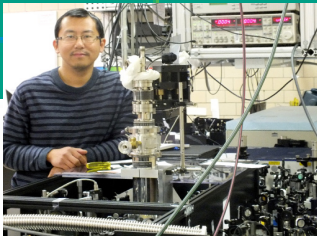


Cosmic
Symphony



Quanta AND
Cosmos
Iowa State Physics and Astronomy Department Newsletter



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Frank Krennrich

A message from the chair



As spring semester 2015 comes to a close and our beautiful campus begins to turn green, our faculty are preparing for their summer months filled with research, scholarly activity and travel. It has been 7 years since you last received a newsletter from us, therefore a brief update on the department is long overdue.

Our departmental research and education community now includes approximately 100 undergraduate physics majors, 90 graduate students, 40 post-doctoral associates, 32 staff members, 8 lecturers and 36 tenured/tenure-track faculty members.

The faculty continues to be highly international; my colleagues come from 19 different countries (Australia, Canada, China, Columbia, Germany, Greece, Hong Kong, Israel, India, Italy, Japan, Nepal, New Zealand, Poland, Russia, Spain, Venezuela, the United Kingdom and the United States) and bring a wealth of cultural and professional experience from many renowned research institutions to Iowa State.

After a year of intense academic searches, 3 new junior faculty will be joining us in FY2016: Zhe Fei from Argonne National Laboratory will be building a research program in experimental mesoscale physics; Xuefeng Wang from the University of Illinois will be joining our biophysics group; and Matthew Wetstein from the University of Chicago will be expanding Iowa State's research effort in experimental neutrino physics.

Our research footprint in high-energy, nuclear, astroparticle and astro-physics covers research laboratories around the world, including CERN (Geneva, Switzerland), Brookhaven National Laboratory (Long Island, NY), Fermilab (Batavia, IL), Argonne National Laboratory (Lemont, IL), the Smithsonian Astrophysical Observatory (Amado, AZ), the Kepler and Spitzer observatories in space, and more recently the SOFIA observatory flying in the stratosphere on a modified Boeing 747 over the Pacific Ocean.

Locally, our condensed matter physics research continues to be well integrated into the Ames Laboratory infrastructure. In spring of 2013, the Critical Materials Institute, a Department of Energy Innovation Hub, was established to study rare-earth materials relevant to applications such as efficient lighting, wind energy and hybrid vehicles. In 2015 we expect the Sensitive Instrument Facility to open and host state-of-the-art instruments to study and characterize materials at the atomic scale.

Our faculty continue to be recognized for their excellence nationally and internationally. Costas Soukoulis won the Max Born Award 2014 and Paul Canfield received both the David Adler Lectureship Award 2014 and a Humboldt Research Award. In 2012 Mayly Sanchez received the Presidential Early Career Award in high-energy physics. Additionally, Serge Bud'ko, Paul Canfield and Costas Soukoulis were listed among the World's Most Influential Scientific Minds 2014 by Thomson Reuters.

A recent event serves as a reminder of the intangible benefits of the intellectual and creative life on a university campus. A collaboration between the Department of Music and astrophysicist Curt Struck led to a multimedia production of Gustave Holst's orchestral suite *The Planets*. The concert was preceded by a filmed lecture and synchronized with dramatic images of our solar neighborhood.

Public outreach is essential in communicating the excitement of scientific discovery. It is important to explain to the general public the intellectual process of gaining and testing knowledge, and it is equally important to articulate our mission to perform world-class research and to educate students.

In order to capture the imagination of the next generation of students, and to excite the campus community and the general public about discoveries in modern physics, a key departmental goal is to establish a prestigious lectureship, the *Zaffarano Lectureship*. This lectureship will be awarded on a yearly basis to a scientist who has made ground-breaking contributions to physics and/or astronomy. The named lecturer will visit our department to meet with faculty, students and alumni and give a public lecture.

I hope you will find the following pages informative and exciting. Please send me comments or suggestions that you might have for future issues of this newsletter.

Frank Krennrich
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MAX BORN AWARD FOR **SOUKOULIS**

In April 2014 the Optical Society of America announced their Max Born Prize would be awarded to Costas Soukoulis, Frances M. Craig endowed chair and Distinguished Professor in condensed matter physics. He is an associated member of IESL-FORTH in Greece. This award honors a scientist who has made outstanding contributions to the field of physical optics. The award committee cited Soukoulis for his “creative and outstanding theoretical and experimental research in the fields of photonic crystals and left-handed metamaterials.” The award was established in 1982, the centenary of Born’s birth, and honors the contributions of Max Born to optical physics.

For his work in meta-materials, Soukoulis has previously received the senior Humboldt Research Award, the APS McGroddy Prize, shared the European Descartes Prize, and is a fellow the APS, OSA, and AAAS. He is also an associated member of IESL-FORTH (Institute of Electronic Structure and Lasers), an Institute of the Foundations for Research and Technology-Hellas in Crete.

PROFESSOR CANFIELD’S **Hat Trick**

Paul Canfield, professor in condensed matter physics and a leader of Ames Lab working groups, has collected several prestigious awards recently. The first of these awards, announced last year, was the David Adler Lectureship Award of the American Physical Society. “The award recognizes outstanding materials physicists who have made noted contributions through their research, review articles and lecturing.”

Last August, Professor Canfield was also announced as a winner of a five-year, \$1.7 million Moore Materials Synthesis Investigator award from the Gordon and Betty Moore Foundation of Palo Alto, California. This award will benefit his team’s research “in the discovery of new electronic and magnetic compounds, and the study of their electrical, magnetic and thermal properties,” according to the LAS College press release.

The most recent award presented to Canfield is the Humboldt Research Award (or the Humboldt Prize), given by the Alexander von Humboldt Foundation. This prestigious and competitive award, given only to a small, select few each year in physics, will provide funding for collaborative work in Europe. Previous recipients of this award include Iowa States’ own Prof. Costas Soukoulis.



IS IT A *Bird*, IS IT A *Plane*? IT'S A *Star*!

A new celestial object

Even the familiar Milky Way, looks different when you look at the sky with new eyes. The new eyes that Professor Charles Kerton has been using are the cameras on the Spitzer Space Telescope, which 'see' in half a dozen mid-infrared bands. The images from each band, which we cannot see, are assigned a corresponding optical color and combined in multi-color images. These images can then be scanned to find the mid-infrared equivalent of optical structures or new objects. The Spitzer field of view is relatively small, while the Milky Way

occupies a lot of sky, so Spitzer's surveys generated tens of thousands of images.

The task of solving this problem was given to the citizen science Milky Way Project under the auspices of the Zooniverse group. The citizen scientists classified a variety of objects, but noticed a particularly eye-grabbing type - bright, yellow fuzzy balls. Although not large, they are easily visible on large-scale Spitzer mosaics of the Milky Way. Intrigued, Kerton and collaborators took on the mystery.

They cross-matched with positions of other catalogued

objects, determined their luminosity, sizes, and quantitative multi-band colors. And what is the result of these forensics? Yellowballs seem to be a characteristic stage in the early life of stars 10-40 times as massive as the Sun. This phenomenon is analogous to the optical emission line bright Stromgren spheres that surround massive stars later in their lives. The discovery promises to help astronomers better understand the early evolution of these stars and of their interstellar birth clouds.



Photo Credit: Astronomy Picture Of The Day NASA; Charles Kerton ISU



The Force Is Strong With This One

John Lajoie, surrounded in his office by Star Trek posters and a few space hero action figures, recently made the case for nuclear physics research and the multi-million-dollar experiments and huge collaborations it takes to make discoveries.

Of course, said the Iowa State University professor of physics and astronomy, big physics experiments such as PHENIX at the U.S. Department of Energy's Brookhaven National Laboratory in Upton, New York, will tell us about the building blocks of the universe. In the case of PHENIX, physicists are learning about the structure, characteristics and energy inside each and every proton.

What we're doing is

studying what makes up the matter in the universe that we can see," said Lajoie. (It sounds French, Laj-wah.)

But there's a lot more that can come from colliding protons and gold nuclei then studying the particles that fly off, he said.

The PHENIX Experiment, for example, uses these collisions to learn about the strong nuclear force that binds the three quarks inside a proton and the protons and neutrons in the nuclei of atoms. Lajoie said understanding and harnessing that force could revolutionize our lives, just like understanding the electromagnetic force harnessed electricity and, eventually, put smart phones in our pockets.

"We mastered one of the

forces of nature and put it to use," Lajoie said. "Now, with the strong force, we're still very much at the beginning, but there is enormous potential."

Over time, as experiments produce more data and better understandings, Lajoie said the scientific yield could include new technologies. Researchers, for example, could engineer super-heavy nuclei that could be used for the rugged spacecraft shields required for long-distance space travel.

Symphony

A Starry Composition

It was an unusual December evening in the auditorium. Fantastic astronomical images swirled across the screen above, with their emotional impact amplified by lush, beautiful music. No, it wasn't a screening of "Interstellar" at "Movies 12" on Duff Avenue, which was pretty cool too. It was a performance of Holst's "The Planets" by the ISU Symphony. The visuals were courtesy of the students of the ISU Planetarium outreach group, led by graduate students Alan Hulsebu and Jill Neeley. The animations were carefully selected from public, mostly NASA sources, and scripted in many hours of

work, to fit the mood and tempo of Holst's masterpiece.

The project began with a coffee-at-the-hub meeting between Professor and Conductor Jacob Harrison, astrophysics Professor Curt Struck, and music Professor Julie Sturm. For weeks in advance of the performance, the Planetarium group worked with students in Dr. Sturm's junior/senior level music composition class to learn about Holst's composition and how the dramatic music might relate to the drama of discovery planetary science. The final product included a filmed lecture on these topics by the students that was shown

at the beginning of the concert. There is an element of reinvention in this, since Holst was originally inspired by his astrological beliefs, but the participants like to think that like the audience, he'd be pretty inspired by the science too!

As a side note, this has been a very successful year for the Planetarium group. These students volunteer their time to give monthly public outreach shows in the Planetarium, along with outdoor observing. The January show, featuring Comet Lovejoy, drew about 100 participants.



Massimo Marengo

Observing With **SOFIA**

Once we agree that the Moon is not made of Swiss cheese, it becomes pretty clear that something violent must have happened in the lunar past. Many of the craters that pepper the surface of our satellite were formed when the Earth-Moon system was less than 800 million years old, in a cataclysmic event called the Late Heavy Bombardment. During that phase the celestial spheres skipped a beat and the sky, quite literally, fell: icy comets and asteroids were swung towards the rocky bodies orbiting the inner Solar System, bringing destruction but also drenching their parched surfaces with water. The same event that transformed the Moon into a block of Emental cheese was the harbinger of life on Earth, and likely occurred in other systems.

At first sight, it may not seem like a practical idea. Taking a big airplane, opening a huge hole in the back, bolting a large telescope into it, and then flying with the door open? Why would anybody dream anything like that?

The answer can be condensed in one word: water. Or rather, the lack of it.

Water may be the elixir of life, but astronomers, as it turns out, are not very fond of it. And this is not because of the many squalls guilty of ruining countless observing nights. It is because water molecules are naturally tuned to absorb infrared light, that part of the electromagnetic spectrum discovered by William Herschel beyond the deepest reds in the rainbow. And astronomers love infrared radiation, because it gives us the unique chance of studying the most elusive subjects in cutting-edge astrophysics research: planets and planetary debris surrounding the Sun and other stars, newborn protostars still hidden in their natal cocoons, dying stars enshrouded by

their dusty winds. While these objects are often too dim to detect in visible light, they are copious emitters of thermal radiation, carried through space in the form of infrared light. It is to reveal the hidden secrets of these infrared sources that astronomers place their telescopes in the driest locations on Earth, blessed by unhindered access to the infrared photons coming from the heavens. The high deserts of Chile and the American Southwest, and the summit of volcanic mountains in the middle of Earth's oceans, offer the best compromise between the needs of infrared astronomy and practical accessibility. The ice dome of Antarctica (9,000 ft. thick at the South Pole) is even dryer (all water vapor is frozen), but is challenged by prohibitive environmental conditions. Deep space is the ideal location for parking infrared telescopes, but the size and weight of their mirrors, as well the possibility of repairs after launch, are limited by current technology and cost.

Enter SOFIA, NASA's Stratospheric Observatory For Infrared Astronomy. A wide-body Boeing 747 cargo aircraft, SOFIA serves as the flying platform for a 2.5-meters primary mirror telescope, designed to capture the infrared sky from the stratosphere. SOFIA's cruising altitude tops at 45,000 ft. - significantly higher than even long-haul transoceanic flights (typically flying at 35,000 ft. and only rarely climbing to 40,000 ft.). At that height the air is very thin and, with a water vapor column reduced by 99% with respect to the ground, almost transparent to infrared radiation. This allows infrared observations at wavelengths that cannot be reached from the surface of Earth, or even from the icy deserts of Antarctica. From SOFIA's stratospheric

platform the “infrared window” is wide open, up to a wavelength of 240 microns: ground-based telescopes rarely achieve observations beyond 20 microns. Its suite of 7 scientific instruments are designed to collect images and spectra in space-like conditions, but with the advantage of flying home at the end of each night, where they can be repaired and upgraded as necessary. The ability to continuously service the system



SOFIA on the tarmac of the Dryden Aircraft Operation Facility, ready to take off.

is one of the main selling points of SOFIA with respect to space telescopes of equivalent capabilities. A human crew servicing SOFIA's telescope and instrumentation has only to climb a ladder in the aircraft hangar. Compare that with servicing the Hubble Space Telescope that, when the Space Shuttle was still available, required the work of several astronauts in dangerous extra-vehicular activities, at costs approaching a billion dollars per mission. Hubble successor, the James Webb Space Telescope, will be not serviceable at all.

Despite being a plane and not a spacecraft, SOFIA is managed by NASA with the feel of a mission to outer space. I got a taste of this in January 2015, when I briefly escaped the sub-freezing temperatures of Iowa's winter to meet my University of Arizona collaborator Kate Su in Palmdale at the border of the Mojave Desert, where the plane is based. SOFIA is housed in the huge building 703 at the Neil A. Armstrong Flight Research Center (formerly known as “Dryden”), located inside the Edwards Air Force base. This is a legendary place in the human quest to conquer the heavens. It is from Edwards that “Chuck” Yeager became the first human to exceed the speed of sound with its Bullet-shaped Bell X-1 ex-

perimental aircraft. The base had also a prominent role during the moon race, leading the testing of essential technologies, including the Lunar Landing Prototype Vehicle that almost killed Neil Armstrong when it tipped over and crashed in a ball of fire (Armstrong ejected at the last minute). During the Shuttle era, Edwards was the alternate landing site for the spacecraft, and building 703 in Dryden housed the two specially modified

747s used to ferry the orbiter back to its launching site at the Kennedy Space Center in Florida. Since the Shuttle retirement, one of the huge Shuttle Carrier Aircrafts has been moved in front of building 703, where it greets the visitors approaching the center from the south entrance. SOFIA now shares building 703 with other NASA aircrafts, including two high altitude jets capable of flying at over 70,000 ft. instrumented to collect atmospheric data at the edge of space.

Planning observations with SOFIA is a logistic ordeal. Since the observing chamber opens on the port side of the aircraft, the telescope can only point to the part of the sky directly on the left side of the plane. The only way to steer the telescope is to turn the whole aircraft. The typical 10-hours observing night then looks like a seemingly random walk through the American and Pacific skies, with each leg chosen to match the orientation of one of the targets in the observing list. At the end of the night the plane must return to base, which further constrains the choice and order of the sources that can be observed. The light plan for my trip brought us all the way down to Mexico, almost to the edge of the Inter-tropical Convergence

Zone, where the moist air from the equator rises up to the stratosphere, an insuperable barrier in our quest for dry skies. All this was shown to us in the pre-flight briefing, where we (the two observers, the instrument scientists, telescope operators and flight support crew, over 25 people in total) all assembled in preparation for the flight. This briefing is what you would expect for the typical NASA operation, with our mission director (Karina Leppik, a charismatic Antarctica winter-over veteran) calling each sub-team for a “go”/“no go” status. At the end of the role-call we were a “go,” ready for our trip to the stratosphere.

Flying on SOFIA is nothing like flying commercial: we were reminded of that in the hour-long safety training we had to complete before boarding the plane. After all, SOFIA flies higher than a regular jet, and a sudden loss of pressurization would make you pass-out within less than 15 seconds. We were instructed to always carry our Emergency Portable Oxygen System (the EPOS, a sort of smoke hood with its own oxygen supply) with us, when walking around in the plane. Stripped of all the furnishing and insulation of regular airplanes, the main cabin of SOFIA is cold and noisy, requiring the wearing of noise-canceling headphones connected to an internal PA system. A cumbersome system, but necessary to communicate with the telescope and camera operators during science time, and with the added bonus of allowing to overhear the cool chatter between pilots and ground traffic control during takeoff and landing (pilots talk a lot, really). Our program was scheduled in the second

half of the night, during the northbound leg of the flight, as SOFIA returned to its base in California. The target of our observations was ϵ Eridani, one of the closest neighbors of the Sun. The goal of our program was to probe the present of ϵ Eridani's young planetary system, as a proxy to study the violent past of our own Solar System. Remember that dramatic event that bombarded the Moon into a maze of craters? It is a daily occurrence on ϵ Eridani, where the local “production” of the Late Heavy Bombardment “show”, is being re-enacted as you are reading these lines. By studying the drama happening today on the stage of Eridani, we can peer into the remote past of Earth's history, at the age when life first appeared in the depths of its newly formed oceans.

Specifically, we boarded SOFIA with the mission of resolving a long-standing controversy about the exact configuration of the swarming comets and asteroids that are circling ϵ Eridani, which are responsible for its meteor bombardment. In a paper based on observations we performed a decade ago with NASA's Spitzer space telescope (the infrared cousin of Hubble), we determined that this star possesses three separate circumstellar belts. Two inner rings are analogous to the Solar System's asteroid belt. On the outside, a broader icy disk is instead similar to the Sun's Kuiper belt, but on steroids: a massive version of the far-out belt that exists in the Solar System beyond the

orbit of Neptune, the realm of comets and icy worlds ruled by Pluto and other dwarf planets. A key result in our work was postulating the presence of clearly defined gaps



Inside SOFIA. The telescope is behind the blue structure in the tail section of the plane; the large box protruding from it is the liquid-He-cooled FORCAST camera used for our observations. On the left the telescope operator station. FORCAST is controlled from the station at the right.

between these three belts, a telltale sign that whole families of planets are actively carving the humongous disk of ϵ Eridani into separate rings. Our conjecture, however, was not based on an actual image of the belts with their gaps, but rather on the spectral energy distribution of the infrared light emanated by the source. Spitzer lacked the visual acuity for imaging the details of ϵ Eridani's disk, but possessed the sensitivity to map the thermal radiation of its emission, from which we estimated the rough distance of its components as they are heated by the central star. Our inference, however, was cast into doubt within a few years from publication, as an independent group derived a new fit of our data with a gapless (and planet-less) disk. A sure way to resolve the controversy was to obtain a true image of the gaps, in case they exist. SOFIA, with its much larger telescope, has an ability to observe infrared radiation at just the right wavelength where a gapless disk would be brightest. It is the perfect tool to answer this puzzle. This was a convincing case for NASA, and we boarded the plane to find out.

In the stereotypical sci-fi Hollywood drama, discoveries follow experiments in real time. It takes just a few seconds for the scientists to look at the elaborate display on huge screens to declare triumphantly that the mystery is solved (and that humanity is inevitably saved by some impending cataclysm). In the real world, science works at a slower pace. As we huddled around the laptop of Andrew Helton, one of SOFIA's staff scientists, the image of ϵ Eridani captured by the FORCAST camera slowly came to life during the three hour-long exposure. Prom-

isingly, it looked like a star - a featureless point in the sky without the extended ring of infrared emission, expected if the gaps in the disk were filled-in with no separation between the belts. Encouraging, but astronomy is a hard science, and as tantalizing as one single image could be, the answer for this puzzle will have to wait for the tremendous number crunching that our computers will perform once all the data is calibrated and merged with all other available evidence. In an age of data-intensive astrophysics, the quality and sophistication of the observations demand complex models for their full interpretation. Our few hours of telescope time, as glamorous as a trip to the stratosphere could be, will now be followed by months of gritty analysis work. The images we collected will be stacked against detailed physical models of the two competing hypothesis; hard numbers will tell us the results and their statistical significance.

As we descended SOFIA's ladder,

heading back to building 703 in the twilight of a new day, we carried with us not just a night worth of data, but a valuable experience in how SOFIA is operated. This will be crucial for the work ahead, because it will allow us to fully appreciate the subtleties of our data, and push our analysis to its finer details. The prize at the end of this road is to understand the true structure of ϵ Eridani's out-of-this-world disk, and its interactions with the cohort of planets likely inhabiting its system. SOFIA, by its unique ability of capturing infrared light in the dry stratospheric sky, is the closest

we have to a time machine, revealing a glimpse of Earth's ancient past by observing the present of a nearby young sun.



Huddling around the laptop of Andrew Helton (bottom right), as ϵ Eridani's images started to appear on the screen. Top right: Kate Su; Massimo Marengo on the left. Photo courtesy of B. J. Anderson.

Jigang Wang

Fast Times In A Terahertz Quantum Materials Lab

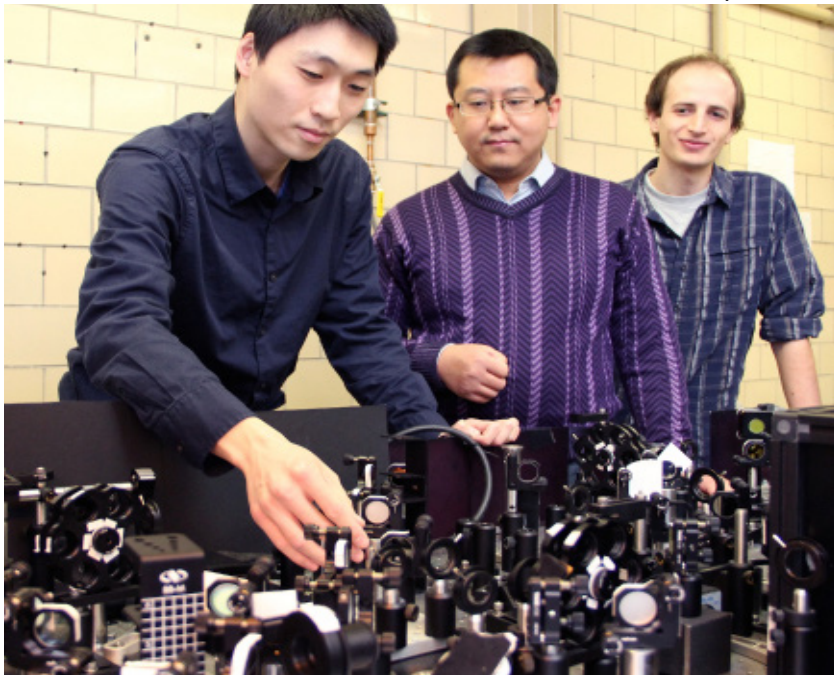
As a physicist at Iowa State University I use the tools of ultra-fast laser spectroscopy to reveal the mysteries of new materials. The technique is similar to high-speed photography, where many images taken in rapid succession reveal subtle movements and changes inside the materials. Observing these dynamics is one emerging strategy to better understand how new materials, such as meta-materials and strongly correlated electronic materials, work so that we can use them to enable new energy technologies.

My research group pioneered an ultrabroadband femto-second (10-15s), resolved approach to the study of quantum materials. My colleagues and I recently used ultra-fast laser spectroscopy to demonstrate broadband terahertz (THz) wave generation using deep-sub-wavelength meta-material emitters, specifically quantum ultrafast magnetic switching and stimulated emission of Dirac fermions in graphene monolayers. We have also used ultra-fast laser

spectroscopy to examine and explain the mysterious electronic properties of iron-based superconductors and dark collective excitations of carbon nanotubes.

Traditional methods for THz wave generation seek to either speed up oscillating waves from the electronic range or slow down waves from the optical range. But the THz frequency of electromagnetic radiation becomes too high to be generated and counted by the conventional elec-

tronic devices used in radio waves and microwaves. And, most techniques to slow down optical waves include mixing two laser frequencies inside an inorganic or organic crystal. However, the natural properties of these crystals result in low efficiency, e.g., spurious absorption, subtle



Professor Wang working in the lab with students Tianqi Li and Aaron Patz, winners of 2013 and 2015 LAS Research Excellence Awards.

phase-matching for locking velocity of the THz waves to the pump. Meta-materials are artificial materials, not found in nature. Luckily, we looked outside natural materials for a possible solution. We used these man-made materials, which exhibit

unique artificial electromagnetic properties, to create highly efficient broadband THz wave emitters. Now we are working on many other technologically relevant nano-composite materials, e.g., consisting of carbon nano-tubes and perovskite solar cells wrapped in polymers.

For complex tasks such as this, we are extremely fortunate to grow in an environment of many groundbreaking work by research groups at Iowa State and Ames Laboratory over the past. Many proj-

ects will not happen without fruitful collaborations with scientists and experts in designing and understanding new materials, developing theoretical models. Some crystals and ideas had been exceptionally well explored by complementary techniques, which made critical contributions to “their close up” under ultra-fast flashes.

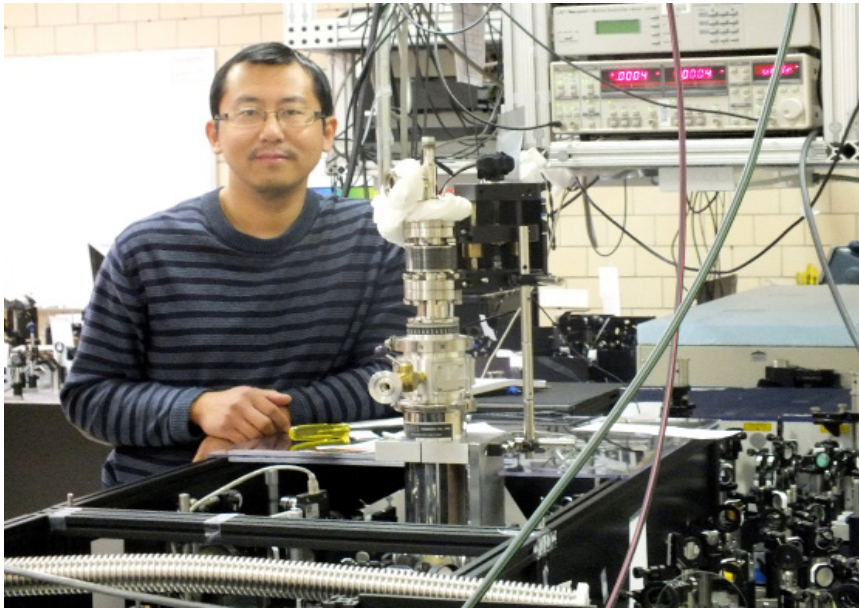
Safety is key in the lab. Newcomers must undertake two weeks of required laser safety and general safety training. Our graduate students have a bright future ahead of them and the last thing we need is for them to get hurt. So safety training is very important and we take it very seriously. In the lab, we also have our own training document, so after the students finish the general training, we have our own procedural training for the lab.

The many projects underway in our lab require lots of hands, and I very much enjoy mentoring students. I consider one

of the paramount goals of my career is to mentor, motivate, transfer knowledge to, and train young researchers for independent thinking and helping them along their journey to success. My research group at

currently consists of three graduate students with three more on board this summer. I’m very proud that three senior students all won Graduate College Research Excellence Award at Iowa State University in the past three years. One of them also received the “Chinese National Award

for Outstanding Self-Financed Students Abroad” for outstanding scientific contributions as graduate researchers (total 518 receipts worldwide given by China Scholarship Council). There are two different avenues by which graduate students come to our group. All new graduate students are free to pursue any research options in the department, and apply to any program they wish. As a very active research group we do recruit, both through the usual channels, and by keeping information on current research projects up-to-date online. I also talk to undergraduate classes and individuals who are interested enough to reach out to us. Even if not always successful, recruiting is mutually beneficial. It allows us to give students a certain vision for the scale of the field, and the grand challenges associated with it. Even small project assignments for the undergraduate researchers give them a taste of how



Jigang Wang in his Iowa State University Lab.

research is done. Regardless of the outcome, this type of activity is ultimately beneficial for science as a whole.

If there is an overriding theme to my research, it is about small and complex things. My fascination with the small started when I was an undergraduate physics student. I was interested in the scientific philosophy of reductionism: that to understand phenomena, we have to go to the small, smaller and smallest until we find and understand the most fundamental particles. By understanding one small piece, we can better understand the whole. The matter around us is very different. The simplest things are made up of huge numbers of electrons. Their properties behave very differently in different situations and they cannot be seen directly. The key thing is, different levels of hierarchical complexity have different organizational principles. You cannot think of their behavior as that of isolated individuals. These complex condensed matter systems are interactive on many scales, not the same as elementary interactions between elementary particles.

My interest in such systems led me to study the very small semiconductor nanostructures in graduate school and carbon nanotubes as a postdoctoral researcher. Along the way, I gravitated toward physicist Philip Warren Anderson's concept of "more is different," which emphasizes the importance of complexity – how small particles organize themselves and how the organization creates different levels of principles that help explain the whole.

We see this concept cuts across different sub-disciplines of condensed matter physics, biology, chemistry, and photonics, of course also in complex materials, like superconductivity or quantum magnets. We have these fascinating functions from the many particles bound by simple interactions. I study these complex systems: their dynamics, or how they change; how cer-

tain changes in the systems correlate to other changes to drive cooperative behaviors; and their nonlinearity, or how the output from a system is different from the input to build functionalities.

My research follows the path of building our understanding on how quantum dynamics emerge from highly correlated electron matter via revealing their organization principles from the nanoscale to the mesoscale, and how we can harness their properties for energy applications. My job can be very hard, but it's a good job; I'm essentially paid to think! This is a privilege. But, the job is no vacation. You have no breaks. You think about it all the time. And of course, without external funding this laboratory would be impossible, there would be no research.

In sum, ultrafast non-equilibrium quantum dynamics is still a relatively new approach and characterization technique. My goal is to help merge the field with the traditional materials research community, which may orchestrate a new paradigm for quantum materials discovery, understanding and control.



Meet Our **New** Faculty

Dr. Zhe Fei will join the department in Fall 2015 and develop an experimental research program based on Near-Field Scanning Optical Microscopy and Spectroscopy. This approach exploits light-matter interactions to study diverse systems with a spatial resolution of down to 10 nm, and also with high temporal resolution. Dr. Fei received his PhD in Physics from the University of California, San Diego with Dimitri Basov in 2014 and moved directly to his current staff research scientist position in the Center for Nanomaterials at Argonne National Laboratory.



Dr. Xuefeng Wang received his Ph.D. in 2009 from Purdue University where he developed optical sensors to detect biological molecules. He then trained as a postdoctoral fellow with Prof. Taekjip Ha at the University of Illinois at Urbana Champaign and pioneered the use of molecular sensors to optically read forces exerted by living cells with single molecule resolution. As a faculty member at ISU, Dr. Wang plans to combine molecular force sensors and cellular imaging to study how mechanical signals are sensed and exerted by cells.



Matt Wetstein obtained his Ph.D. at the University of Maryland in 2009. He worked as a postdoc at Argonne National Laboratory until 2011 where he became a leader in the characterization of a new kind of photodetector devices called LAPPDs. He possesses unique expertise in this area and has made significant contributions with 10 related publications. Wetstein is currently a Grainger fellow at the University of Chicago and has recently won the Lee Grodzins award from the Massachusetts Institute of Technology. This award was created to recognize the importance of original and unique work by postdoctoral fellows within the experimental nuclear and particle community. He is also co-spokesperson on a new neutrino experiment (ANNIE), recently approved to run at Fermilab, based on the novel photodetectors. Matt will join Iowa State as an Assistant Professor in the Fall of 2015.



ALUMNI MEETING

Saturday October 25, the Physics and Astronomy Alumni Council held its annual daylong meeting. Following Chairman Frank Krennrich's usual summary of the state of the department and current plans, there were several presentations given to the Council of current research in the department. These included a talk by Professor Paul Canfield on 70 years of research on superconducting materials, which he linked to the LAS colleges Signature Theme on new materials. Professor James Vary spoke about high performance computing at national lab supercomputing facilities, and algorithms his group has developed to use these resources to advance our knowledge of nuclear structure. The council traditionally enjoys hearing student perspectives and graduate student Josh Cardenzana described his experiences and thesis work in gamma-ray astrophysics.

In the afternoon the Council's work was a little heavier. The department's strategic plan, approved in the previous year, and its implementation were discussed. A plan to initiate an endowed lectureship to bring a premiere physicist to the campus once a year was discussed. The Council was enthusiastic about this proposal, and contributed some helpful insights. The latter included a suggestion to begin the program as soon as possible, even with limited funding, while working to achieve the full endowment on a longer timescale. The final dinner was a delightful social occasion, with terrific stories from the department's past.

NAMED LECTURESHIP

Departmental faculty and staff are strongly focused on our primary missions of research and teaching, and generally doing the best we can for our students. In carrying out these missions the department has benefited greatly over the years from alumni giving. This has come in the form of undergraduate and graduate scholarships, equipment and other research needs, and helpful external viewpoints. Sometimes, however, our efforts in alumni communications haven't been as consistent as those in teaching and research. We're trying to improve!

Firstly with the revival of this newsletter, which was partially a casualty of abrupt budget cuts in the recession. Now digital publishing makes both the production effort and the financial burden lighter. A second planned improvement is the initiation of the *Zaffarano Lectureship* described in the Chair's introduction above. As Dr. Krennrich noted, with alumni help, this lectureship should advance the departments goals and reputation in several important ways. Not least of these is providing another means of interaction with our alumni. Let us know what you think of these and other departmental activities described in this newsletter. Please feel free to contact the department if you'd like to learn more about any of these initiative, and how to help support our students.

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