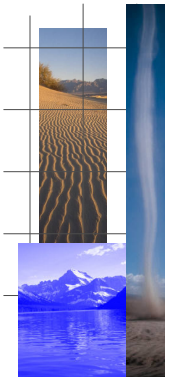


Schrödinger's Tiger

The Clemson University Physics and Astronomy Newsletter

Fall 2015 Volume 10, Issue 2

Physics Department Incorporated into New College of Science

In this issue:

Creation of the New College of Science

Chairman's Message

Terry Tritt Appointed Interim Physics Chair

Review of State-of-the-Art in Thermoelectrics

Carl W. Ulbrich 1932-2015

A Swift Response Matters

It's a Girl Thing!

Josh Alper Joins Faculty

CNC Hosts Two Conferences

Nano-Bio Lab Receives Major Research Grant

Graduate Students Showcase Research

Pioneering Research for Early Detection of Tuberculosis

Math Fun for Young Students

Department News

Dr. Mark Leising is Dean of the New College of Science

After twenty-one years in the College of Engineering and Science, Clemson Physics and Astronomy will move to the College of Science in 2016. We will join the departments of Biological Sciences, Chemistry, Genetics and Biochemistry, and Mathematical Sciences in the new college. This structure becomes official on July 1, 2016 for business, fiscal, and personnel matters, and after the August graduation for academic matters. The two Life Sciences departments are moving out of the College of Agriculture, Forestry, and Life Sciences. The present college structure emphasizes applications over curiosity-driven science, but Clemson University is making a renewed commitment to fundamental scientific research.

The apparent convergence of math and physical science principles and techniques with forefront problems in the science of living systems presents a significant opportunity for the new college.

These five units share not only core research values, but similar educational cultures as well. Mathematics and science general education courses, taken by every Clemson undergraduate, will be housed in the new college, as will the many service courses taken by all STEM majors. Seemingly inevitable enrollment increases have very similar impacts on all the departments in the College of Science. Graduate teaching assistants in these units are essential instructors in hundreds of laboratories, recitations, and lectures every semester.

The Chair of Physics & Astronomy, **Dr. Mark Leising**, has moved to Interim Dean of the College of Science as of December 1, 2015. He will oversee the development of budgets, tenure and promotion practices, bylaws, business and research services, and student advising over the next seven months. Leising joined Clemson in 1991 as an assistant professor. He held a Humboldt Fellowship from 1997 to 1998 in Garching, Germany. In 2011, he became Interim Chair of the university's Physics and Astronomy Department and was named Chair in 2013. He has directed Clemson's astronomy labs and the Clemson Planetarium since 1994. Moreover, Leising was inducted into the Thomas Green Clemson Academy of Scientists and Engineers in 2014.

Terry Tritt, professor of Physics and Astronomy, has taken over as Interim Chair. While Physics and Astronomy has fared well in the College of Engineering and Science, with many productive collaborations with researchers, the faculty regards this change as a significant opportunity for new directions and improved support for the department.

A Message from the Department Chair

Change is coming to Clemson Physics and Astronomy. The creation of a new College of Science is the most significant element of the university's college reorganization plan. There are both opportunities and risks for Physics and Astronomy in this plan. We will move from the largest college to a relatively small one, with four other like-minded departments. Most of the essential work of the university: teaching, research, and service, are accomplished by the faculty in departments. Colleges, at their best, simply facilitate this work. It is becoming clear that the new college will have to be constructed over the next several months mostly by the faculty and leadership of the Science and Mathematics departments, rather than by the central administration. This will be a challenge in our environment of limited resources, but we will have the opportunity to define our priorities and values. We learned from the previous reorganization twenty-one years ago that for a sound department to thrive a reasonably well-organized college can be more important than shared philosophy. Now we have a chance to develop both.

We have enjoyed a successful run in the current College of Engineering and Science, including many fruitful collaborations with researchers who will remain in CoES. We expect to continue those, and to develop new and stronger connections to our Life Sciences units. Watch this space to see how it turns out. At least the next few Chair's messages will be authored by **Terry Tritt**, who is taking over as Interim Chair.

Dr. Mark D. Leising, Chair
Voice: (864) 656-3416
email: lmark@clemson.edu

Creating a Legacy — Giving to Clemson Physics & Astronomy

You can create a lasting legacy through your donation to the Clemson University Physics and Astronomy Department Foundation. Endowments to Clemson assure the best faculty, the brightest students and the most creative research projects. A substantial endowment can transform a good university into a great one. As a non-profit organization, the Foundation is exempt from federal income tax under Section 501(c)(3) of the1986 Internal Revenue Code, as amended. The Foundation has been classified by the IRS as a public charity operated for the benefit of a state university as defined in the Internal Revenue Code of 1986 Section 170(b)(1)(A)(iv). Contributions to the University through the Foundation by individuals, corporations, organizations and other foundations qualify as tax deductions.

There are several ways to donate. You may use the enclosed envelope or send a check to the Clemson University Foundation, P.O. Box 1889, Clemson, SC 29633. Checks should be made payable to the Clemson University Foundation with Physics and Astronomy specified on the memo line. Alternately, you may visit the Clemson website: **http://www.clemson.edu/giving/how/** and make a secure electronic donation. Again, please specify that the donation go the Physics & Astronomy Department and indicate to which project you would like to donate.

Thank you, as always, for your continued support of the Department. You may contact the Annual Giving Office at (864) 656-5896, should you have any questions regarding your donations. If you have other questions you may contact the Department directly at (864) 656-3416.

Dr. Terry Tritt Appointed Physics and Astronomy Interim Chair

On Friday December 11, 2015, **Dr. Mark Leising**, Physics Chair and **Anand Gramopadhye**, Dean of the College of Engineering and Science, announced that **Professor Terry Tritt** will assume the leadership role as Interim Chair in the Department of Physics and Astronomy, effective immediately, noting his scholarship in the field of thermoelectric materials, as well as having been an inspiring mentor and teacher to many graduate and undergraduate students at Clemson.

Tritt is an Alumni Distinguished Professor of Physics at Clemson University. This is one of eighteen such positions supported by the Clemson University Alumni Association and awarded to faculty who exemplify the highest qualities of service to the university and students, while also exhibiting international standing in their field of research.

Dr. Terry Tritt assumes the helm of the Physics and Astronomy Department.

Tritt is a graduate of Clemson University, obtaining his B.A. in 1980 and Ph.D. in 1985. He then served as a National Research Council Fellow at the Naval Research Laboratory (NRL) in Washington, DC (1985-1989) and then as a Research Physicist at NRL from 1989 until 1996, before joining the faculty at Clemson University in August of that same year.

The focus of his current research centers on materials for thermoelectric (TE) refrigeration and power generation applications. His primary research expertise lies in electrical and thermal transport properties and phenomena (a special focus in measurement and characterization techniques) in new and novel materials, especially thermal conductivity. His recent activities are focused on the synthesis and characterization of TE nanomaterials and nanocomposites and investigation and characterization of their parameters, especially thermal conductivity.

Tritt has served as a symposium organizer of four Materials Research Society Symposia on Thermoelectrics Materials (MRS Volumes 478, 545, 626 and 1044) and has served as an author and lead editor of a MRS Bulletin Theme (March 2006) on Thermoelectric Materials and Devices. He edited a three-volume set on "Recent Trends in Thermoelectric Materials Research" (Academic Press-2000) and has also edited a book by Kluwer Press in 2004 on thermal conductivity (still in press, on Amazon). He has served several terms as a member of the Executive Board of the International Thermoelectrics Society (ITS) (1999-2008 and 2010 to present) and served as Chairman and host of the 24th ITC-2005 at Clemson in June of 2005. He was elected as an Academy Fellow and Vice President of the International Thermoelectrics Academy. In 2008, he was selected as the SCAS Governor's Research Professor of the Year and the Clemson University Alumni Award for Outstanding Achievement in Research. In Spring of 2009, he served as one of four Materials Research Society's Meeting Chairs for the annual MRS Spring Meeting in San Francisco that hosted over 5000 scientists from all over the world. He recently served as a guest editor for a *Focus Issue of the Journal of Materials Research* (JMR) on advances in thermoelectric materials (August, 2011) and is currently working on another (for Sept. 2015). He holds positions as a Guest Professor at Zhejiang University and Wuhan University of Technology, both in China. In 2012, he was elected a Fellow of the American Physical Society. He has written over 150 refereed journal publications, and regularly gives invited presentations at national and international meetings, as well as many university seminars. His hobbies include: golf, bluegrass guitar and mandolin (he has cut five CDs), target shooting, hunting and fishing, along with enjoying spending time with his five granddaughters.

The cover shows a triangle illustrating thermoelectrics from a complex crystal structure to a thermoelectric device. Courtesy of Dr. Yongkwan Dong, the University of South Florida.

Focus Issue of the Journal of Materials Research Reviews State-of-the-Art of Thermoelectric Materials

Terry M. Tritt, the new Interim Chair of Physics, **Ryoji Funahashi** of the National Institute of Advanced Industrial Science and Technology in Osaka, Japan, and **Harald Böttner Fraunhofer** from the Institute for Physical Measurement Techniques in Freiburg, Germany have collaborated as guest editors of the *Focus Issue of the Journal of Materials Research*, published on September 14, 2015.

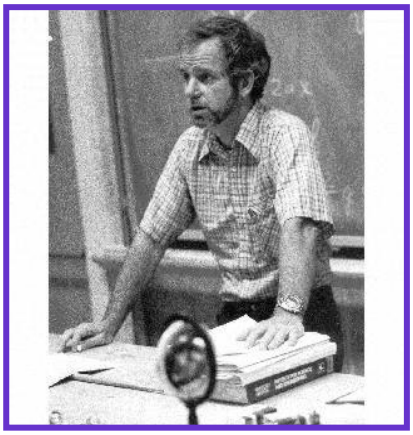
This is the second issue of the *Journal* and is a follow-up to the first edition published in August of 2011. That Focus issue captured a snapshot of the research performed at that time. Much of the importance of thermoelectric materials research that was discussed then is still relevant today, especially in the area of world abundant and cost-effective materials. In this *JMR Focus Issue: Advances in Thermoelectric Materials II*, the editorial team has tried to capture a portion of the broad spectrum of the research in thermoelectric materials that has evolved over the past four years. Many new materials (such as the silicides) have become significant due primarily to their world abundance and as cost-effective materials.

In addition, many new advances in nanomaterials and nanocomposites have become evident. The use of Spark Plasma Sintering or (Electric Field Assisted Sintering) has indeed played a very important role in the synthesis of fine powdered and highly densified bulk materials and/or nanocomposites. Dr. Tritt and his collaborators hope the readers will find this volume a significant collection of papers representing the rapid advancement in the field of thermoelectric materials.

The last twenty years have seen the Figure of Merit for thermoelectrics double. This has resulted from a much better understanding of ways to reduce thermal conductivity such as "rattler atoms" and nanostructuring methods. Tritt believes that future advancement will be from improvements on electronic properties. He has found that thermoelectric materials research has been a great teaching tool for graduate students in preparing them for the workplace. They are involved with measurements and understand the thermal conductivity of materials, as well as the characterization of electronic properties of semiconductors. In addition, they are typically required to understand structure property relationships and perform scanning electron microscopy in order to correlate the materials properties to their inherent microstructure. In order to perform thorough research in thermoelectric materials, a complete understanding of the interaction of Solid State Physics, Solid State Chemistry and Materials Science is required.

Thermoelectric (TE) materials were first discovered or observed almost two hundred years ago by **Thomas Seebeck**. Interest was rekindled in these materials in the 1940s and 50s when **A. F. Ioffe** proposed the use of semiconductor thermoelements for TE devices. Subsequently, devices were developed for both TE cooling and power generation for many important applications. However, progress was slow. Then when the world's energy demands were pointed at renewables and electronics were becoming ever and ever smaller and compact the need for small scale solid state cooling and power generation was greatly increased. Consequently, TE materials research has experienced a dramatic rebirth over two decades ago and is still very vibrant today, as evidenced by the breadth of articles contained in this publication.

Department Mourns the Loss of Retired Faculty Member Dr. Carl Ulbrich (1932-2015)



Carl Ulbrich lecturing in his Physics of the Weather class

The Physics and Astronomy Department is saddened by the recent loss of **Dr. Carl Ulbrich**, who died December 6, 2015 after a long illness. He was 83.

In addition to his wife of 53 years, **Holley Hewitt Ulbrich**, he is survived by three daughters, **Christine Prado (Keith)** of Central, **Carla Ulbrich (Joe Giacoio)** of Somerset, New Jersey, and **Katrina Miller (Neil)** of Aiken; four granddaughters, **Abigail**, **Caroline** and **Samantha Miller** and **Isabella Prado**; a sister, **Thelma Kay Inderdohnen**; eleven nieces and nephews, and twenty grandnieces and nephews. He was preceded in death by a half-brother, **Robert Karcher**.

Carlton Wilber Ulbrich was born October 1, 1932, in Meriden, Connecticut to **Carl and Ruth Karcher Ulbrich**. He graduated from New Britain High School and received a B.S. in Mechanical Engineering and an M.S. and Ph.D. in Physics from the University of Connecticut. He served three years in the United States Coast Guard before starting college. He joined the faculty at Clemson University in 1966 as a professor of physics, where he taught and did research in radar meteorology and rainfall measurement. After his retirement in 1993, he continued his sponsored research through 2005. In 1997, he was honored as a Fellow of the American Meteorological Society.

Carl was an avid sailor and was active for many years in the Western Carolina Sailing Club. He also loved baseball, sports cars, photography, building furniture, playing the trumpet, being a husband and father and father-in-law and grandfather, and fixing things. He was passionate about science and the natural world, and used every opportunity to help people understand the science behind climate change and other environmental issues. He loved teaching, not just at the University but in the community: coaching youth basketball; teaching girl scouts carpentry and leatherwork and knot tying; guiding junior sailors through the doldrums; and serving on the board of the Clemson Child Development Center.

Carl was an active member of the Unitarian Universalist Fellowship of Clemson where he taught Sunday school, worked on the building and grounds, and served in a variety of leadership roles. His family and many friends knew him as a gentle soul with a quick wit, generous with his time and resources, who lived life to the fullest. A memorial service was held at the Unitarian Universalist Fellowship of Clemson on Friday, December 11th to celebrate his life. Memorials may be made to UUFC, 230 Pendleton Road, Clemson, or to the Clemson Child Development Center, 216 Butler Street, Clemson.

One of Carl's legacies is a research site in Fants Grove, six miles from campus, established for radar and raindrop size distribution experiments. His colleagues named it the Clemson Atmospheric Research Lab (CARL) in his honor. Research continues at this site, including **Dr. Miguel Larsen's** new radar systems and rocket payload tests. **Dr. John Meriwether** plans to deploy a Fabry-Perot Interferometer there, and student astronomy projects and measurements of the 2017 total eclipse of the Sun will also be conducted at the facility. The site is currently undergoing an upgrade, including improved security and ethernet connections, so CARL's research will continue into the foreseeable future.

(*Adapted from the Anderson Independent Mail Legacy.com*)

A Swift Response Matters

In the late sixties, the phenomenon of Gamma-Ray Bursts (GRBs) was discovered, and remained mysterious for decades. When Physics and Astronomy professor **Dr. Dieter Hartmann** used a Fulbright stipend in 1983 to study at the University of California at Santa Cruz, California, his mentor, **Dr. Stan Woosley** drew his attention to this topic. Hartmann continues to study this dramatic phenomenon to the present. During his graduate work, GRBs were believed to take place within our home galaxy. Since he joined Clemson in 1991 the field has advanced, and Hartmann and other researchers have realized that GRBs are associated with very violent explosions that occur throughout the Universe.

Light from GRBs that leads to their discovery is, as the name indicates, predominantly emitted in the part of the electromagnetic spectrum that is higher in energy than X-rays. These bursts last only for seconds and originate in random locations on the sky, about once per day. These properties require a wide field of view detectors in space, and, thus, NASA has had a leading role in many of the related observations. In fact, the high-energy sky is highly variable and exhibits transients from many different object classes, including black holes, neutron stars, white dwarfs, novae, supernovae, and active galaxies. Currently there are two NASA space missions that contribute the bulk of the observations in this field: Swift (launched in 2004) and Fermi (launched in 2008).

When a mission is past its design period, (typically a few years), NASA reviews its performance every two years. This requires that the mission team must submit a report, describing the status of the instruments and outlining past successes and plans for future observations and the scientific questions these address. Hartmann serves as the Chair of the Users Group of the Swift mission, and with the mission Principal Investigator, **Dr. Neil Gehrels** of the Goddard Space Flight Center (GSFC), he organized a conference in Clemson to prepare for the presentation to NASA.

This two-day conference began on October 19, 2015 at Clemson and brought together scientists working on topics from time domain astronomy, (especially those who have who have had Swift GI programs), as well as those who have made use of Swift's ToO capacity and/or have participated in follow-up observations of Swift transients. The goal of the meeting was to discuss key science topics from Swift's successful past decade and to focus attention on opportunities for further improvements in its observing program and ToO strategies. A comprehensive analysis of the road ahead is extremely important considering that Swift is in its extended life operating phase and that the upcoming NASA Senior Review will present stiff competition.

Swift science crucially depends on the active role our community plays in the design of a vital scientific program. When Swift was launched in 2004, its prime objective was to chase GRBs. However, it was quickly realized that its multi-wavelength and fast scheduling capacity make it the most versatile mission ever flown. It is used for an impressive variety of targets: active galaxies, supernovae, novae, magnetars, tidal disruption events, variable stars, etc. Swift observed nearby solar system objects (comets), monitors the galactic center, and has reached out to explosive transients in the early Universe. The recent detection of a strong UV pulse from a newborn Type Ia supernova in a galaxy about 200 million lightyears from earth provided clear evidence for a particular scenario of this class of supernovae, an advance in our

(Continued on next page)

knowledge that was enabled by Swift's rapid response capabilities and a sophisticated network of ground-based facilities. The first meeting in this series was held in 2012, and this year it convened for the second time, again dedicating attention to the theme of time domain astronomy, as probed by high-energy space missions and ground-based observatories. Time domain astronomy is an exciting area of research, and Hartmann hopes that NASA will continue supporting Swift and Fermi, as these two missions are the workhorses of the field. Many researchers and students depend on them for the creation of new insights into the violent aspects of the Universe, to which we ultimately owe our existence.

"It's a Girl Thing!"

As part of the outreach effort of Women in Science and Engineering (WISE), "It's a Girl Thing" is an educational activity focused on familiarizing middle school girls with all the science and engineering fields (STEM). **Ms. Emily Thompson**, a Clemson physics senior, recently participated in such an event organized at McCants Middle School in Anderson, South Carolina. She gave a PowerPoint presentation about the importance of physics among fundamental sciences, about influential women physicists and some other interesting facts from her experience as an intern at CERN in Geneva, Switzerland over the summer. The presentation was followed by a captivating practical demonstration that showcased liquid nitrogen as a frigorific agent in freezing flowers, that the participants tested for hardness, and ice cream making, an application that everyone got to enjoy.

Emily Thompson (left) and an aspiring scientist at girls' science outreach program

Emily answered many interesting questions related to the relevance of physics in academic areas outside science, such as medicine and finance. WISE will continue the "It's A Girl Thing" program throughout the year, visiting two local high schools every month, and focusing on a different STEM field each month.

Josh Alper has joined the P&A faculty.

Josh Alper Joins Faculty of Physics and Astronomy

Dr. Josh Alper has joined the Physics and Astronomy Department as an assistant professor. Most recently, he held a postdoctoral position in the Department of Molecular Biophysics and Biochemistry at Yale University. Previously, he worked as a post-doc at the Max Planck Institute of Molecular Cell Biology and Genetics in Dresden Germany. He received his Ph.D. in Mechanical Engineering from MIT in 2010.

In his lab, Alper and graduate students **Rachel Andorfer**, **Subash Godar**, and undergraduate **Donovan McKinley** focus on molecular motor proteins, including the kinesin, myosin and dynein families, that are mechanoenzymes that convert chemical energy to mechanical work. They are critical for muscle contraction, cell division, cell migration, and intracellular transport. The goal is to understand the fundamental physics that underlies the action and coordination of molecular motors and the complex biological systems that use them. The research group takes multiple experimental approaches including: optical tweezers; high resolution microscopy; in vitro biological reconstitutions; forward engineered biophysical systems; and, mathematical and computational modeling. Alper's hope is to answer questions in molecular biophysics and to develop strategies to engineer biology, thus enabling the development of novel therapeutics for human pathologies.

the Podila group will explore nanomaterial physicochemical properties and establish signaling pathways in the mast cell response to nanomaterials, while the Brown group will elucidate the role of genetics in mast cell responses to nanomaterials.

A knowledge of the underlying mechanisms will allow design better models and in vitro screening tools to predict nanotoxicity, which will be important for risk assessment. More importantly, the physicochemical properties that lead to mast cell degranulation will be leveraged to engineer nanomaterials to prevent allergic/mast cell responses to nanomedicine.

Graduate Students Showcase Research at Fifth Annual SIRPA Conference

Graduate student Wren Gregory explains her research to fellow student Nicholas Underwood.

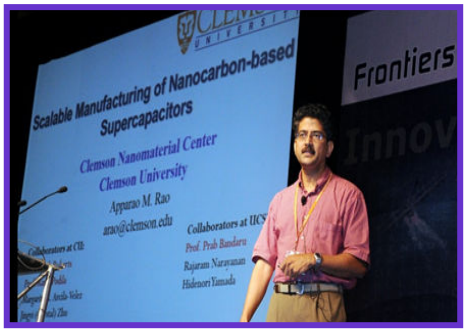
The Fifth Annual Symposium for the Introduction to Research in Physics and Astronomy was held on Monday, August 17, 2015 at the Madren Conference Center. This year's keynote speaker was **Dr. Eric Ford** of Penn State University. In his talk, "The Quest for Earth-Like Planets," Dr. Ford spoke about his pioneering work in exo-planet detection and the diversity of planetary systems discovered by NASA's Kepler space telescope. Faculty members, graduate students, and undergraduate students gave a wide variety of talks at this year's SIRPA. Highlights included senior **Emily Thompson's** presentation on her summer work on the ATLAS trigger and data acquisition system at CERN, **Amber Porter's** talk on the spectropolarimetry of thermonuclear supernovae, and **Dr. Gerald Lehmacher's** discussion of measurements of mesospheric turbulence. New faculty member **Josh Alper** gave a fascinating overview of his plans to measure piconewton forces of molecular motor proteins. Additionally, sixteen students presented posters on their work in their various fields of study.

A number of firsts for SIRPA occurred this year. A lunchtime Physics Jeopardy tournament pitted three teams of two against each other. Graduate students **Andrew Garmon** and **Adithya Kandhadai** took home the grand prize in the inaugural event. The inaugural award for Outstanding Student Talk went to graduate student **Anthony Childress** for his talk, "Exploiting Nano-Scale Physics for Improving Materials Performance," which was judged the best among several truly outstanding student presentations.Graduate student **Joe Denison** was in charge of planning and running the event. He had great help and support from **Amanda Ellenburg**, **Nick Underwood**, **Ethan Kilgore**, **Jessica Denison**, and many others to make this another hugely successful display of department research.

At right: Dr. Sean Brittain explains the size of the Universe to SIRPA attendees.

Clemson Nanomaterials Center Hosts Two Conferences

Dr. Apparao M. Rao led the efforts in organizing two major conferences in India in December 2014 and June 2015. An international conference on "Frontiers in Nanoscience, Technology and Applications" (FiNSTA '14) was held in December 2014 at the Sri Sathya Sai Institute of Higher Learning, India as the second in a series of international conferences conducted by the Conference Development Center, India. FiNSTA '14 brought together a diverse nanoresearch community from nine countries and forty-five institutions to showcase the latest in nanoresearch to industry and academia, and provide a forum through which the nanoscience community may collaborate to develop futuristic and sustainable nanotechnologies. Though FiNSTA '14 was intended for all stakeholders of nanoresearch, a majority of the participants included researchers from academia, national labs and industries, teachers and students.



Dr. Apparao M Rao presents the keynote address at FiMPART '15. The National Institute of Advanced Studies, India, intends to use the CNC as a case study for nanomanufacturing of energy storage devices.

Clemson professors Drs. Rao **and Ramakrishna Podila** chaired the scientific organizing committee. Rao and **Dr. Deepika Saini** (former PandA student) served as guest editors for a special issue of *Nanotechnology Reviews* (NTREV), which published peer-reviewed proceedings of FiNSTA '14.

In June 2015, Rao also led the nanomaterials focus session of "Frontiers in Materials Processing, Applications, Research, and Technology" (FiMPART '15). FiMPART is the first of its kind to cover all major areas of materials research under a common platform. The meeting and discussions in this conference were targeted at enabling innovation. Over 350 participants from forty-seven countries participated in FiMPART and covered various aspects of materials research, processing, fabrication, structure/property evaluation, and applications of ceramic, polymeric materials, biomaterials, materials for energy, aerospace structural materials, bulk metallic glasses and other advanced materials. The scalable nanomanufacturing research carried out at Clemson Nanomaterial Center (CNC) was one of the highlights of FiMPART '15. **Dr. Baldev Raj** (scientific advisor to the Prime Minister of India) invited CNC to publish its research and development activities as a chapter in a book "Nanotechnology for Energy Sustainability." The National Institute of Advanced Studies, directed by Raj, intends to use CNC as a case study for nanomanufacturing of energy storage devices.

Nano-Bio Lab Receives $1.9 Million to Explore Nanotoxicity

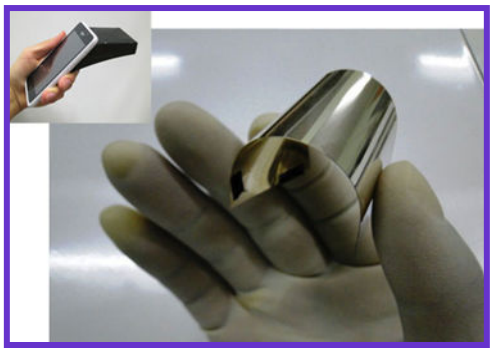
The Clemson Nano-Bio Lab led by **Dr. Ramakrishna Podila** was recently awarded $1.9 million dollar grant through a National Institutes of Health R01 to explore mast cell activation by nanomaterials. This project will be undertaken in collaboration with **Dr. Jared M. Brown** at the University of Colorado, Denver. Nanomaterials research and development continues to grow rapidly, but the health and safety of nanomaterials still remains a major concern to the public as well as to policy makers and funding agencies. While there has been considerable investigation into the properties of nanomaterials that elicit toxicity, little work has focused on the ability of nanomaterials to promote or exacerbate allergic disease. Mast cell activation, which is central to the development of allergic disease, has been an impediment for a number of pharmaceuticals and represents a challenge for nanomedicines. In this regard, as a part of this project,

(Continued on next page)

Smartphone-based Nano-biosensors Developed at Clemson for Early Detection of Tuberculosis

Tuberculosis (TB) is a widespread infectious disease caused by M. Tuberculosis (MTB), which most commonly affects the lungs, but can also attack other body parts. It is estimated that one-third of the world's population is infected with M. tuberculosis at least once, and new infections continue to occur in about 1% of the population each year. More than 80% of TB infections come from underdeveloped/ developing communities that lack easy access to health care providers.

A typical preliminary test for TB includes culturing the samples for at least one to two weeks in a lab, followed by examination under a fluorescence microscope. The lack of rapid, accurate, and inexpensive point-of-care tools for detecting low amounts of M. Tuberculosis is a critical bottleneck in early diagnosis and appropriate treatment.



Silver and fullerene coated cellulose-acetate sensors are flexible and could be used to detect tuberculosis in early stages. The inset shows a smartphone-based detection scheme for use in point-of-care settings.

The Clemson Nano-Biophysics Lab has developed a rapid and flexible nano-biosensor for diagnosing TB in early stages using smart phones. **Ramakrishna Podila's** group reported their findings in the September 8, 2015 online edition of *Physical Chemistry Chemical Physics* (Phys. Chem. Chem. Phys., 2015,17, 25049-25054). These inexpensive biosensors are fabricated by coating thin films of silver and fullerenes (spherical carbon cages, also known as the buckyballs) onto a flexible cellulose acetate substrate. In these sensors, the isotropic fluorescence from dye-stained bacteria can be coupled to the silver-coated cellulose substrate using surface plasmons. The emission from the dye is observed by taking a picture with a smartphone camera attached to a simple diffraction grating made from compact discs.

The intensity of the emission recorded by the smartphone provides information on the density of bacteria and, thus, the stage of the infection. These new findings show that surface plasmons, when coupled optimally through fullerenes, boost the efficiency to levels where even a single bacterium could also be detected.

"The isotropic nature of fluorescence is a major limiting factor in today's sensors," notes **Bishwambhar Sengupta,** a graduate student in the Podila Lab, who was a part of this study. "We previously showed that the concept of surface-plasmons could be used to collapse the otherwise isotropic emission into a directed emission to boost the efficiency. We built on this surface plasmon directed emission to detect bacteria such as MTB even at low densities as in the early stages of the disease."

Although surface plasmons have been known for at least two decades, a major challenge in coupling it to fluorescence from dyes has been the absence of efficient spacer layers. An optimal distance between the dye and silver films that exhibit surface plasmons is necessary to achieve high-signal enhancements. "We have been looking for the best spacer layer with a controllable thickness to enhance the coupling," says Podila, who was the principal investigator in this project. "We realized that graphene and fullerenes are the best choice. In fact, they not only provide optimal spacing but also protect silver films from oxidation. This enhancement allows us to use a simple camera app on a smartphone to capture vital information about the progression of the disease."

In addition to detecting TB, the team showed that these sensors could be used as forensic tools for sensing body fluids such as semen in crime scenes. Most of the on-field diagnostic tests (such as UV-illumination) for detecting semen are presumptive; however, the plasmon-based sensors developed in this study can selectively identify semen over other body fluids such as saliva and urine. These flexible sensors could also be used as swabs to collect samples in crime scenes. The team hopes that these sensors could be used for forensic purposes or point-of-care sensing in resource-limited settings to effectively diagnose and, thereby, prevent and cure new TB infections. This project was partially supported by a grant from Haworth, Inc. for developing nanomaterial-based antibacterial agents and bacterial sensors.

Physics and Astronomy Whips up Some Math Fun for Young Students

Graduate student Jeremy Capps whipped up some liquid nitrogen ice cream for the winners at the 2014-2015 awards ceremony.

For the past two years, under the sponsorship of Clemson University through a Creative Inquiry grant, the Department of Physics and Astronomy has organized math contests for K-12 students. These events are designed to promote interest in advanced mathematics and science in a friendly atmosphere of competition and fun. Each year we are happy to welcome more and more participants and are excited by the increasing interest.

Over three hundred students in grades 1 through 12 participated in the competitions organized by us during the 2014-2015 academic year. First, in November 2014, 96 middle schoolers competed in the AMC 8 competition, with several scoring high enough to quality for national recognition.

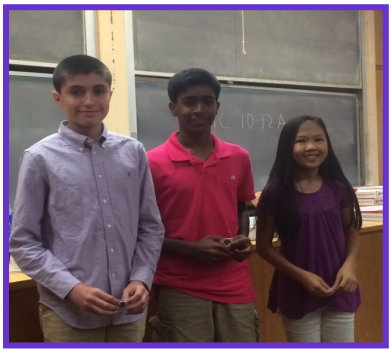
In March 2015, we hosted our largest even so far, MathKangaroo, where 120 students as young as first grade battled it out.

National and state-ranked students were honored in a special end of year ceremony, where they were awarded prizes in form of science college textbooks generously sponsored by **Mr. David Murch**, the Pearson publishing representative on campus.

Under the guidance of **Dr. Jason Brown**, the contest manager, thirty undergraduate students from Physics and other departments , as well as several physics graduate students with interests in outreach, actively participated in organizing the event, from designing the t-shirts promoting the competition to proctoring the test.

Physics graduate student **Andrew Garmon** led several practice sessions with middle schoolers that proved to be very well attended by test takers. The kids found the events fun while the parents appreciated the impeccable organization and the smooth flow of activities.

If you have children interested in upcoming mathematics competitions at Clemson University, please do not hesitate to contact Dr. Jason Brown (brown6@clemson.edu).



Winners of the 2014 AMC8 with their pins of distinction

The Clemson University Physics and Astronomy Newsletter

118 Kinard Laboratory
Box 340978
Clemson, SC 29634-0978

Tel: (864) 636-3416
Fax: (864) 656-0805
E-mail: hdebra@clemson.edu

CLEMSON
PHYSICS AND ASTRONOMY

We're on the Web!
physics.clemson.edu

Nonprofit Organization
U.S. POSTAGE PAID
Clemson, S.C.
Permit No. 10

Department News

Congratulations to Dr. Marco Ajello and is wife, Lyudmyla Tsykalova, on the arrival of their new baby, Maria Duilia. Maria was born on December 9, 2015.

Slaven Radic, who graduated in the summer of 2015, has accepted a post-doctoral appointment at the City University of New York (CUNY).

Professor John Meriwether is on leave to the National Science Foundation as Director of the Geospace Facilities Program in the Division of Atmospheric and Geospace Sciences.

Dr. Jens Oberheide has been promoted to full professor of Physics and Astronomy. Jens is a professor of atmospheric physics with a specialty in satellite data analysis, climate and weather of the Sun-Earth system, and atmospheric tides.

To subscribe or unsubscribe to *Schrödinger's Tiger*, please go to our mail list at: **https://lists.clemson.edu/mailman/listinfo/panda-newsletter**

*****Please recycle*****