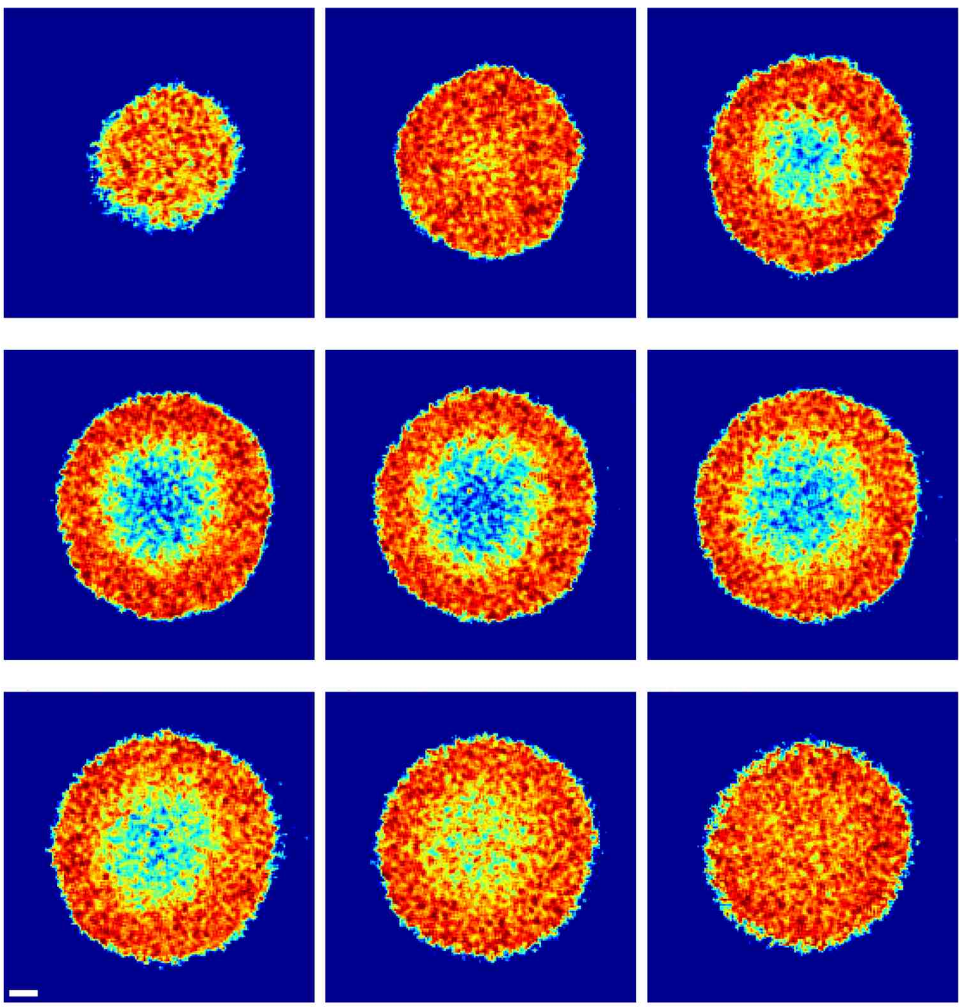
Physics
INTERACTIONS
A NEWSLETTER HIGHLIGHTING THE DEPARTMENT OF PHYSICS AT PURDUE UNIVERSITY
2012

Bringing the Coherence of Light to the Complexity of Cancer



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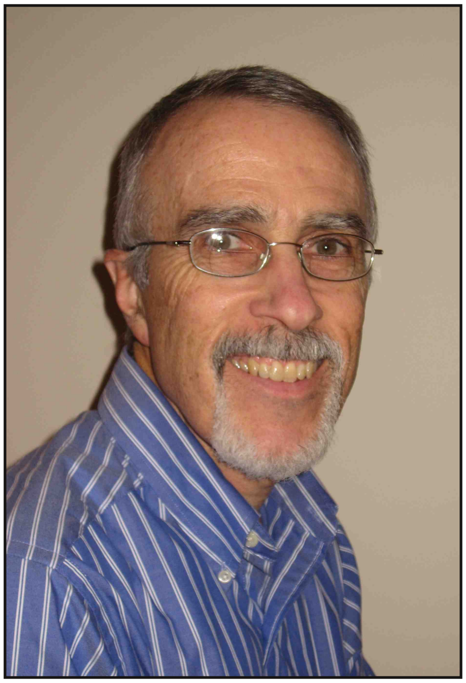

From the Head

Welcome to the latest edition of *Interactions*, the annual newsletter from the Department of Physics. Recently I was asked how I would characterize the past year in the department, and the first phrase that came to mind was "building a bright future." Many aspects of this bright future are highlighted in this newsletter. We are excited about the two new faculty members who have joined us (page 4). Dimitrios Giannios will bring new theoretical expertise to our astrophysics group; he comes to us after several years as a research scholar at Princeton. Chris Greene is a theorist who works in the area of atomic, molecular, and optical physics (AMO), and comes to us from the University of Colorado. An exciting aspect of Chris' appointment as a Distinguished Professor is that the administration has agreed to provide resources for us hire several more faculty in AMO in the next few years. This will be an important new group for our department and for Purdue, and will build important new connections between the departments of Physics and Chemistry, and with Engineering.

Another example of our bright future has been the significant increase in research funding -- our total department grant support has increased 30% over the past five years. This is a result of the success that all of our faculty, and especially our young faculty, are having in growing world leading research programs. These programs are in an incredibly wide range of areas, and include the participation by our high energy group in the experimental discovery of the Higgs boson (see page 11), the planetary science studies by Jay Melosh and his students (page 7), the very creative new imaging techniques developed by David Nolte and his group which make it possible to literally look inside cancer cells (page 8), and the new initiatives to study recently discovered topological phases on condensed matter by Mike Manfra, Yong Chen, and collaborators in our condensed matter group. (This list could go on for several pages, and I apologize to faculty and students who were not mentioned!)

Any mention of the future of the department must also mention the activities of our students, and here again the future looks very bright. During the past 10 years our undergraduate enrollment has increased by 25% while our graduate enrollment has increased by 60%. I am also proud of the important new initiatives that our graduate students have undertaken in recent months. As an example, the Physics Graduate Student Association has started a new graduate student seminar series at which students talk about their research to an audience of (mainly) other students. This is proving to be a great forum for student-to-student mentoring. The graduate students are also organizing a number of social events to build a stronger sense of community and support for students in the department.

I have had the great pleasure of being Department Head for the past five years. It was particularly gratifying this past summer to be asked by the department (and the Dean!) to continue in this role for another few years. I am eager to do what I can to help the department continue move forward in the coming years.

Nicholas J. Giordano ('73)
Hubert James Distinguished Professor of Physics and Department Head

Credits

Physics Interactions is published annually by the Department of Physics at Purdue University.

Department Head
Nicholas J. Giordano

Editor
William L. Fornes
wfornes@purdue.edu
765-494-3001

Contact Information
Department of Physics
525 Northwestern Avenue
West Lafayette, IN
47907-2036

www.physics.purdue.edu
Telephone: 765-494-3000
Fax: 765-494-0706

An electronic version is available at:
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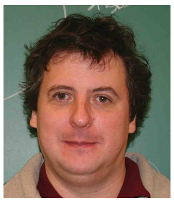
Front Cover Credit: David Nolte
Back Cover Credit: Don Davis

Faculty Honors

Lynn Bryan was named Chair-Elect of the National Association for Research in Science Teaching, was appointed as Director of Purdue University's Center for Research and Engagement in Science and Mathematics Education, and was named the 2012 Outstanding Science Teacher Educator of the Year by the Association for Science Teacher Education.

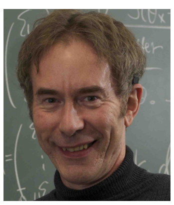
Marc Caffee was named a Fellow of the Geological Society of America.



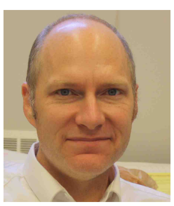
Martin Kruczenski was named a University Faculty Scholar.

Maxim Lyutikov was named a Simons Fellow in Theoretical Physics.

Paul Muzikar received the Ruth and Joel Spira Award for Outstanding Undergraduate Teaching.

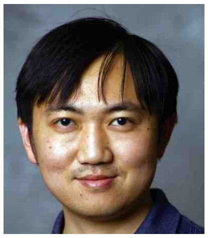


Ian Shipsey was named Chair of the CMS Collaboration Board.

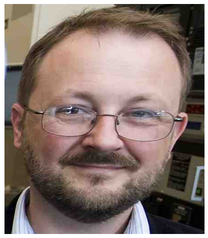


Brian Todd received the Ruth and Joel Spira Award for Outstanding Graduate Teaching.

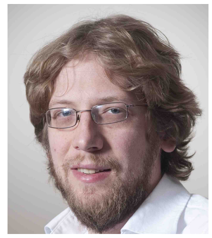
Faculty Promotions



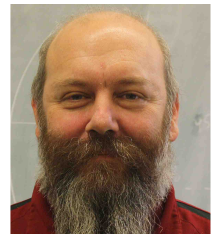
Yong Chen was promoted to Associate Professor.



Gabor Csathy was promoted to Associate Professor.



John Peterson was promoted to Associate Professor.



Ken Ritchie was promoted to Professor.

New Faculty

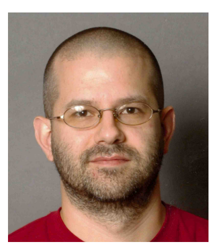
Dimitrios Giannios, Assistant Professor, specializes in theoretical high-energy astrophysics. His research interests focus on the processes responsible for the observed radiation from relativistic jets in gamma-ray bursts, active galactic nuclei, and X-ray binaries. Prof. Giannios comes to Purdue from Princeton University where he was an Associate Research Scholar in the Department of Astrophysical Sciences. He holds a B.Sc. from the University of Patras, Greece, and a Ph.D. from the University of Crete, Greece.

Christopher Greene, Distinguished Professor, is a theoretical atomic, molecular, and optical physicist whose research focuses on ultracold atomic gases, electron-molecule collisions, and laser-molecule interations. Prof. Greene received his B.S. in Physics and Mathematics from the University of Nebraska-Lincoln and his Ph.D. from the University of Chicago. He was previously a faculty member at the University of Colorado at Boulder.

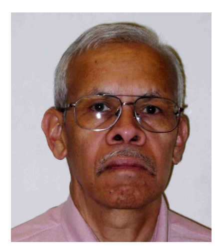
Staff Recognitions

Kirk Arndt received a College of Science Professional Achievement Award.

Pam Blakey received a College of Science Customer Service Award.



Mark Linvill received a College of Science Professional Achievement Award.

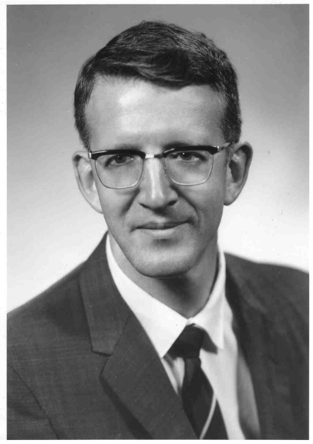


Virendra Saxena received a College of Science Professional Achievement Award.

In Memorium

Prof. Gabriele Giuliani
April 13, 1953 –
November 22, 2012
Years of Service:
1984 – 2012

Prof. Norman Pearlman
August 2, 1922 –
June 28, 2012
Years of Service:
1954 – 1993

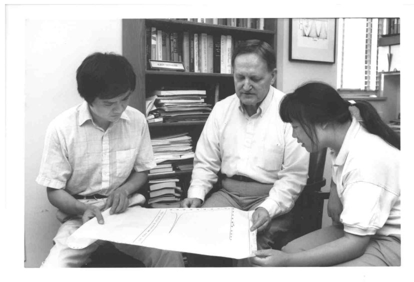


Prof. Ronald Sladek
September 19, 1926 –
August 17, 2012
Years of Service:
1961 – 1992

Remembering Prof. Albert Overhauser

Professor Albert W. Overhauser, the Stuart Distinguished Professor Emeritus of Physics at Purdue University passed away on December 10, 2011, just prior to the printing of the Physics Interactions 2011 newsletter. His full obituary appeared in the October 2012 issue of Physics Today and can be viewed online at the Department of Physics homepage.

President Clinton awarded the National Medal of Science to Prof. Overhauser in 1994.



Overhauser PhD Students

Niranjan Banik, 1978
Mark Boriack, 1977
Ximing Chen, 1990
Luc Daemen, 1989
Francisco Fragachan, 1984
Shaoping Hu, 1987
Yong Gyoo Hwang, 1988
Domnita Marinescu, 1996
Mi-Ae Park, 1996
Alexander Pozamantir, 1999
Kimie Takusagawa, 1992
Yao Rong Wang, 1986
Xiaodong Zhu, 1984

Graduate Student Awards

Outstanding Graduate Student Teacher
Cyrus Vandrevala & Jonathan Nistor

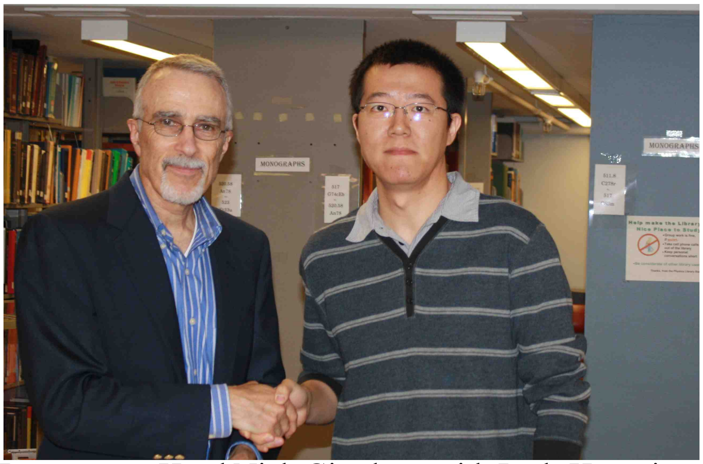
AAPT Outstanding Teaching Assistant
Adrien Chauvet & John Doyle

Akeley-Mandler Award for Teaching Excellence
Adrien Chauvet

Dr. Warner L. Black Award
Sourav Dutta

George W. Tautfest Award
Karolos Potamianos

H.Y. Fan Award
John Watson


Department Head Nick Giordano with Lark-Horovitz Award winner Helin Cao.

Karl Lark-Horovitz Award
Helin Cao

Lijuan Wang Award
Katherine Davis & Niharika Ranjan Singh

Bilsland Dissertation Fellowship
Daniel Whitenack & Nodar Samkharadze

Gary L. Wright Memorial Fellowship
Vineetha Mukundan


Department Head Nick Giordano with Wright Fellow Vineetha Mukundan.

Undergraduate Student Awards

Bottorff Physics Scholarship
Amanda Kollak & Justin Ruiz

Shalim and Paul Sargis Memorial Scholarship
Ryan Senkpeil & Christopher Majors

David G. Seiler Physics Scholarship
Jennifer Larson

Kenneth S. and Paula D. Krane Scholarship
Yuedong Fang & Chengliang Zhu

Lijuan Wang Award
Rachael Fulper

AAPT Outstanding Learning Assistant
Austin Beidelman & Harvey Kaplan

College of Science Outstanding Student Award
Nathan Houtz (Fr), Joshua Knobloch (So), Yuedong Fang (Jr) & James Gloudemans (Sr)

Richard W. King Award
Yuedong Fang (Jr) & James Gloudemans (Sr)

Judith Peters Humnicky Memorial Award
Caitlin Steele

Graduate Research Focus

Impact spherules and ancient impacts on Earth

Brandon Johnson

Impact craters are the most obvious indication of asteroid impacts, but craters on Earth are quickly obscured or destroyed by surface weathering and tectonic processes. Earth's impact history is inferred therefore either from estimates of the present-day impactor flux as determined by observations of near-Earth asteroids, or from the Moon's incomplete impact chronology. Asteroids hitting Earth typically vaporize a mass of target rock comparable to the projectile's mass. As this vapor expands in a large plume or fireball, it cools and condenses into molten droplets called spherules (back cover and figure 1). For asteroids larger than about 10 km in diameter, these spherules are deposited in a global layer. Spherule layers preserved in the geologic record accordingly provide information about an impact even when the source crater cannot be found.

We recently constructed a numerical model of spherule formation in an impact produced vapor plume (Johnson and Melosh 2012a). This model tracks the expansion of the vapor plume using a one-dimensional Lagrangian hydrocode coupled with the ANEOS (ANalytical Equation Of State) for silica. We then include the equations for nucleation and growth as described by homogeneous nucleation theory to describe the process of spherule formation. Using this model we can estimate the average spherule size and spherule layer thickness that a given impact will create. We find that a 9-14 km diameter asteroid impacting the Earth at ~21 km/s will create a 3mm thick spherule layer composed of spherules that are ~250 micron in diameter. This is in good agreement with the K/Pg boundary layer, a 3 mm thick spherule layer that was created 65 Myr ago by the approximately 10 ± 4 km diameter Chicxulub impactor.

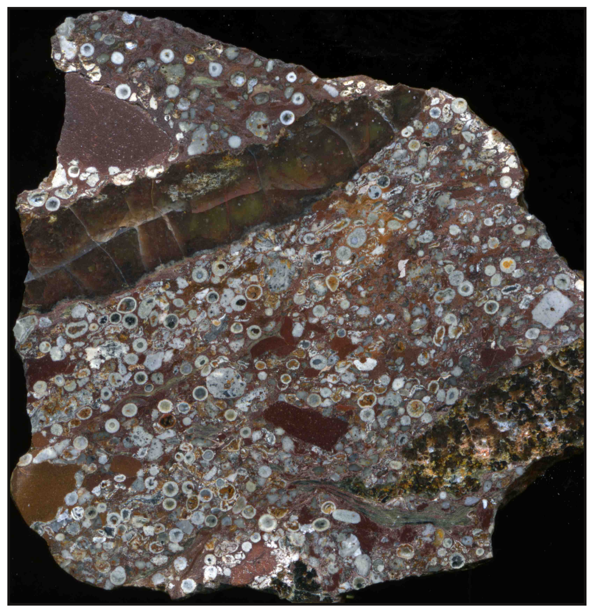


Figure 1: Sample of the 2.63 billion year old Jeerinah spherule layer from Western Australia. The light circles and oblong objects with darker cores are mm scale spherules. We estimate that an asteroid that was approximately 20 km in diameter created this layer. (Credit: Oberlin College/ Bruce M. Simonson)

Using our model and data on ancient spherule layers we are able to estimate the size of the impactors that created the ancient layers even when no source crater can be found. Our analysis indicates that 3.5-2 Gyr ago the Earth was being bombarded by more large asteroids than previously expected (Johnson and Melosh 2012b). Some of the impactor sizes we calculate are more than 5 times the size of the Chicxulub impactor, which caused a massive extinction and killed of the dinosaurs when it impacted 65 Myr ago. Thus, it is not hard to imagine that these large impacts may have played a significant role in the evolution of early life.

References

Johnson, B. C. and Melosh, H. J. Formation of spherules in impact produced vapor plumes. Icarus 217, 416–430 (2012).

Johnson, B. C. and Melosh, H. J. Impact spherules as a record of an ancient heavy bombardment. Nature 485, 75–77 (2012).

Brandon Johnson is advised by Professor Jay Melosh. His work is supported by NASA.

3-D Motility Contrast Imaging of Cancerous Tissue

David Nolte, Ran An, Dan Merrill, John Turek

Like snowflakes, no two cancers are alike. The genetic fingerprint of any cancer is unique to each specific patient. Within a single patient, protein profiles vary from tumor to tumor, and can even vary spatially across a single tumor as cancer cells respond adaptively to differing local environments. This wide spectrum of genetic and phenotypic behavior is known as cancer heterogeneity, as some patients or some regions of a tumor respond well to an anti-cancer drug while others do not. This is why most chemotherapies ultimately fail. In stark contrast to the wide variety of cancers, cancer care in clinics today is blandly homogeneous, with a "one size fits all" approach that fails to provide benefit to more than 60% of all patients and exposes them all to debilitating side effects. Even the hope of genetics for cancer drug discovery, following the sequencing of the human genome in 2000, has diminished in recent years because drugs developed for single genetic or protein targets usually fail. An alternative to target-based drug discovery is a systems approach known as phenotypic profiling that measures the global systemic response of cancer tissue to an applied drug. In this approach, the details of all affected protein signaling pathways may not be discoverable, but the overall efficacy of the drug against that cancer may be monitored despite all of its heterogeneity and within all of its diverse microenvironments.

As part of this effort, our laboratory has developed a new type of phenotypic profiling that gets at the very core of the functioning health of living tissue by measuring intracellular motions. An overarching principle of life—and the realization that strikes anyone looking through a microscope at live cells—is that everything is in motion. Biology is more than molecular and mechanical structures—it is how structures interact and induce changes and drive transport. As an analogy, consider how a Swiss watch is like living tissue. The catalogue of the gears and springs and jewels that make up the watch are like the genetic blueprint. They specify in great detail what the individual components look like, but say little about how they all fit together. Further, an image of the assembled watch is like the protein profile and microscope image. We can infer much about function by seeing how the parts fit together, but all it takes is one grain of sand in the works to stop the clock. A movie of the working watch, on the other hand, tells us nearly everything—how all the parts function in unison, and also when they don't.

We use coherent light scattering to measure the collective motions of the components of cells inside living tissue. Our approach, called motility contrast imaging (MCI), produces three-dimensional images of the activity inside tissues [1]. It is based,

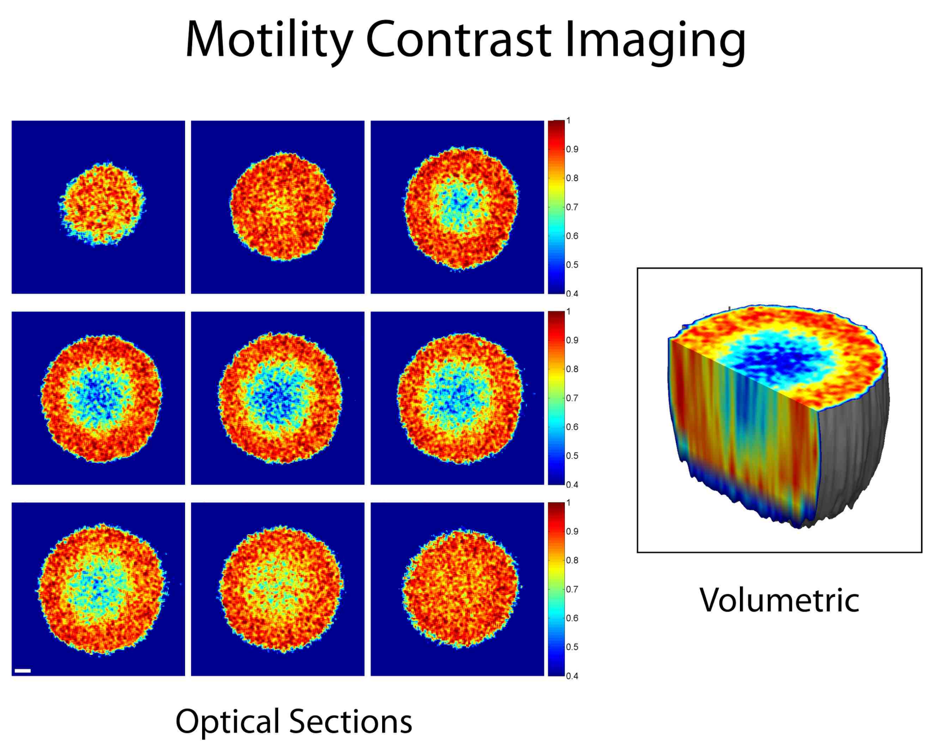


Fig. 1 *Motility contrast imaging of a 0.8 mm diameter tumor. a) Cross sections of tissue activity color-coded red (active) and blue (quiet). b) Volumetric reconstruction showing the proliferating shell surrounding the necrotic core.*

in part, on dynamic light scattering—like the Doppler effect—sensitive to submicron displacements at ultralow frequencies between 0.005 Hz and 5 Hz [2]. These frequencies match the speeds (around a micron per second) of the molecular motors that are the work-horses of cellular biodynamics. In addition to the phase fluctuations, another aspect of MCI is low-coherence interferometry performed using digital holography. This enables laser ranging—like laser radar—to capture the motional signals volumetrically to accuracies of tens of microns. Figure 1 shows an example of a motility contrast image of a 0.8 millimeter-diameter tumor, color-coded to the degree of internal motion (red is high motion and blue is low motion). Various cross sections are shown on the left, with a volumetric reconstruction on the right in which a shell of proliferating cancer cells surrounds a necrotic core.

Low-coherence dynamic light scattering is in the field of statistical optics, and quantitative investigation proceeds through decorrelation and spectral analysis. The combined motions of all the constituents of the illuminated cells leads to coherent speckle that fluctuates dynamically in time with characteristic decorrelation functions and spectral power densities that carry signatures of the subtle changes induced by applied drugs on dynamic motion inside cells [3]. This opens the door to a spectroscopic approach called tissue dynamics spectroscopy (TDS). An example of a time-frequency spectrogram of living tissue responding to the anti-mitotic drug cytochalasin is shown in Fig. 2a. The drug is applied at time t = 0, and the spectrogram plots the relative changes in the fluctuation spectral content as a function of time. Drugs with different mechanisms of

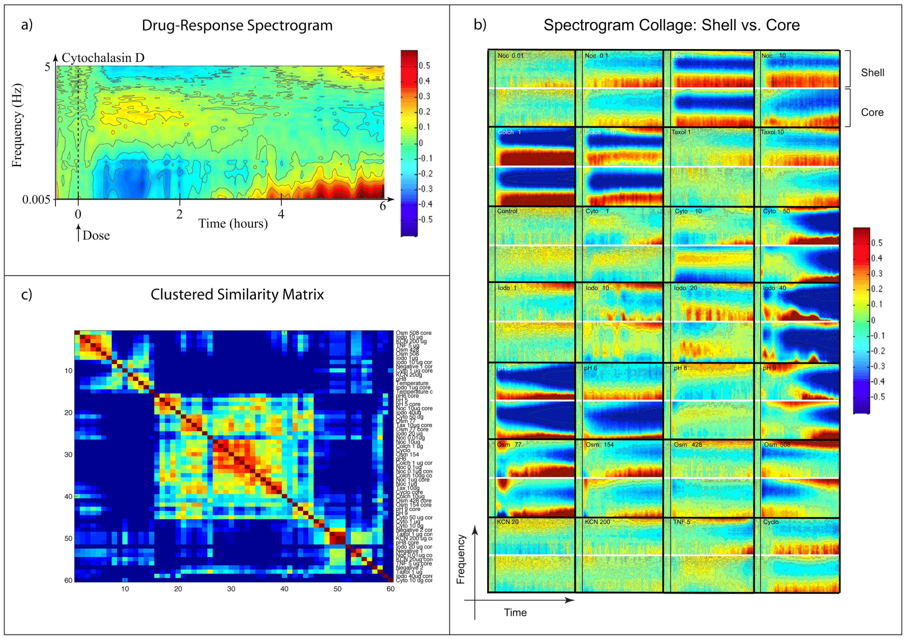


Fig. 2 *Tissue dynamics spectroscopy (TDS) and phenotypic profiling. a) The drug response spectrogram showing the relative change in spectral content as a function of time after the anti-mitotic drug cytochalasin is applied. b) Library of drug response spectrograms. c) Similarity matrix after unsupervised clustering of drug responses.*

action have different drug-response signatures. A small library of spectrograms is shown in Fig. 2b across several different drugs, doses and conditions. The similarity (or dissimilarity) among the different drug responses are expressed in the similarity matrix in Fig. 2c that has an approximately block-diagonal structure after unsupervised hierarchical clustering. Similar spectrograms cluster together, with little correlation among other blocks of spectrograms [4]. Based on the similarity matrix for such a library of drug compounds, phenotypic profiling captures different aspects of tissue responding to drugs, including overall metabolic activity, cytoskeletal reconstructions, membrane motions, mitochondrial transport, and the induction of programmed cell death (apoptosis) versus uncontrolled cell death (necrosis). In a drug-screening phenotypic profiling application, new drug compounds of unknown mechanism would be compared against a broad library of highly characterized reference compounds. If the new drug is clustered near known beneficial compounds, or displays promising characteristics, it can move further along the development pipeline.

Tumor heterogeneity, and the uneven response of tumor tissue to drugs, is a central problem in cancer therapeutics. Tissue dynamics imaging (TDI) spatially resolves different drug-response spectrograms from different parts of a tumor. An example of TDI is shown in Fig. 3 for a live colon cancer tumor responding to the drug Sorafenib. The MCI image in Fig. 3a shows a relatively uniform motility map. However, when Sorafenib was applied and the drug-response spectrograms were generated for small groups of pixels,

David Nolte is a professor in the Department of Physics. Ran An and Daniel Merrill are graduate students in Professor Nolte's research group. John Turek is a professor in the Department of Basic Medical Sciences.
Their work is supported by the National Science Foundation and the Purdue Research Foundation.

Faculty Research Focus (cont.)

the drug response across the tumor was heterogeneous, with two significantly different classes of response spectrograms, shown in Fig. 3b. The upper spectrogram shows a strong enhancement at high frequencies (near 5 Hz) associated with mitochondrial transport. The lower spectrogram has a mid-frequency enhancement associated with active membrane undulations. Taking these spectrograms as signatures, the TDI image in Fig. 3c is coded into two colors: red for enhanced mitochondrial motion (high-frequency response type) and green for enhanced membrane fluctuations (mid-frequency response type). The high-frequency response was strong near the outer portions of the tumor, but weak towards the center, where the tissue tends to be hypoxic and acidic. More strikingly, there is a localized region of the tumor that is coded in green for the mid-frequency signature. The cancer cells in this region respond in a very different way than most of the rest of the tumor, showing membrane stress without enhanced mitochondrial participation. Therefore, the application of Sorafenib against this cancer type exhibits a highly heterogeneous response, and other drugs should be sought that elicit more uniform positive response prior to the start of chemotherapy.

The applications of motility contrast imaging and tissue dynamics imaging are anticipated to go well beyond the examples presented here. All living tissue is characterized by

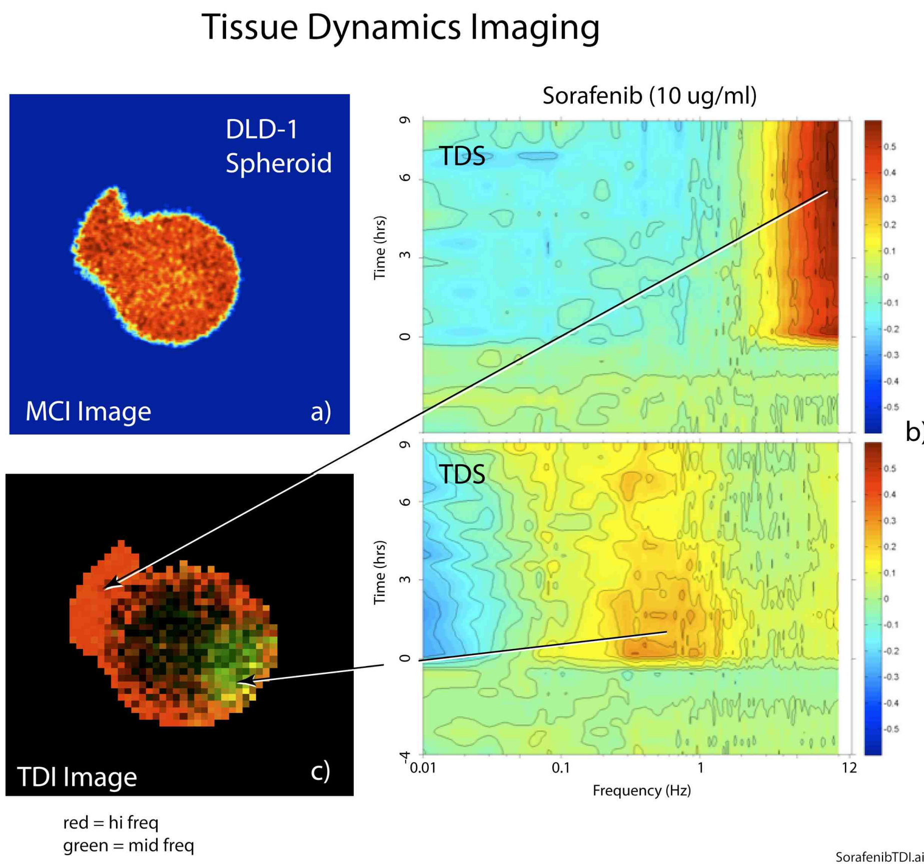


Fig. 3 *Tissue dynamics imaging (TDI) of a colon cancer tumor responding to the anti-proliferation drug Sorafenib. a) Motility contrast image of cellular activity. b) Two strikingly different spectrogram signatures of tissue responding to the drug. c) Tissue dynamics image that is colorcoded by red and green for the two types of spectrograms. The tumor response is heterogeneous, with a localized area showing a highly different response to the drug.*

internal motions that are highly specific to the functions driving that motion. We envision a new type of microscopy, called biodynamic microscopy, that can become a versatile tool in life sciences laboratories. For instance, we currently have a TRASK award from the Purdue Research Foundation to use MCI and TDI also in the field of in vitro fertilization to assess the viability of embryos prior to implantation. This could improve the success rate for pregnancies, reducing cost and eliminating complications. This application, and others, suggests a promising utility for biodynamic imaging.

References:

[1] K. Jeong, J. J. Turek, and D. D. Nolte, "Imaging Motility Contrast in Digital Holography of Tissue Response to Cytoskeletal Anti-cancer Drugs,," Optics Express, vol. 15, pp. 14057-14064, 2007.

[2] D. D. Nolte, "Diffraction and Light Scattering," Chapter 3 in Optical Interferometry for Biology and Medicine, Springer, 2012, pp. 49-94.

[3] K. Jeong, J. J. Turek, and D. D. Nolte, "Speckle fluctuation spectroscopy of intracellular motion in living tissue using coherence-domain digital holography," Journal of Biomedical Optics, vol. 15, p. 030514, May-Jun 2010.

[4] D. D. Nolte, R. An, J. J. Turek, and K. Jeong, "Tissue dynamics spectroscopy for phenotypic profiling of drug effects in three-dimensional culture," Biomed. Opt. Express, vol. 3, pp. 2825-2841, 2012.

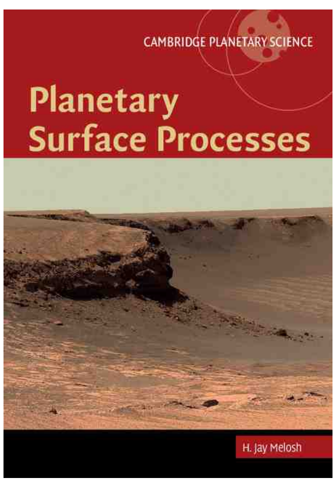
Purdue and the Higgs Boson

Prof. Alan Walker (Edinburgh University), Prof. Ian Shipsey (Purdue University), Prof. Peter Higgs (Edinburgh University), and Prof. Daniela Bortoletto (Purdue University) at the July 4, 2012 announcement of the discovery of the particle that may be the Higgs Boson. (Purdue University photo/courtesy of Bortoletto).

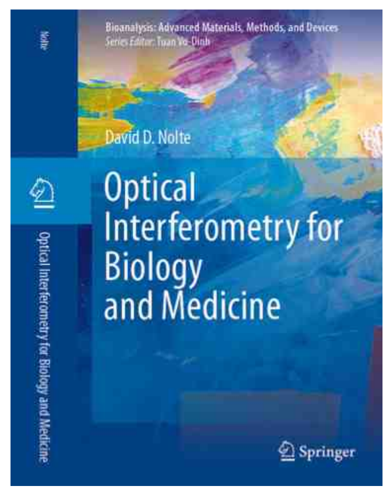
The Department of Physics' particle physics group, working on the largest ever international experiment in particle physics, were part of a the July 4th announcement of the discovery of a new particle that may be the Higgs boson, which could confirm the Standard Model of physics and provide insight into how the universe formed. For more information on the discovery and Purdue's role, visit the Department of Physics homepage at www.physics.purdue.edu.

Particle Physics Group	
Prof. Virgil Barnes	Prof. Matthew Jones
Prof. Daniela Bortoletto	Prof. David Miller
Prof. Art Garfinkel	Prof. Norbert Neumeister
Prof. Laszlo Gutay	Prof. Ian Shipsey

Books by Faculty

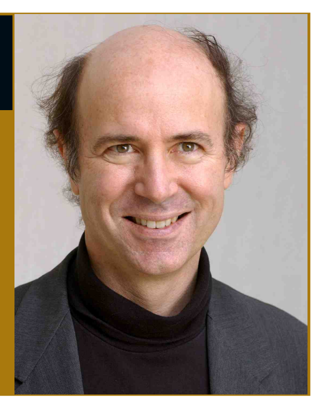


Department of Physics faculty continue to be active authors. Professor Jay Melosh has written a comprehensive advanced textbook on the processes that shape planetary surfaces. Professor David Nolte's book presents fundamental physics of optical interferometry as it applies to biophysical, biological and medical research.



Hubert James Lecture

Prof. Frank Wilczek, 2004 Nobel Laureate, delivered the 20th annual Hubert M. James Lecture on October 24, 2012. Prof. Wilczek is the Herman Feshbach Professor of Physics at the Massachusetts Institute of Technology. His lecture was on the topic of "Quantum Beauty."



2012 Distinguished Alumni Award

The Department of Physics and the College of Science honored Dr. David Leckrone as its 2012 Distinguished Alumnus on April 13, 2012.

David S. Leckrone

BS '64 Purdue University, Physics
MS '67 UCLA, Astronomy
PhD '69 UCLA, Astronomy
MAS '87 Johns Hopkins University, Management

Dr. David Leckrone, BS 1964, has distinguished himself as a leader in the astrophysics community. From 1976 to his retirement in 2009, Dr. Leckrone participated in the Space Telescope Program (now known as the Hubble Space Telescope), becoming Senior Project Scientist in 1992. In this role, he acted as the chief advocate for the Hubble's scientific objectives and served as scientific lead for shuttle servicing missions in 1993, 1997, 1999, 2002, and 2009. Hubble accomplishments to date include measuring the age of the universe at 13.7 billion years, establishing that supermassive black holes are the nuclei of nearly all galaxies, and detecting the first organic molecule outside of the solar system. The Space Telescope Science Institute estimates there are 12 independent discoveries made every week based on the findings of Hubble. In addition to his duties with Hubble, Dr. Leckrone was Head of the Astronomy Branch in the Laboratory for Astronomy and Solar Physics at Goddard Space Flight Center during the 1980s and served as the Chief Scientist for the NASA Engineering and Safety Center (NESC), formed by the Agency in response to the recommendations of the Columbia Accident Investigation Board, during 2003-2005. Dr. Leckrone's accomplishments have been exceptional, furthering the mission of NASA and enabling outstanding astrophysics research around the world.

Career Highlights

1992	Named Senior Project Scientist for the Hubble Program
	NASA Oustranding Scientific Achievement Medal
1994	NASA Outstanding Leadership Medal
1996	Honorary Doctorate of Philosophy, University of Lund, Sweden
2008	Presidential Rank Award of Merit, U.S. Civil Service
2009	NASA Distinguished Service Medal
2011	George Van Biesbroeck Prize by American Astronomical Society

2012 Outstanding Alumni Awards

The Physics Department and the College of Science hosted the 2012 Outstanding Alumni on September 28, 2012.

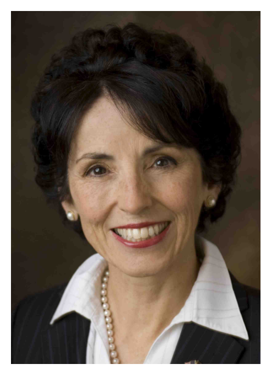
Rebecca Barfknecht (BS 1979)

Rebecca Barfknecht has made her career in Information Technology for over 30 years in the areas of Infrastructure Engineering and Hosting and Application development for Russell Investments, Intuit, Charles Schwab and Pacific Bell. She is known for building strong teams, implementing effective processes, establishing financial discipline, and delivering excellent service availability. Rebecca holds a Bachelor of Science degree in Physics from Purdue University. She enjoys backpacking, scuba diving, running and flying (as a private pilot) with her husband, Andy.

Mark Ramsbey (BS 1983)

Mark Ramsbey graduated from Purdue University in 1983 with a B.S. in Honors Physics and from the University of Illinois in 1990 with a PhD in Condensed Matter Physics. In 1990 he joined Advanced Micro Devices (AMD) as a wafer fab rotation engineer working in the Submicron Development Center in Sunnyvale, CA. In 1999 he was responsible for AMD's first process flow for nitride storage based Flash memory and led the process integration groups for the first four generations of Mirror BitTM Flash memory, work which resulted in over 100 patents. By 2006 Mark was a director and AMD had spun off its Flash memory division as a separate company named Spansion where he currently works. Mark and his wife Mai live in Sunnyvale, California.

2012 Honorary Doctorate



Dr. France Córdova, Purdue's eleventh president (2007-2012), received an honorary Doctor of Science at the Spring 2012 commencement. Among Purdue's many accomplishments during Dr. Córdova's tenure are a doubling of the number of research awards, the formation of the College of Health and Human Services, development of an Office of Engagement, creation of the Global Policy Research Institute, and establishment of the Honors College. In October, Purdue dedicated the France A. Córdova Recreational Sports Center. Prior to Purdue, Dr. Córdova served as Chancellor of the University of California Riverside and Vice Chancellor of Research at the University of California at Santa Barbara. Dr. Córdova currently serves on the Smithsonian Board of Regents (where she is chair), the National Science Board, the Mayo Clinic Board of Trustees, the Science Applications International Corporation Board of Directors, and the Indiana Chamber of Commerce. Dr. Córdova's research expertise is in observational and experimental astrophysics, multi-spectral research on x-ray and gamma ray sources and space instrumentation. She has over one hundred publications to her name.

From the Director of Development

The world of Physics had many developments in 2012, bringing a new energy to the field. This past summer we witnessed what is believed to be the discovery of the long-hunted Higgs boson particle. With this evolution, physics will have new challenges and directions to explore, and require new generations of well-trained, innovative physicists to explore them. This is nothing new for the Purdue Physics Department who has been preparing students diligently since 1904 when its doors first opened.

As we consider what direction future research and advancements will take, it is necessary to prepare our students by providing the best possible experience we can. The department had the opportunity to renovate a room within the Physics Building to create a space to conduct research, strengthen the CMS's group connection with CERN, and host outreach events. While the room is renovated, we are continuing to work towards our goal of funding furniture for the space.

As always, we could not be the department we are without the support of our alumni and friends. Thank you. You are always welcome to visit the department, and I would be happy to answer any questions you might have regarding our Purdue Physics.

Hail Purdue!

Kaethe Ann Beck
Director of Development
765.494.0669
beck35@purdue.edu

Physics Degrees

December 2011 - August 2012

Bachelor of Science

Barclay, Thomas S.
Boguski, John C.
Brewster, Warren A.
Callahan, Nathan B.
Coates, Charles L.
Coiro, Anthony F.
Czerny, Michael T.
Decocq, Zachery A.
Erturk, Erol P.
Gloudemans, James M.
Gustafson, Robert I.
Haengel, Eric C.
Harwood, Robert J.
Houck, Matthew A.
Kagan, Max L.
Klamo, Timothy J.
Langfield, Samuel P.
Lehman, Landon K.
Matovina, Kevin P.
Monroe, Lyman K.
O'Beirne, Logan T.
Pace, Ryan D.
Park, Chan Soo
Phillips, Mitchell R.
Roark, Jacob B.
Sauer, Anne M.
Schuster, David R.
Seffrin, Sean P.
Specht, Aaron J.
Steele, Caitlin E.
Teasdale, Nolan D.
Turczi, Matthew A.
Zachman, Michael J.
Zukowski, Samual R.

Master of Science

Bairnsfather, Christopher A.
Fink, Michael K.
Garrelts, Richard P.
Hruby, Lorenz K.
Lorenz, John D.
Moody, Cristina I.
O'keefe, Daniel
Palenik, Mark C.
Steckloff, Jordan K.

Doctor of Philosophy

Alvarez, Jorge A.
Clausen-Brown, Eric R.
Fang, Chen
Kramer, Andrew R.
Lawrence, Tom M.
Potamianos, Karolos J.
Singh, Niharika R.
Woodruff, Thomas E.
Zhao, Yanjie

Congratulations to our newest alumni!

Recognizing Our Donors

We recognize and thank our alumni and friends who made gifts to the Department of Physics in fiscal year 2012 (July 1, 2011 - June 30, 2012).

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Artist conception of the Chicxulub impact. (Page 7)