*. American Physical Society March Meeting, Baltimore, MD, March 13, 2006.

24. Goldberg, D.M., *"Weak Gravitational Flexion"* contributed talk in "Cosmological Probes of Baryons and Dark Matter. Aspen, CO. January 2006.

25. Goldberg, D.M., *"Weak Gravitational Flexion"* (invited seminar). Institute for Advanced Study, Princeton, NJ, March 2006.

26. Hu, D. Liu, E., and Yuan, J.M. *"Applications of non-equilibrium thermodynamics to signaling and metabolic pathways"* (Poster Presentation). 2006 American Physical Society March Meeting, Baltimore, MD. March 13, 2006.

27. Karwa, A., Papazoglou, E. , Pourrezaei, K., Murthy, S. , and Tyagi, S. *"QD Detection of Inflammatory Markers in vivo in DSS Model of Colitis"*. Daily Digestive Week Conference, Los Angeles, May 20 -26, 2006.

28. Karwa, A., Papazoglou, E., Pourrezaei, M., Tyagi, S., and Murthy, S. *"Targeting in situ and Imaging Multiple Inflammatory Biomarkers with quantum Dots in DSS Model of Colitis."* Biomedical Technology Showcase 2006, Drexel, July 2006.

29. Leonard, A., Goldberg, D.M., and Massey, R. *"Weak Gravitational Flexion"*. Proc. Bull. American Astron. Soc.

30. Lim, Teck-Kah, Directed the Teaching Portfolio Workshop. Presented at Bridge-to-the-Doctorate Retreat for Drexel and Delaware State students.

31. McMillan, S. Speaker and moderator, MODEST-6d/e N-body and Software Frameworks Workshops, Amsterdam, the Netherlands, March 2006.

32. McMillan, S. Invited participant, Program on Physics of Galactic Nuclei, Kavli Institute for Theoretical Physics, UC Santa Barbara, June/July 2006.

33. McMillan, S. SOC member, invited panelist, and session chair, MODEST-7 workshop on Dynamics of Dense Stellar Systems, Prague, Czech Republic, August 2006.

34. McMillan, S. *"Dynamical Mass Segregation in Young Star Clusters."* Poster presentation at the General Assembly of the International Astronomical Union, Prague, Czech Republic, August 2006.

35. Paik, H., 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. *"Rabi Oscillations in an asymmetric dc SQUID qubit with a gradiometer loop"* Applied Superconductivity Conference, Seattle, WA, Aug. 30, 2006.

36. Papazoglou, E., Pourrezaei, K., Tyagi, S., and Weingarten, M. *"Optical Diagnosis and Treatment Optimization for Chronic Diabetic Wounds"* A translational Research Project Platform Presentation by Coulter Awardees, Biomedical Technology Showcase 2006, Drexel, July 2006.

37. Sun, Y. and Ramos, R.C. *"Quantum States and Energy Levels of Multiple Coupled Josephson Junction Qubits"* 17th Annual Sigma Xi Research Symposium, Philadelphia, PA. April 22, 2006. Judged as the Most Outstanding Presentation by a Graduate Student.

38. Sun, Y., Bi, W., Yang, Y. and R. C. Ramos, R.C. *"Quantum States and Energy Levels of Multiple Coupled Josephson Junction Qubits"* (Poster), Drexel Research Day, April 25, 2006.

39. The KamLAND collaboration, *"KamLAND"*, Prog. Part. Nucl. Phys. 57 (2006): 106-126.

40. The KamLAND collaboration, *"KamLAND status and results"*, PoS HEP2005 (2006): 174.

41. The KamLAND collaboration, *"Reactor- and geo-neutrino detections from KamLAND"*, AIP Conf. Proc. 815 (2006): 19-28.

42. The KamLAND collaboration, *"KamLAND: Studying neutrino oscillation with reactors and measuring anti-neutrinos from the earth"*, Acta Phys. Polon. B37 (2006): 245-256.

43. Tyagi, S. *"Fiber-optical sensors and Nanotechnology"* (Invited speaker) Workshop for teachers from nine local (PA and NJ) community colleges. Immaculata College, April 5, 2006.

44. Venkataraman, T.S., conducted a workshop for New University Science and Engineering TAs on " Great Teaching Assistant and Good Teaching Strategies for Engineering and Science Courses" summer 2006.

45. Vogeley, M.S. *"Cosmic Voids and Void Galaxies"*, Invited opening review talk. Proceedings of Korean Astronomical Society meeting, Daegu, Korea, October 13, 2006.

46. Vogeley, M.S. Organizer and presentations at multiple sessions of Aspen Center for Physics Summer 2006 workshop *"Cosmic Voids"*, May 29-June 17, 2006.

47. Wang, J.C., Kwong, S., Benjamin, L.J., Ferrone, F.A., Turner, M. Briehl, R.W. *"Deformation and Spiculation of Red Cells by Growing Sickle Cell Hemoglobin Fibers and Vesicle Formation Upon Fiber Dissolution"* (Poster Presentation). Biophysical Society Annual Meeting, Salt Lake City, Utah, February 18-22, 2006.

48. Weng, W., Rotter, M.A., Ferrone, F.A. *"A Micromethod for Measuring Sickle Hemoglobin Solubility Using Continuous Laser Photolysis"* (Poster Presentation). Biophysical Society Annual Meeting, Salt Lake City, Utah, February 18-22, 2006.

49. Yang, Y., and Ramos, R.C. *"Energy Levels of a Josephson Junction Qubit Entangled with an LC Harmonic Oscillator"* (Poster), Drexel Research Day, April 25, 2006.

50. Yang, Y., Lin, F-C., and Yang, G. *"A temperature control device for single molecule measurements using the AFM"* (Poster Presentation). Biophysical Society Annual Meeting, Salt Lake City, Utah, February 18-22, 2006.

51. Yuan, Jian-Min. (Invited Speaker) Mini-Symposium II on Systems Biology, National Central University, Chungli, Taiwan, June 19, 2006.

52. Yuan, Jian-Min. (Invited Speaker) Fifth Cross-Strait Workshop on Biology-Inspired Theoretical Science (BITS5) held at Tung Hai University, Taichung, Taiwan, June 20-24, 2006.

53. Yuan, Jian-Min. (Invited Speaker) 8th Taiwan International Symposium on Statistical Physics (StatPhys-2006) organized by the Institute of Physics, Academia Sinica Taipei. June 26, 2006.

54. Yuan, Jian-Min. (Invited Speaker and Chair of the Session) Biological Signaling at the 5th Joint Meeting of Chinese Physicists Worldwide International Conference (OCPA5), National Taiwan University, Taiwan, June 27-30, 2006.

55. Yuan, Jian-Min. *"Unraveling design principles and controlling outputs of signaling pathways using non-equilibrium thermodynamics and sensitivity analysis"* (Invited seminar). Centre for Computational Science and Engineering at the National University of Singapore. Singapore, July 3, 2006.

56. Yuan, Jian-Min. (Invited speaker and a session Chair). International Workshop of Exploring the Mechanisms and Landscapes of Cellular Networks, Telluride, Colorado, August 14-17, 2006.

57. Zubkov, L., Zhu, L., Papazoglou, E., Weingarten , M., Pourrezaei, K., and Tyagi, S. *"Optical Properties of Animal Tissue as Diabetes Progresses"* Biomedical Technology Showcase 2006, Drexel, July 2006.

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 computer/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. This facility is used for education and public outreach, as well as for research.

Biophysics Laser Laboratory

Research is focused on the development of pulsed laser instrumentation systems and their application to the measurement of time-dependent biophysical and biochemical processes. Laser photolysis of caged-ATP, caged-Ca2+, caged protons and caged neurotransmitters have been used in the study of the molecular mechanisms of muscle contraction, neuron communication and proton-dependent biochemical and biophysical processes. Facilities include frequency-doubled ruby, neodymium-glass, liquid dye, solid-state holmium-YLF and erbium-glass lasers.

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.

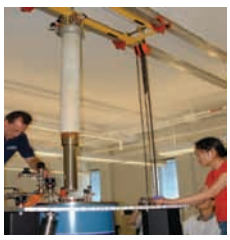
Computational Biophysics Laboratory

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 an 80 gigabyte drive and 1 gigabyte of RAM.

Magnetic Materials and Thin-Film Laboratory

Research is being conducted on amorphous magnetic thin films, fiber optical sensors, and high-T superconductors. 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 8.9mK), 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.

Surface Science Laboratory

Emphasis is on studies to relate static structure and dynamic processes at solid surfaces and interfaces at the atomic level. Facilities include a scanning tunneling microscope, an Atomic Force Microscope, and a surface analysis system for ultraviolet photoemission spectroscopy.

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

Two clusters of off-the-shelf computers act as a parallel computer. The first cluster is a new 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.

Undergraduate Students Lounge

We are proud to announce that renovations of the Undergraduate Lounge are complete. 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 redecorated with comfortable furniture and it is located on the 7th floor of Disque Hall, Room 708. Keys were distributed to all our undergraduates.

Central Electronics Shop

The College of Arts and Sciences Electronic Shop provides facilities, support and expertise for development and construction of specialized equipment. It includes electronics, computer components and mechanical apparatus.