Department of Physics and Astronomy

Physics Matters

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Michael Allen and grade-school children checking out the Spitz A3 projector at the WSU Planetarium.

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Histories of the J.R. Jewett Observatory and the WSU Planetarium

Professor Sidney G. Hacker: A Man with a Vision

Article written by the Department of Physics and Astronomy office support staff, with inspiration from Professor Guy Worthey. Copious references are taken from "Origins of the J. R. Jewett Observatory and of the WSU Planetarium" by Sidney G. Hacker, August 1980, Mathematics Notes, Vol 23. No. 3.

In 1948, Washington State College (WSC) professor **Sidney G. Hacker** had a mission—he wanted his institution to build a joint observatory-planetarium complex. From his 1980 article on the origins of the project, it was clear that Hacker needed patience as well as a network of friends and acquaintances with a shared interest in astronomy to accomplish his goal. His initial proposal to then-college president, **Wilson Compton**, included an observatory-planetarium complex where students could congregate and conduct research.

Compton was impressed with Hacker's proposal and he clearly understood the value of the sciences. Two of Compton's brothers were well-known physicists. One of them, **Arthur H. Compton**, won the Nobel Prize in physics, in 1927. However, because of budgetary concerns President Compton was reluctant to pursue both campaigns simultaneously. Priority was given to the planning and construction of an observatory. The creation of a separate planetarium would come later under the leadership of WSC president **C. Clement French**.

Professor Sidney G. Hacker

Hacker was no stranger to the field of astronomy. He received his Ph.D. in astronomy from the Princeton University in 1934. Teaching positions in astronomy were hard to come by, and he began his career as an instructor of mathematics at the University of Indiana at Bloomington. Three years later he moved to Pullman to teach mathematics at WSC where he spent the next 10 years rising through the faculty ranks in the Department of Mathematics. However, he never forgot his first love—astronomy. He knew there was a need for more and better astronomy courses at WSC. Prior to World War II "descriptive astronomy had grown from a class of a dozen or so students every year to classes four or five times as large every semester," he wrote. There was also an active astronomy club that met twice a month and was open to the public. Meeting the growing demands of the discipline was a difficult task.

Funding was a challenge as well. The Great Depression, followed by World War II, had depleted the public coffers and tax dollars were scarce. Although WSC possessed several telescopes, many were in disrepair. The most noteworthy telescope was a 12-inch refractor with an alt-azimuth mounting made on site which was put to use in the fall of 1929. According to Hacker, by the late 1940s both its mirror and mounting mechanism "had deteriorated so seriously as to be beyond any practicable employment." Undaunted by aging instruments "with two or three relatively inexpensive three-inch reflectors mounted on tripods under the supervision of previously briefed advanced students, it was possible to satisfy a modicum of observational interest," reported Hacker. Yet, so much more was needed!

Sidney G. Hacker Papers (unproc.), courtesy of Manuscripts, Archives, and Special Collections, WSU Libraries.

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The James Richard Jewett Observatory of Washington State University has as its main instrument a 12-inch-aperture Alvan Clark & Sons refracting telescope with an Alvan Clark equatorial mount. The tube is 15 feet long, and still features the original lens polished in 1887-1889 by Carl Lundin, the same optician who fabricated the world's largest (40-inch) lens at Yerkes Observatory.

After getting the go-ahead from Compton, Hacker did his homework. He contacted astronomical equipment manufacturers regarding availability and costs and made inquiries on campus. Meanwhile Compton approached **George Jewett Sr.**, a Compton acquaintance and former president of Potlatch Lumber Company, about becoming a benefactor of the observatory project. Compton was unsuccessful in his initial proposal to Jewett. About the same time, astronomy Professor **Leon Campbell** of Harvard told Hacker about the availability of a 12-inch achromatic lens made by **Carl Lundin** of **Alvan Clark & Sons Co.** At the time of its manufacture, Alvan Clark & Sons was the leading telescope manufacturer in the US, if not the world. It had been made for an amateur astronomer who died shortly after the lens passed essential optical testing in 1889. The lens was carefully stored in the vault of a Boston bank until a settlement of the estate prompted its sale years later. At $2400, Hacker believed it "could only be regarded as an exceptional bargain."

In a favorable turn of events **James Richard Jewett**, George's father, was a professor of Ancient Languages at Harvard and had been an ardent amateur astronomer. He was a long-time friend of Campbell's and an acquaintance of Lundin's. George fondly recalled his father's associations and, in a follow-up visit by Compton and several colleagues, including dean of the faculty and noted physicist, **S. Towne Stephenson**, George pledged $24,000 for the project.

Just when things seemed to be looking up—funding was in place, the project was gaining momentum, the universe and stars were waiting—Compton abruptly resigned (April 1951). A few weeks later, Leon Campbell died. Campbell was the principle liaison with the Alvan Clark Co., and Hacker was concerned that the work on the telescope mount would stop. One of the main problems was that Alvan Clark was no longer a thriving institution and Hacker had received conflicting reports on the progress of the telescope's construction. "It became clear that their very capable instrument maker, **H. F. Gage**, was making very slow progress, as were perhaps any sub-contractors whom they were employing in the manufacture of the telescope tube and the castings for certain parts", wrote Hacker. To get a handle on the situation, Hacker approached Professor **Harlow Shapley**, Director of the Harvard Observatory, who agreed to lend him the services of the observatory's head instrument maker, **Walter A. Locke.** Locke and Gage had successfully worked together on past projects, but Hacker still needed reassurance that Gage "knew how to find the necessary parts in the clutter of old machinery that littered the place, and despite his declining years, had retained his technical skills and was capable of assembling a suitable 'Alvan Clark mounting' worthy of the Lundin lens."

Reassured by Shapley, Hacker made a trip to Boston to work with Gage and talk to Locke. Hacker's visit was fortuitous. "During a search among materials that lay discarded or long forgotten in the work room cabinets I found, meticulously boxed, the attractive three-inch refractor that now serves as the finder for the telescope. It was clear that progress on the telescope was going to be slow, and it was our estimate that it would take another six months before the instrument would be ready for the required testing previous to shipment and this proved to be so," he wrote.

Choosing a permanent location for the building that was to hold the telescope was another big challenge. The telescope had exacting requirements and would need to be mounted on "a very substantial concrete pier" and "centrally located in a necessarily unheated circular room of 25 feet inside diameter with steel reinforced concrete floor and sidewall, the latter supporting a rotatable hemispherical dome with a two-sided shutter that could open horizontally to an adequate width from the base of the dome to somewhat past the zenith," wrote Hacker. The limited budget seemed to require rooftop installation, which few found appealing. At one point Compton elected to place the observatory on top of **E.O. Holland** Library. He relented when influential individuals raised concerns about the aesthetics and the fact that the lights of the campus would compete with the skyline. Hacker believed the telescope needed a separate "well-placed building of its own." Eventually, a bare-bones, but separate structure was erected on the east perimeter of campus, the site now known as "Observatory Hill."

WSC architects, **Philip E. Keene** and **Glenn W. Wegner**, began designing the structure in 1950 with advice from numerous astronomers, including the world-renowned cosmologist, **Henry Norris Russell**. It proved difficult to get a bid on the dome. Not a single company showed interest in a steel-and-aluminum structure. Finally Timber Structures, Inc. was intrigued with building a rotatable hemispherical dome. They believed they could make the dome with a wooden framework sheathed by molded plywood at a very modest cost. Another major component of the building, the steel-and-aluminum shutter that provided the opening and closing of the dome, was built by General Machinery Co. They also built the motors that rotate the dome. Construction of the wooden dome cost roughly $2400, the shutter and motors twice that amount. The building itself was contracted to **H. Halverson, Inc.** of Spokane for $15,500. At this point Hacker's $24,000 budget was just about spent and it became necessary to ask George Jewett for additional funds. Jewett provided an additional $11,000 and it was at this time that he requested the building be named the "James Richard Jewett Observatory" in honor of his father.

The 15-foot long telescope steel tube, along with its six-and-a-half-foot high cast iron pedestal arrived to a fully ready building in June 1952. Hacker reported that it took "experienced crews from the Department of Buildings and Grounds [now Facilities Operations] along with several pieces of the College's specialized equipment to safely install the instrument." According to Hacker, among the curious observers of the assembly of the telescope was renowned astronomer **H. P. Robertson**, there on a personal visit to the area.

In Hacker's 1980 article, he included a meticulous accounting of how much and where the money was spent in the construction of the observatory. Funds for modifications and improvements of the instrument were provided by the College, "as were those for the initial preparation of the site, the installing of the telescope and the many inherent costs owing to the work of College personnel," explained Hacker. The Jewetts' contributions were used for the basic instrument and the construction of the building. At today's standards, their portion of the project would cost more than $410,000; the $2400 "bargain" the University paid for the Lundin lens would have a replacement value of at least $28,000.

The official dedication was held on May 14, 1953, before a capacity audience in Todd Hall Auditorium. In attendance were several members of the Board of Regents, Mr. and Mrs. George Jewett, College president French, and Professor Hacker. In a modest description of the ceremony, Hacker indicated he had the honor of accepting the formal presentation of the Observatory.

Sidney Hacker's observatory project endured six years of starts and stops before it was finally completed. Without his dedication and perseverance, it most likely would not have evolved into what continues today to be a teaching entity for a host of students and visitors. However, he was not finished. While the observatory portion of the equation was solved, the planetarium remained to be built.

Four years after the dedication of the observatory, Hacker found sufficient funding for what he termed a "modest kind of planetarium"—a 'Proto-Planetarium' with a Spitz Planetarium Model A-1 console type projector, complete with a variety of auxiliary projection apparatus." The original structure was a "14-foot hemispherical dome of 'metal fabric'…a substantial, portable aluminum framework over which was stretched a thick canvas covering, its whole interior having to be painted a flat white after installation," he wrote. After much discussion on where to locate the dome, physics professor **Paul A. Anderson** volunteered a "sizeable air-conditioned room" the university [WSC had become Washington State University, September 1, 1959] had assigned to the physics department. Located in Dana Hall, there were many limitations to the space, including the fact that the ceiling height was too low; a person of "small stature would have to bend low to get under the dome edge and once inside its perimeter he had to negotiate a narrow passageway to a seat," lamented Hacker. With student enrollment above 100 for descriptive astronomy, the 'Proto-Planetarium' was highly inadequate.

Shortly after, a new space was found in the soon-to-be completed Sloan Engineering building. Sloan room 231 was large enough to accommodate a dome of "24 feet in diameter at a height suitable for focusing of the star and planetary images and yet with a perimeter at a distance above the floor as to be essentially unnoticeable upon entry to the seating. This would call for an extension of the room into the floor above," Hacker wrote.

WSU architects and facilities people grappled with the height issue and finally decided that the best solution would be to design and build a plastic-laminated, fiberglass dome that could be inserted into the Sloan building once it was completed. Glen Wegner, who was instrumental in the design and construction of the Jewett Observatory, was put in charge of the special design, including specialty lighting and exhibits. In 1961 the Spitz Co. provided the fiberglass dome at a cost of $5,000 and the following year supplied the seating, as well. The original projector from the 'Proto-Planetarium' was moved to the new location and, by April of 1962, the planetarium was ready for students and visitors. According to Hacker the projector from the 'Proto-Planetarium' lasted five years and in 1966 it was upgraded to a Spitz A3 star projector. The Planetarium, along with the A3 projector, still resides in the same location today.

If not for Sidney G. Hacker's vision of an observatory-planetarium complex, his diligence in pursuing donors, and what could perhaps be described as "scavenger efforts", WSU would not have this effective training and research tool. For a certainty, the unsung efforts of Professor Hacker and his host of friends, along with the Jewett family's benevolence, continues to benefit future generations.

"Project: Sky Tours"
WSU Pullman's Popular Planetarium in Pecuniary Plight

The unique design of the department's donation box is the skilled work of Technical Services employee, Lauren Frei (with some preliminary assistance from Dave Savage). Proudly displayed by Michael Allen.

Washington State University's Planetarium is in need of a launch into the 21st Century. Consider the following. With a 55-seat capacity, it is the only planetarium in the Pacific Northwest supported by a full-time astronomy research faculty, and its role in science education is unique. Annually it hosts 1,750 to 2,000 visitors. In fact, more than one-quarter of all school districts in Whitman and adjacent counties have visited WSU's planetarium. Like many rural universities, WSU plays a vital role in the intellectual life of otherwise isolated communities. The planetarium is a valuable teaching aid. Astronomy Professor **Guy Worthey** describes it as 'an immersing environment'—a cosmic mapping tool that helps people identify what to see in the night sky. So what could be the down side to this valuable asset?

In 2001 when the Department of Physics and Astronomy assumed responsibility for the planetarium, it was discovered that its star projector, although still working, was antiquated. The apparatus, which projects stars onto an overhead 24-foot dome, was purchased by the University in 1966 and has been in continuous use since that time. Astronomy faculty instructor **Michael Allen** would like to see the university move to a digital system. Allen, who routinely conducts "sky tours", knows first-hand about the idiosyncrasies of the Planetarium. "The flaws are considerable: the projector shudders and creaks when in motion and partially blocks the sky during presentations; the stars and the Milky Way are out of focus, faded, incomplete, and have unrealistic colors; there is no way to project myth-inspired depictions of the constellations; the sun, moon, and planets no longer move or phase accurately; projectors for twilight, satellites, and meteors are time-worn; and there is no ability to simulate eclipses, show astronomical images or animations, or demonstrate the devastating effects of light pollution." In short, *"It has not been upgraded in the past 40 years—a death knell for science education,"* says Allen.

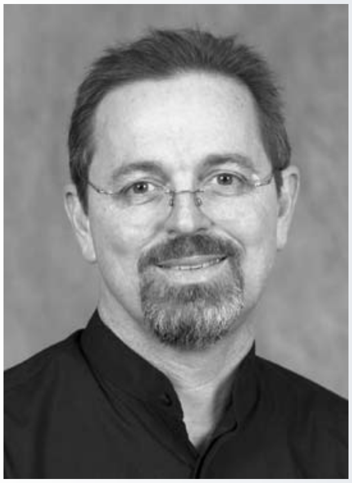
The current goal is to find funding to buy a state-of-the-art digital projector. The physics department, along with the efforts from a few key individuals, is trying to build awareness and support for what they are calling "Project: Star Tours". A new more compact and programmable projector will allow the incorporation of new discoveries and sparkling images, inspiring a new generation of students. The projector is versatile and can be used for various exhibitions and events, and will help focus on the mysteries of the galaxies and on our universe in a way that is meaningful and practical. Visits to the planetarium will be a stellar and awe-inspiring memory and WSU will find its Planetarium firmly placed in the 21st Century. **For more information about "Project: Sky Tours" please contact the department chair's assistant, Sabreen Dodson at 509 335-9532. To make a gift visit www.supportscience.wsu.edu/planetarium**.

Star Parties!

The James Richard Jewett Observatory of Washington State University has as its main instrument a 12-inch-aperture Alvan Clark & Sons refracting telescope with an Alvan Clark & Sons equatorial mount. The tube is 15 feet long, and still features the original lens polished in 1887-1889 by the Carl A. R. Lundin, the same optician who fabricated the world's largest (40-inch) lens at Yerkes Observatory located at the University of Chicago.

Jewett Observatory is our direct window to the heavens. In spring, summer, and fall the Department of Physics and Astronomy holds monthly public "Star Parties", where interested persons can view the cosmos. These parties can be quite popular. During "Mars Week"—a September 2004 event, Jewett Observatory drew more than 3,000 people. Traffic police were needed to assist with parking and people waited in line well into the night. It was a smashing success.

WSU's planetarium and observatory are priceless assets to our curriculum and to the community. Please help us to go digital so that we can all experience the awe inspiring majesty of the universe.



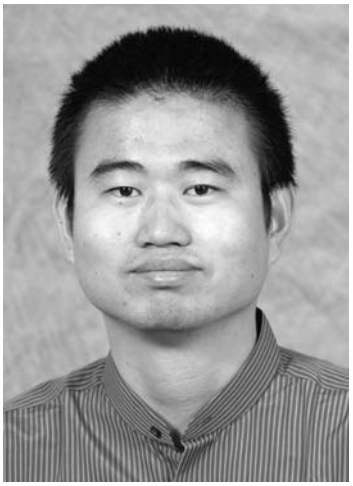
Greetings from the Chair

Since our last issue of *Physics Matters*, we have welcomed a new assistant professor in theoretical physics, **Chuanwei Zhang**. We are also pleased to report that more majors will graduate this year than in any year that I can recall. Our graduate student population is at or near an all-time-high. Two of our international graduate students, **Afsoon Soudi** and **Shoresh Shafei**, are profiled in this issue. Our faculty continues to outperform those in departments of similar size across the country. I can't say enough good things about them.

It is always interesting to peek into one's history. In this issue, you will find an article on the WSU planetarium and observatory and how they came to be. It is a tale of extraordinary effort by mathematics professor **Sidney G. Hacker**. His story, which began more than sixty years ago, is still having an impact on the WSU community. The two facilities, although still very much in use, have aged a bit and we have initiated "Project: Sky Tours" to improve them. We are all aware that budgets have been adversely impacted by the developing economic crisis. Nevertheless, we are carrying on unabated with our efforts to continually improve how we serve the community. I hope you will find this year's read an interesting one.

Sincerely,
Steve Tomsovic
Chair, Department of Physics and Astronomy

The Department Welcomes a New Physicist



The Department of Physics and Astronomy is pleased to announce the addition of a new faculty member this fall. Assistant professor **Chuanwei Zhang** is a theoretical physicist working in atomic physics and condensed matter physics. His research interests and activities include ultra-cold atoms in optical lattices, physical implementation of quantum information in cold atomic, photonic, and superconducting systems, quantum chaos in Bose-Einstein condensates (BEC), Berry phase and semi-classical wavepacket dynamics, physics of strongly-correlated multiferroic materials, and high temperature cuprate superconductivity.

Chuanwei did his undergraduate work in quantum information at the University of Science and Technology of China, where he worked on a quantum state clone and its physical realization in optical systems. His Ph.D. work in theoretical atomic physics was done at the Center for Nonlinear Dynamics at the University of Texas at Austin, where he studied quantum chaos in BEC, Berry phase effects in a superfluid with a vortex, and quantum information in photonic systems. He first discovered and characterized the transition to chaos induced by strong interactions between atoms in a kicked BEC, a nonlinear generalization of the well-known quantum δ-kicked rotor. He was also the first to reveal the unusual quantum level statistics for Bogoliubov quasiparticle excitations of a BEC in chaotic billiards. His work on Berry phase in a superfluid has ruled out the existence of the Iordanskii transverse force acting on the vortex in a superfluid, a controversial problem in the past several decades.

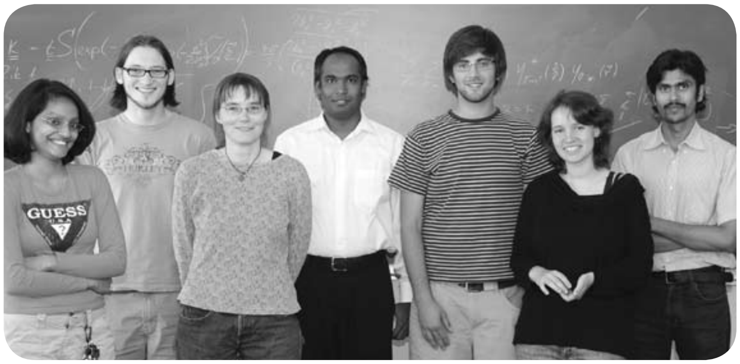
Before coming to WSU, Chuanwei spent two-and-a-half years at the Condensed Matter Theory Center at the University of Maryland at College Park as a postdoctoral research associate. He worked on a broad range of topics, including topological quantum computation in chiral p-wave superfluids/superconductors and in optical lattices, coherent quantum computation using cold neutral atoms in optical lattices and optical dipole traps, strongly-correlated quantum states in optical lattices, non-equilibrium spin dynamics of degenerate Fermi gases with effective spin-orbit interactions, a phenomenological Ginzburg-Landau theory for the multiferroic material $CoCr_2O_4$, and the *d+id* density-wave state in underdoped cuprate superconductors. Chuanwei has coauthored twenty-six publications, including ten in Phys Rev Lett and one in PNAS.

At WSU, Chuanwei looks forward to setting up a theoretical research group focusing on the interface between atomic physics and condensed matter physics. His current research interests include: topological quantum computation, quantum chaos with cold atoms, optical lattice emulation of condensed matter models, and physical properties of multiferroic materials. More information about his research can be found at the website http://terpconnect.umd.edu/~cwzhang/.

Good News from Around the Department

The Spokane Astronomical Society invited **Michael Allen** to give a talk about a research project that he and undergraduate senior, **Urszula Szafruga** are working on using the PARI radiotelescope. The project includes mapping the Stockert Chimney, a large funnel-shaped collection of gas that is channeling supernova-driven gas out of the disk of the Milky Way Galaxy. Michael has also been busy with the Palouse Astronomical Society, helping to refurbish an 18-inch Newtonian telescope on a Dobsonian mount, which is currently being used in conjunction with the on-campus Jewett Observatory.

Doerte Blume published a series of five papers on the few-body physics of ultracold two-component Fermi gases from November 2007 to July 2008. Two were single-author papers and three were in collaboration with colleagues from JILA, an institute associated with the University of Colorado at Boulder. She also spent time last summer working with two undergraduates on special projects. Physics major, **Kristofor Nyquist** worked on the classical description of trapped ionic and polar particles. Kris was awarded a Colleges of Science Mini-Grant and, according to Doerte, he made extremely fast progress. As part of the REU Summer 2008 program, Doerte worked closely with **Dina Genkina**, a sophomore from New York University. Dina used numerical and analytical methods to try to understand the interaction between two quadrupoles in a harmonic trap. She appreciated the time Doerte spent in explaining the problem, "assigning ways to approach it, and with extraordinary patience, helped resolve difficulties that arose along the way."



Left to right: Graduate research group members, Krittika Kanjilal and Kevin Daily, Professor Doerte Blume, graduate student, Muhammad Asad-uz Zaman, undergraduate, Kristofor Nyquist, REU intern, Dina Genkina, and graduate student, Debraj Rakshit.

Sukanta Bose and **Frederick Raab**, Head of LIGO Hanford Observatory and Co-PI, have a one-year $80,000 bridge funding grant from NSF, titled: "Theoretical and Experimental Efforts for Detecting Binary Black Hole Mergers with a Network of High-Precision Gravitational-Wave Interferometers."

Last fall **Nicholas Cerruti** became the faculty advisor to the Physics & Astronomy Club. Club highlights for the year include the annual "Pumpkin Drop" held during Dad's Weekend and a "Myth Buster's" demonstration show presented during Mom's Weekend. The club also hosted the Society for Physics Students (SPS) chapter of Green River Community College while they toured the university. Nicholas spent part of his summer in collaboration with **Philip Marston** and **David Thiessen** on modeling the interaction of evanescent waves on buried objects.

WSU chemistry professor **Aurora Clark** served as a faculty mentor to physics REU intern, **Sarah Landstrom**. Professor Clark and Sarah performed computational studies of the structures and physical properties of actinide ions in aqueous solution. As Clark notes, "the behavior of these ions in water is of fundamental importance to their environmental remediation at nuclear waste disposal sites such as Hanford." Sarah also worked closely with research associate Matthew Wander, who helped supervise her daily activities.

Professor Aurora Clark (back) with undergraduate researcher, Stephanie Westcott and REU intern, Sarah Landstrom.

Gary Collins and his research group continue to study diffusion and lattice locations of tracer atoms in intermetallic compounds with support from the NSF using "PAC", an obscure, specialized gamma ray spectroscopy. His group is the only one in North America that uses PAC to study solids. Students who finished and have left this year include Pullman high school student **Justin Ahn**, who entered Northwestern University this fall, **Ben Norman** (B.S. 2008), who enrolled in the doctoral program in physics at the University of Michigan, and **Xia (Sean) Jiang** (M.S. 2008), who is beginning his studies in medical physics at the University of Chicago. Students graduating from Gary's group have a background in nuclear instrumentation and measurement that puts them on a good track for success in medical physics. Earlier students entering medical physics include **Jiawen (Jay) Fan** (Ph.D. 1991), and **Praveen Sinha** (Ph.D. 1995). Gary also served as a faculty mentor to summer REU student **Megan Lockwood**, from New Mexico State University. Megan gave a presentation on her WSU research at the Four Corners [APS] meeting last October. Physics Ph.D. graduate student **Randy Newhouse** and **John Bevington** from Materials Science were part of Gary's group this past year. Last October Gary presented two papers at an international conference on diffusion held in the Canary Islands.

Susan Dexheimer was awarded a $360,000, three-year renewal of her NSF Condensed Matter Physics Program grant, "Dynamics of Localized Photoexcitations in Condensed Matter Systems." Susan served on an invited panel study on Ultrafast Materials Science for the U.S. Department of Energy's Office of Basic Energy Sciences, Division of Materials Sciences and Engineering in October 2007. The panel was charged with developing a comprehensive and strategic framework for research in Ultrafast Materials Science that identifies research opportunities to advance scientific progress in this rapidly developing field. She has been equally busy this fall having presented two invited conference talks, one to the Optical Society of America Frontiers in Optics Annual Meeting/APS Interdisciplinary Laser Science Conference in Rochester, New York and another to the Materials Science and Technology Meeting in Pittsburgh. She is currently serving on the International Program Committee for the upcoming Optical Terahertz Science and Technology Conference, to be held in Santa Barbara in March 2009.

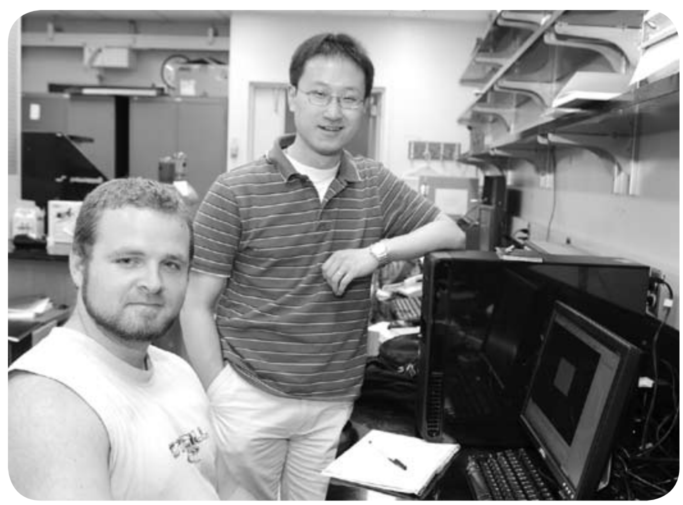
Jet-setter, **Tom Dickinson** gave a number of invited talks on several topics involving laser materials interactions at the following conferences: SPIE-International Society for Optical Engineering, Photonics West, San Jose, January 2008; Laser Institute of America, 3rd Pacific International Conference on Applications of Lasers and Optics, Beijing, China, April 2008; SPIE-International Society for Optical Engineering, High-Power Laser Ablation Conference VII, Taos, New Mexico, April 2008; Department of Energy Workshop on High Sensitivity Methods of Materials Analysis, Annapolis, Maryland, May 2008; and the 6th International Conference on Photo-Excited Processes and Applications, Sapporo, Japan, September 2008. He also chaired the topical symposium entitled Non-Linear and Ultra-fast Laser Interactions with Materials at the American Physical Society March Meeting in New Orleans, March 2008.

REU intern, Megan Lockwood, Gary Collins with graduate students John Bevington and Randy Newhouse

Peter Engels' lab has conducted very successful research in the field of nonlinear pulse propagation in Bose-Einstein condensates (BECs). While the BECs used in this experiment are a fairly unique state of matter that only exists near absolute zero, the physics show intriguing parallels to the behavior of pulses in nonlinear fibers and in certain condensed-matter systems.

This research is supported by an NSF grant. A new publication, with WSU physics graduate student **JiaJia Chang** as first author, has just appeared in *Physical Review Letters*. After a recent substantial equipment upgrade, Engels' lab is now closing in on the next big step, the creation of "artificial crystals" in optical lattices and the inclusion of ultracold fermions. These fermions are much tougher to tame, but are intriguing because fermionic superfluidity is a key phenomenon in such diverse systems as helium-3, nuclear matter, superconductors, and even neutron stars.

In addition to teaching, **Fred Gittes** is currently supervising research in forensic blood spatter analysis (with graduate students **Christopher Varney** and **Gabriel Hanna**), unconventional electric motor design (with undergraduate **Gunnar Skulason**), Venturi flow meters for safety inspections of swimming pools (with undergraduate **Bryan Young**), and aspects of nonconservative force fields in optical trapping (continuing work done with **Ingmar Saberi** – M.S. 2007). He is also supervising **Kyle Welch's** (Neuroscience) undergraduate honors thesis on the ATP synthase molecule. As if there is a lot of time left over, Fred is co-author of a paper recently submitted to the *Journal of Physical Chemistry*, on "Leveraging Single Protein Polymers to Measure Flexural Rigidity."



Orson Bell with REU advisor, Yi Gu. Orson worked on the fabrications of device electrode patterns using photolithographic and electron-beam lithographic techniques. He also wrote LabView programs for automated data acquisition.

Yi Gu has received a seed grant in the amount of $18,021 from WSU. The title of his grant is "Surface Effects on Minority Carrier Diffusion Length in Gallium Nitride Nanowires." Yi also has a two-year grant for $50,000 from the American Chemical Society Petroleum Research Fund for research on the "Effects of Hydrogen-Surface Interactions on Photogenerated Electron Diffusion in Zinc Oxide Nanowires for Efficient Photovoltaics." Yi served as faculty mentor to REU intern and WSU graduating senior, **Orson Bell**.

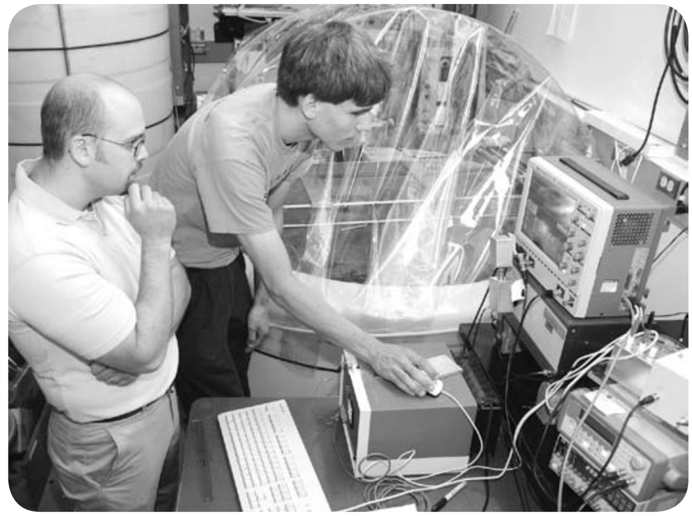
A team of scientists at WSU's Applied Sciences Laboratory (ASL) has been awarded an $8.5 million DARPA research contract to develop and demonstrate reactive materials to be used for a new generation of national security applications. ASL, a component of the Institute for Shock Physics (ISP), is a contract research organization whose mission is to link academic research to practical applications. It is based at WSU Spokane.

"We've been asked to make a material that is mechanically as good as steel, and yet can release chemical energy on demand," said **Yogendra Gupta**, one of five principal investigators on the project. The other principal investigators are **Atakan Peker**, director of advanced materials for ASL; **Choong-Shik Yoo**, professor of chemistry and associate director of ISP; **Gordon R. Johnson**, of the Southwest Research Institute; and **James Gran**, of SRI International. Their expertise spans the fields of materials science, chemistry, physics, and mechanical engineering. "Without the expertise of all five principal investigators, the work could not be done," Gupta said. "This is not [the kind of work] universities typically do. If it were not for ASL, we could not have competed for this project."

A renewal grant for $47,000 was awarded to **Mark Kuzyk** by AT&T and the Air Force for one year to continue research on "Materials with Enhanced Two-Photon Cross-Sections for Optical Limiting." Mark also has an NSF three-year grant for $282,657 for his work on "QMHP - Numerical Optimization of Molecular and Nano-Scale Structures for Nonlinear-Optical Applications."

Professor Kelvin Lynn with research graduate assistant, Romit Dhar and REU intern, Alys Hugo.

REU intern **Alys Hugo** worked closely with her faculty mentor, **Kelvin Lynn**, and Kelvin's research assistant, **Romit Dhar** (Mat. Sci.), on a project using single crystal piezoelectric material (PMN-PT) for energy harvesting from an acoustic source. Alys did measurements on an acoustic tube setup and compared properties of the unimorph samples prepared. The major goal was to realize the factors (both physical parameters and electric circuit) affecting the performance of the device. The main task was to motivate the experiments in order to relate between several parameters which are coupled. In addition she was introduced to several sample measurement techniques and data analysis. As Kelvin reports, Alys was very "systematic and kept one of the best lab books I have ever seen. I think she has had a good experience as she always beats me bowling, which is her only weakness."



Mathew D' Asaro working on an experiment that uses high frequency sound to image objects near surfaces. Shown here with graduate research assistant Jon La Follett (left), in Professor Philip Marston's laboratory.

The U.S. Navy provided **Philip Marston** with a grant renewal of $130,000 over two years for research on "Novel High Frequency Signatures for Classification/Identification of Mines." He was awarded a second Navy grant renewal of $160,000 over two years for his work on "Acoustic Scattering Processes for Target Discrimination." And finally, Phil recently received a 30-month renewal grant for $200,000 to continue researching "Scattering of Evanescent Acoustic Waves By Regular and Irregular Objects." As a faculty mentor, Phil provided REU intern, **Matthew D'Asaro** an opportunity to study the reflection of waves from objects in various mediums, including light in air and sound in water or oil. Matthew solved problems in the various experiments and then provided Phil with feedback regarding the findings.

Steve Tomsovic was so impressed with former REU student, **John Elton's** research that he invited John back for further collaboration. John was one of two REU students who, in summer of 2007, worked with Steve in Dresden, Germany where Steve was working on a year-long Martin Gutzwiller Fellowship. This go-round, John spent a few weeks working with Steve in Pullman and then a month in Paris, France at the University of Paris XI. They also traveled to Dresden, where they carried out research at the Max Planck Institute for Complex Systems. In another international exchange, a Ph.D. student from the Technical University of Dresden, **Christoph-Marian Goletz**, spent a month doing research with Steve at WSU working on propagating quantum wave packets in chaotic systems. Both students enjoyed their experience and greatly appreciated their opportunities for international travel.

"Heather, steady, steady…" Left to right: Graduate research assistant, Samuel Teklemichael, Professor Matthew McCluskey with REU intern, Heather Ploeg.

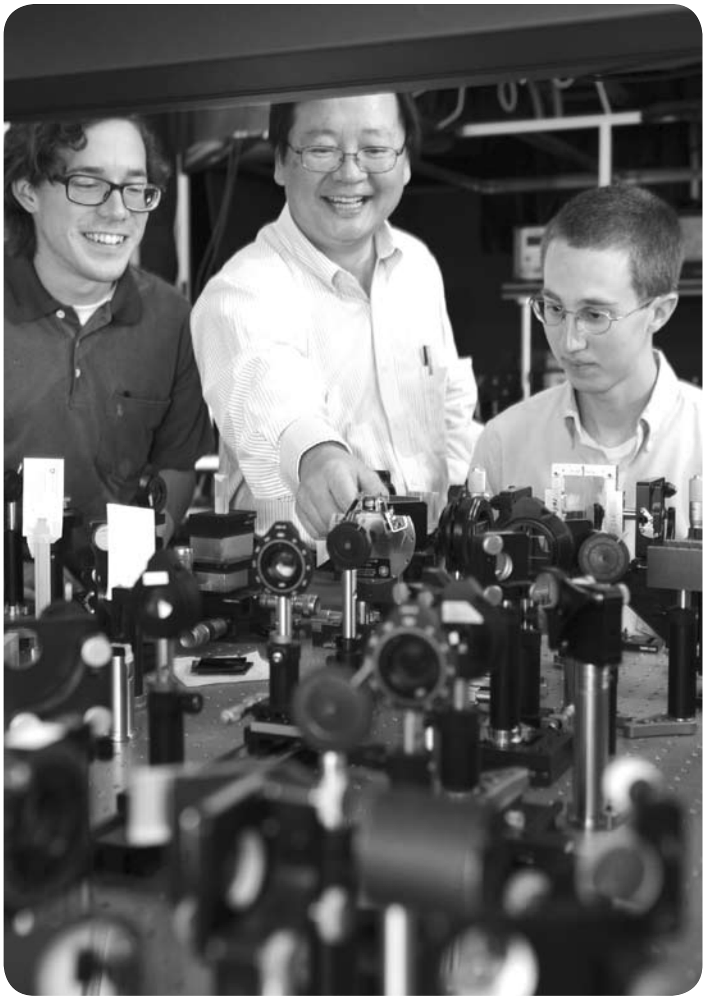
The Boeing Corporation awarded **Matthew McCluskey** a two-year $121,507 grant for the development of polymer light-emitting diodes for energy efficient lighting. Matt is collaborating with **Alex Jen** from the University of Washington. REU intern, **Heather Ploeg** investigated the freezing of water under large hydrostatic pressures. Using a digital camera, she captured images of water freezing rapidly. Matt guided Heather's overall research direction and graduate student **Gabriel Hanna** supervised the day-to-day activities. Matt chaired the 2008 Gordon Research Conference on Defects in Semiconductors held at New London, New Hampshire. The meeting was a huge success, with 105 attendees, up from 78 at the 2006 conference.

Lai-Sheng Wang has been appointed to the Karlsruhe Center for Functional Nanostructures (CFN) International Advisory Board. CFN, which is a German science foundation funded entity, supports much of the nanoscience research in Karlsruhe (presently about 80 subprojects ranging from physics through chemistry to electrical engineering and biology). Lai-Sheng will participate in the molecular nanostructures in gas-phase section of the board.

Guy Worthey has been on sabbatical leave fall 2008 visiting the University of Central Lancashire in Preston, England. He is working with a group of astronomers at Lancashire on galaxy formation and chemical evolution of the universe. Guy reports that it really does rain a lot in Britain and admits that he has opinions about British cuisine; what those opinions are he will not say, beyond murmuring aimlessly about mushy peas, bangers, pasties, chips, and jacket potatoes.

An unexpected personal bonus for Guy and his wife Diane is that a branch of Diane's ancestors inhabited the Preston region for at least three generations, from about 1790 to 1868, the date when her great-grandfather, Aloysius Gillet emigrated to Massachusetts as a young man. The Lancashire Records Office and Harris Library collections have allowed them to trace further back in time, uncovering census records, baptismal records, newspaper ads, and other records that have revealed three generations of forebears. Truth being stranger than fiction, the sabbatical location was chosen and settled on before they became aware of the family connection!

REU summer interns, **Raymond Clay, III** and **Joseph Lanska** performed high pressure materials research at the Institute for Shock Physics (ISP). Joseph's project was in static high pressure physics, and it involved squeezing a sample of carbon dioxide with a diamond anvil cell and then analyzing it with Raman spectroscopy to determine how the molecular structure changes under extreme constant pressure (up to 500,000 times atmospheric pressure). Raymond used various spectroscopic methods to determine the kinds of structural and chemical reactions that would occur in a particular type of organic crystal (sodium cyanide) at very high temperatures and pressures. Professor **Choong-Shik Yoo** served as the students' mentor. He explained the background physics and chemistry, provided the project proposals and regularly met with the students to discuss their laboratory experiences. ISP scientists, **Amartya Sengupta**, **Jing-Yin Chen**, and **Minseob Kim** guided the students in their daily experiments. Both Joseph and Raymond expressed heart-felt appreciation for the hands-on assistance they got from everyone.



Left to right: REU intern, Raymond Clay III, Professor Choong-Shik Yoo and REU intern, Joseph Lanska

Cougar

Ben Arthurs (B.S. 2008) entered the University of Washington Medical School, WAMI program in the fall. Ben's faculty mentor was **Tom Dickinson**.

There is a new book out featuring the early years of distinguished alumnus **Philip Abelson** (M.S. 1935) entitled, *Uncle Phil and the Atomic Bomb*. The story includes an unpublished autobiography that Philip wrote prior to his death, with asides and interpolations by his nephew, **John Abelson**. The book covers the elder Abelson's life until 1947, by which time, at the age of 34, he had already made important contributions to the Manhattan project as well as having designed the conceptual plans for the atomic submarine.

Kyungmin Baik (Ph.D. 2008) received a "Best Student Paper in Structural Acoustics and Vibration" first place award for his presentation at the 154th Meeting of the Acoustical Society of America in New Orleans, November 2007. His research was funded by the Office of Naval Research. Kyungmin studied under the direction of **Philip Marston** while at WSU and is now working in a postdoctoral position at University of Southampton, U.K. with Tim Leighton, a world-renowned expert in physics of sound. We heard from Kyungmin recently and while he is hard at work and enjoying his experience, he misses "the golden horizon formed by wheat, fresh air, kind people, and comfortable atmosphere" of Pullman. We miss you, too!

The American Physical Society Topical Group on Shock Compression of Condensed Matter (GSCCM) was founded in 1984 to promote the development and exchange of informa-

Tracks...

Where Are They Now?

tion on the dynamic high-pressure properties of materials. In 2007, to recognize contributions to understanding condensed matter and non-linear physics through shock compression, the group renamed their biennial award the ***George E. Duvall*** *Shock Compression Science Award*. The award is presented in odd-numbered years and consists of a cash award of $5,000, a plaque citing the accomplishments of the recipient, and an allowance for travel to the meeting where it is presented. Duvall's career spanned 40 years and was regarded by his colleagues as being the "dean of shock wave" research in the US. He was a member of the WSU Physics Department from 1964 until he retired in 1988. He served as department chair from 1974 to 1976.

Natnael Embaye (Ph.D. 2007) was recently offered a position at Intel Inc., in Hillsboro, Oregon. He joins two other WSU alums—physics graduate, **Wei Wei** (Ph.D. 2005) and Materials Sciences major, **Loren Cramer** (Ph.D. 2005) who are working as staff scientists. Natnael's major advisor and mentor was Mark Kuzyk.

Dennis Grady (Ph.D. 1971) is currently an associate and principal scientist with the South West Division of Applied Research Associates (SWDARA) headquartered in Albuquerque. He retired from Sandia Laboratories as a distinguished member of the technical staff in 1996 and joined SWDARA that same year. He has been involved with the experimental measurement and theoretical description of condensed matter under the extreme pressure and temperature stimulus of shock and high-velocity impact for more than 30 years. Dennis' mentor was **George Duvall**.

Ben A. Johnson (B.S. 1984) is the technical director for an Australian radar company, RLM Pty. Ltd. He has been heavily involved in the design, deployment, and incremental improvement of a network of high-frequency radars in Australia. After graduating from WSU, Ben worked for five years at Hughes Aircraft Company in Los Angeles, designing signal processing algorithms for airborne radar systems, and worked on a Master's degree in Electrical Engineering at University of Southern California. In 1998 he moved to Australia where he is working on a doctorate in adaptive signal processing in addition to leading RLM's research and development program. Ben visited with **Tom Dickinson** recently and expressed his appreciation for how valuable his physics background at WSU has been—especially while working with high frequency radars and the physics principles that have helped him understand and optimize various radar signal processing algorithms.

A hearty congratulations goes to **Tom Matula** (Ph.D. 1993), who has accepted the position of Director of the Center for Industrial and Medical Ultrasound (CIMU) at the Applied Physics Laboratory at the University of Washington. CIMU is an inter-departmental, multi-disciplinary organization dedicated to ultrasound education, research, and technology development for the academic, industrial and medical communities. Tom has been an APL employee for the last fifteen years and the acting Director of CIMU for the past eighteen months. Tom's major professor was **Phil Marston**.

John Renshaw (B.S. 2006) is working on his doctorate at the School of Physics at the Georgia Institute of Technology in Atlanta. John's research interests lie in solar energy and his advisor, Regents Professor, Ajeet Rohatgi, is an internationally recognized leader in photovoltaics. John laments that while he is having a good time in graduate school, he misses the friendly and easy-going atmosphere of Pullman.

Ralph Simmons ('79 Ph.D.) and his wife, Linda, visited the department last spring to give a lunchtime talk to the Physics & Astronomy Club on "Experience as a Physicist in the Data Storage Industry." Many graduate and undergraduate students enjoyed Ralph's insights into getting and maintaining a career in industry. He retired from Hewlett-Packard in June of 2007. Graduating senior, Bobbie Riley has spent the last two summers with Ralph and Linda working on an internship at HP. The Club hopes to host more talks on career and professional development in the future. Tom Dickinson was Ralph's major advisor.

Weiya Zhang (Ph.D. 2006) is working as an associate specialist at University of California at Merced on concentrating photovoltaic (CPV) solar energy system. Mark Kuzyk was his major advisor.

Another one of **Mark Kuzyk's** Ph.D. students, **Juefei (Jeff) Zhou** (Ph.D. 2007) is working in a postdoctoral position in the Department of Physics at Case Western Reserve University in Cleveland. Some of the projects he has been researching include: photovoltaics, photonic crystals and all polymer lasers.

Student Awards and Recognition
Physics Textbook Scholarships 2007 - 2008

Jacob Abel
Ben Arthurs
Christopher Bates
Margaret Betts
Aaron Colby
Rosanne Garcia
Kimberly Hansen
Cayla Jewett
Mark C. Kuzyk
John Lee
John Leraas
David Mackay
Sarah Myers
Ben Norman
Kristofor Nyquist
Bobbie Riley
Nickolas Schachtsick
Brandon Shibley
Urszula Szafruga
Jonathan Thompson
Ashley Tracey
Nicholas Ulrich
Bryan Young

The Claire May Band Scholarship in Physics and Astronomy

Brittany Corley – Klahowya Secondary School, Silverdale, Washington

Granted Degrees, August 2007 – May 2008

Bachelor of Science

Ben Arthurs
Christopher Bates
John Leraas
Ben Norman
Andrew Nelson

Doctorate

Kyungmin Baik
Natnael Embaye
Joel Lonzaga
Seth Root
Juefei Zhou

Master of Science

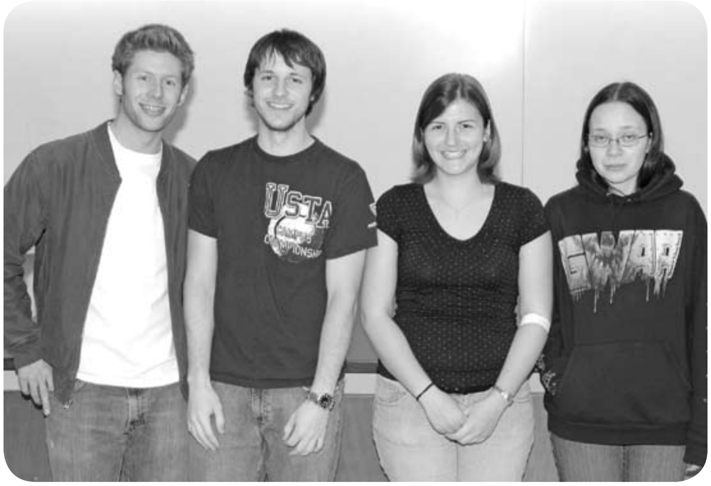
Xia Jiang
Jon La Follett
Brandon Lalone
Ingmar Saberi
Jennifer Schei
Muhammad Asad-uz Zaman
Ye Zhu

Materials Science

Christopher Dudley
Win Maw Hlaing Oo

Some of our recent M.S. and Ph.D. recipients: Front row: Jennifer Schei, Win Maw Hlaing Oo; Kyungmin Baik, Jon La Follett, Muhammad Asad-uz Zaman, and Professors Matt McCluskey and Steven Tomsovic

Outstanding Undergraduates



Undergraduates: Christopher Bates, Mark C. Kuzyk, Bobbie Riley, and Urszula Szafruga

Ben Arthurs: Honors College "Pass with Distinction"; Sigma Xi Undergraduate Third Place Award for paper titled, "AFM Studies of Gypsum Single Crystal Growth".

Christopher Bates: Center for Integrated Biotechnology Award – 2008; Honors College "Pass with Distinction" award - "Thesis with Distinction"; Sigma Xi Undergraduate Research Recognition. Chris is working in a Seattle hospital and applying to medical schools.

Bryant Hawthorne: Building Industry Association of Washington, 2007 Scholarship and College of Sciences Student Ambassador.

Bobbie Riley: Boeing Scholar in the Sciences; College of Sciences Student Ambassador.

Jeremy Smith: One of three WSU students newly licensed by the U.S. Nuclear Regulatory Commission as Nuclear Reactor Operators at the WSU Nuclear Radiation Center.

Urszula Szafruga: Boeing Scholar in the Sciences.

Bryan Young: NASA Space Grant Scholarship. Bryan is heading up the Engineers Without Borders (EWB) solar project to help produce renewable energy for developing nations.

College of Sciences - Undergraduate Research Mini-Grant Awards: ($2,500)

Kristofor Nyquist, faculty mentor Doerte Blume
Gunnar Skulason, faculty mentors James Bruce and Tom Dickinson

Undergraduate Research Poster Competition (Physics and Mathematics Division)

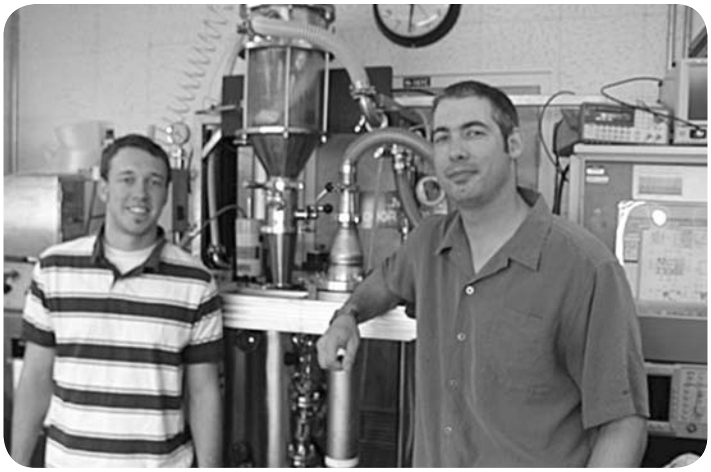
First Prize: Christopher Bates, faculty mentor, Tom Dickinson
Second Prize: Mark C. Kuzyk, faculty mentor, Mark G. Kuzyk

Ellen Hauge Abelson Endowed Scholarship in Sciences

Robert Dawson
Ryan Larson
David Mackay

2008 Summer Internships

Bobbie Riley – Hewlett-Packard, Boise.
Brandon Shibley - Los Alamos National Laboratory, New Mexico.
Ashley Tracey – Schweitzer Engineering Labs (SEL), Pullman.



Graduating senior, Brandon Shibley (left) spent the summer at Los Alamos National Lab in the Materials Physics and Applications, group 11. He worked under the direction of Dipen Sinha and Curtis Osterhoudt (Ph.D. 2007) who research acoustics and sensors technology. Brandon worked on instrumentation for Swept Frequency Acoustic Interferometry (SFAI), doppler spectroscopy as well as other ultrasonic sensing techniques. Seen here with Curtis Osterhoudt.

Graduate student **Jon La Follett** received a second prize of $200 for the best student paper award in underwater acoustics at the June meeting in Paris. His paper, "Elastic and Interfacial Contributions to SAS Images of Tilted Metal Cylinders: Laboratory Experiments" was the result of collaboration with his advisor, **Philip Marston**, and **Kyungmin Baik** (Ph.D. 2008). In other good news, Jon has been selected as a student council representative for the Physical Acoustics Technical Committee. The two-year term began in November at the 156th Meeting of the Acoustical Society of America held in Miami.

Kudos to doctoral candidate, **Leiming Wang** who was awarded the *Leon and Barbara Radziemski Graduate Fellowship* in the Sciences last spring. In September he took first place in the Graduate Student Poster Competition at the 19th Annual Symposium of the Pacific Northwest Chapter of the AVS Sciences and Technology Society held in Richland, Washington. Leiming's poster, "Doping the Golden Buckyballs: M@Au16- Clusters," brought him a cash prize of $500 and an additional $500 for his travel to an AVS national meeting. He collaborated on the project with **Wei Huang** and **Lai-Sheng Wang**. Leiming has been working closely with his major professor, Lai-Sheng at the WSU Tri-Cities campus since January of 2006.

Wiley Research Expo Recipients: Engineering and Physical Sciences

First place: Sharon John George
Second place: Romit Dhar (Mat. Sci.)
Third place: Kelly Jones (Mat. Sci.) and Xia Jiang

"Sharon, is it true that there is life after graduation?" Doctoral candidate, Sharon John George with her mentor, Tom Dickinson.

"All work and no play …" Second year graduate students, front and clockwise, Szymon Steplewski, Brooks Harrop, Kevin Daily, Christopher Varney, Marc Binney and Violet Poole.

"Pumpkin Tossers," for Dad's Weekend 2007, Front: Ashley Tracey, Megan Betts, Congresswoman Cathy McMorris Rodgers, John Leraas, Jeremy Smith, Christopher Bates with WSU President Elson Floyd and far back, Brandon Shibley.

Graduate Assistance in Areas of National Need

The GAANN Fellowship is a program designed to enhance teaching and professional development.

GAANN Fellows 2008 – 2009

Mark Binney, Brooks Harrop, Michael Humpherys, Drew Haven and Josef Felver. Not shown, Gregory Bowers.

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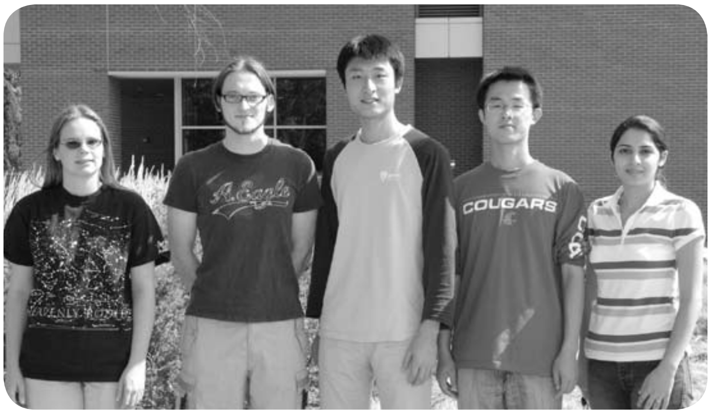
Millennium Fellows were created for students who are ready to focus on a specific line of research. The Millennium Fellowship is an attractive alternative to a teaching assistantship; it provides support for the first year of study to work in one of our world-class laboratories or theory groups.

Millennium Fellows 2008 – 2009



Violet Poole, Kevin Daily, Zhaozhe (David) Li, Yinyin (Eric) Qian and Afsoon Soudi.

IN MEMORIAM

Constance "Joy" Schroeder, who worked as a graphic illustrator in the WSU physics department for many years, died July 19, 2008 in Pullman. Joy was 87 years old. After her retirement in 1983, she and her husband Carl traveled extensively.

Awards and Recognition

2008 has been a fruitful year for **Tom Dickinson**. The Honors College at WSU presented him with their *Undergraduate Research Mentor Award* for 2008. Tom was made a fellow by the Materials Research Society "for contributions to understanding the mechanisms involved in fracture, tribology, and laser interactions with materials through innovative experimental studies of fractoemission, nanoscale tribochemistry, laser-induced emission, and surface modification." This is in addition to him being a "most happy fellow" of the American Association for the Advancement of Science, the American Physical Society and the American Vacuum Society.

KWSU Media launched a new series: EXPERIENCE WSU. The series focuses on producing short-form documentaries that offer a glimpse into the rich intellectual, artistic, and scientific life of Washington State University. The first five episodes featured Special Collections Librarian Trevor Bond, Director of the Center for Reproductive Biology Michael Skinner, and from the Department of Physics and Astronomy, Professors **Mark Kuzyk**, and **Lai-Sheng Wang**, and Instruction/Classroom Support Tech. IV, **Tom Johnson**. Coming soon will be the taped September visit of WSU alumnus and former astronaut, John Fabian and cosmonaut Pavel Vinogradov, the test-cosmonaut of the 'Energia' Rock Space Corporation'. Fabian and Vinogradov gave a public talk and later visited the Physics and Astronomy Department where they spoke to a large group of interested students. EXPERIENCE WSU originally aired on KWSU-TV and is available online. Visit www.kwsumedia.org and click on EXPERIENCE WSU at the top of the page.

Philip Marston was elected to a three-year term on the *Physics Today* Advisory committee. Last spring the College of Sciences honored Philip with their "Distinguished Faculty Award at their annual recognition event.

Steven Tomsovic was inducted into the Academy of Sciences and Arts (ASA) at Michigan Technological University (MTU). The ASA gives public recognition to alumni who "have brought distinction to themselves, the College of Sciences and Arts, and Michigan Technological University through their outstanding contributions to and leadership in their chosen professions." As part of the award, he gave a colloquium talk in the department of physics. Steve received his Bachelor's from MTU in 1980 and went on to do his Master's and Ph.D. work at University of Rochester.

Lai-Sheng Wang has been elected to the rank of fellow in the American Association for Advancement of Science (AAAS). Wang's AAAS election recognized his "distinguished and innovative contributions to the field of atomic clusters for pioneering work on gaseous multiply charged anions."

Afsoon Soudi and Shoresh Shafei.

From Tehran to Pullman: From “Rush Hour” to “Rush Minute”

Iran is the18th largest country in the world in terms of area—only slightly smaller than the state of Alaska. Until 1935 internationally know as Persia, Iran has a population of over seventy million and according to Wikipedia, has one of the highest urban-growth rates in the world. Tehran, the capital of Iran is the country’s largest city and the political, cultural, commercial, and industrial center of the nation. It has a population of 7.7 million and is home to nearly 11% of Iran’s population.*

In the fall of 2007, two graduates from the University of Tehran left one of the “world’s oldest continuous major civilizations” for the thriving, albeit tiny, town of Pullman. Population, including students is 27,150. **Afsoon Soudi** and her husband **Shoresh Shafei** had little idea they would find such a huge contrast between Tehran and Pullman. At first sight they loved the campus, but the town was almost nonexistent compared to home. However, as Shoresh explains, “One of our first friends in Pullman told us that for a student it doesn’t matter where one lives because there is little time for anything except studying. Afsoon and I both grew up in populated cities. Our life experiences and conditions were completely different from Pullman. It took us a while to adjust to the quiet nature of a small town. We have since discovered there are some benefits to living in such an environment. For example, we have plenty of time to do the things we need to do—there is no traffic and no stress. We can easily concentrate on our physics, which is our primary reason we are here.”

Shoresh has always been curious and has had a desire to learn. “From a very early age I was interested to know about fundamental laws governing the world. Similar to Einstein, I want to know how God thinks and I believe physics is the best way to approach this goal. Our religious beliefs strongly encourage us to learn and experience science. Also, my high school physics teacher inspired me to learn physics and investigate the world.” Afsoon agrees, “I love physics because one can understand and interpret everything—even things one cannot see—through electronics, quantum, optics … and I also had very good physics teachers in high school. Their enthusiasm was inspiring and they helped me learn to love physics.”

Having the opportunities to study physics in a small town environment is both exciting and challenging. Afsoon and Shoresh agree that one of the main reasons they find life in Pullman so agreeable is because of the people. “We would like to thank everyone—the staff, the faculty and our friends who have encouraged us. They all have helped us to adapt to new situation and our life is such that can we can enjoy our studies at WSU.”

**Taken from: en.wikipedia.org/wiki/Iran*

Women in SCIENCE:

Opportunities Are For the Taking

Ashley uses a diamond blade saw to remove a portion of a circuit board in preparation for cross-sectioning.

Undergraduate women researchers in physics are still the exception rather than the rule. Two outstanding students, **Ashley Tracey** and **Bobbie Riley**, share their viewpoints and experiences studying in a traditionally male-dominated field.

Q: What attracted you to WSU?

A: Bobbie: "Representatives from the physics department at WSU actually came to my high school.…I was quite surprised and impressed at the incredibly warm welcome WSU gave me even before I had decided I would be attending and thought, if that was the kind of reception I could expect as simply a potential student, then I definitely could see myself attending WSU for college."

A: Ashley: "I grew up in Bothell, Washington and during my senior year of high school I decided I wanted to go away for college. I applied to schools in Colorado and California and to Washington State University. When it came to choosing what school I would attend the next fall, I looked at the location of the schools relative to my hometown. I wanted to get away but I didn't want to go too far. When I accepted my invitation to come to school at WSU, I hadn't even seen the campus before. In fact, my first visit to Pullman was when I came here for summer orientation just a month before my freshman year began. When I got here, I loved it instantly: the people, the campus, my classes, everything. I had no idea what to expect, but I couldn't be happier that I chose to spend the last four years here."

Ashley views a cross-section sample using a metallurgical microscope.

Q: Describe your research and laboratory experience.

A: Bobbie: "At WSU I worked in Professor Matthew McCluskey's laboratory where I pioneered the development of three-dimensional imaging techniques for samples in a Diamond Anvil Cell—a device used for high static pressure experiments. The new 3-D imaging allows for greater insight into phase changes, crystal structures, hysteresis paths, etc. by showing a physical picture to correspond to pressure, temperature, and composition data attainable through measurements using the Diamond Anvil Cell."

A: Ashley: "I've been a process engineering intern at Schweitzer Engineering Laboratories, Inc., (SEL) in Pullman since December of 2007. SEL designs and manufactures power grid protection relays, making electric power safer, more reliable, and more economical. I do research in failure analysis and manufacturing processes. Much of my time is spent in the Forensics Lab at SEL, where I have learned how to cross-section and evaluate an assortment of electronic materials, including circuit boards and PCB components, such as resistors, LEDs, and integrated circuits. This process consists of encasing a specimen for analysis in an epoxy/hardener mixture, then grinding and polishing the encased specimen until the suspected failure site is exposed. During the analysis process, I've learned how to use a variety of technologies. By the use of a metallurgical microscope, I've been able to detect intermetallics, cracks, or impurities present in boards or components. Also, by utilizing the energy dispersive spectroscopy function of one of WSU's scanning electron microscopes, I've been able to determine the composition of materials, identifying any ionic contaminants or organic materials which may be causing process anomalies. It's definitely been challenging at times, but I've had a lot of fun and have learned how and where I can apply my last four years of school to industry."

Q: Do you plan to go to graduate school?

A: Bobbie: "Yes, absolutely. The longer I stay in school working toward my Ph.D. the more opportunities I get for summer internships and research positions and the better of an idea I get for what I really want to do."

A: Ashley: "I want to work on my Ph.D. in materials science and engineering so I can have the option of teaching later on, but I am also anxious to join the work force."

Q: Outside of the usual course work, what preparation, if any, would you recommend undergraduates make before entering graduate school?

A: Bobbie: "Apply for internships. I did an internship [for the past two summers at Hewlett-Packard, in Boise] and it was such an eye-opening experience to see so many opportunities outside of academic research that I hadn't even considered. I think the best preparation you can have for grad school is being able to go in knowing you are doing something that you want to do, not something you think you might want to do."

A: Ashley: "… focus on truly learning the material presented in class, establish good relationships with your professors and obtain an internship or participate in some sort of research in your department. This looks good on graduate school applications and it helps you figure out your interests. Also, get involved in school clubs that relate to your major. Not only are they fun, but you learn a lot and have the opportunity to build a network of individuals whose academic and professional interests are the same as yours."

Q: Do you believe there is a gender bias regarding women in the sciences—specifically, in the realm of physics? Do you believe your gender will help/hurt you attain your long term goals?

A: Bobbie: "A woman in a primarily male-dominated field is a rare commodity and if she can achieve her goals over the dozens of other male counterparts in her field, then she'll get greater recognition for it in the long run."

A: Ashley: "I wouldn't be telling the truth if I said there was not a gender bias regarding women in the sciences, physics included. How much of a bias, I do not know, but it is obviously there. All of my physics classes, except one, have had an enrollment dominated by males. For this reason, I believe that my education and career goals will be affected by my gender, and I hope positively. It may assist me with my acceptance into graduate school or even help me get an initial interview with a company. However, I hope it ends there because I would like to believe that I achieve my long term goals due to my talents, and not my gender."

Bobbie Riley

Q: What are your long term plans?

A: Bobbie: "Grad school. Then I eventually want to work for a space program. Who knows, maybe I'll get an opportunity to go to space someday and I think that would be my ultimate dream come true."

A: Ashley: "Part of me still wants to go to grad school but the other part of me likes what I do at SEL and would like to stay there. I am torn. So, I'm going to take the GRE's, apply to some schools and take it from there."

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What's special about Zinc Oxide?

WSU physics department researchers who are focusing their attention on zinc oxide (in the summer, they all "sunlight" as life guards at local beaches protecting their noses, as shown here, with ZnO). From left to right: Matt McCluskey, Farida Selim, Tom Dickinson, Yi Gu, and Marc Weber. Their ZnO work is sponsored by several grants from the National Science Foundation and the Department of Energy.

Several people in the physics department have recently focused a good portion of their research time on a compound that is becoming more and more important technologically: Zinc Oxide (ZnO). In the old days, the most commonly used sunscreen was loaded with very fine particles of ZnO. The "whiteness" of the sunblock is simply due to light scattering from the small ZnO particles, like powdered sugar. But the protection from sunburn is due to the fact that ZnO itself is a strong absorber in the UV. Zinc Oxide is a transparent semiconductor with a direct bandgap energy of ~3.37 eV at room temperature, which means it absorbs light with wavelengths shorter than 360 nm. It is a wide bandgap semiconductor. It occurs in nature as the mineral zincite. Single crystal ZnO is piezoelectric and also exhibits thermochromatism, changing color from white to yellow when heated. A wide variety of ZnO nanostructures can be generated, some are discussed below, making it an important nanomaterial.

Today, one of the most common applications for ZnO is in laser diodes and light emitting diodes in the blue to UV region of the spectrum. Because of a very healthy quantum efficiency, ZnO is a strong candidate for energy efficient lighting applications. The latter is partially due to its large exciton binding energy which results in a high probability for radiative recombination even at high temperature. ZnO can also be used as a transparent conducting oxide coating and has potential for use in solar cells, LCD, and flat panel displays.

With regard to future improvements and extending ZnO applications, the role of doping, oxygen vacancies, zinc interstitials, and hydrogen impurities are of considerable interest. Robust p-type doping has not yet been achieved. On a positive note, doping with elements such as Mn and Co, have led to potential magnetic semiconducting materials with possible applications in spintronics. Clearly there is a lot of motivation to understand and improve this material.

Farida Selim, one of our physics teaching postdoctoral fellows, has been focusing on research addressing the barriers to forming stable p-type ZnO. She, with **Marc Weber** and **Kelvin Lynn**, has studied the nature of point defects in ZnO using positron annihilation and optical transmission. Their goal is to understand the origin of native donors and reveal the reasons behind the difficulty in p-doping. One study started with the defects generated by heating ZnO crystals at 1100 C in Zn vapor. One consequence is a very red/orange crystal shown in Fig. 1.

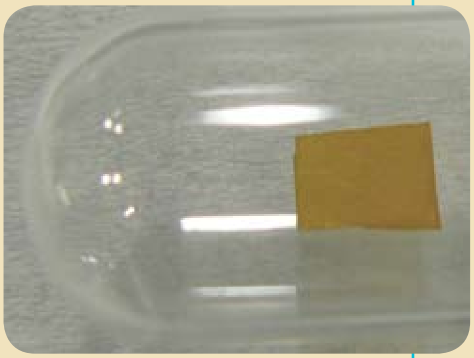

Fig.1

Careful work has first confirmed that oxygen vacancies play a critical role in the origin for the shift in the optical absorption band that causes the red or orange coloration. Secondly, they showed that hydrogen, not Zn interstitials, was the dominant donor in as-grown ZnO. However, the role of compensating defects in preventing p doping is still under investigation. Recently, because defects play a major role in providing the carriers that mediate ferromagnetism, Farida has been examining point defects in transition metal-doped ZnO. She is also examining the novel uses of radiation to achieve p-type ZnO--methods which might overcome current doping problems. Her studies are carried out in collaboration between our department, the WSU nuclear radiation center, and the University of Idaho. Farida is also putting together a comprehensive review book on ZnO with contributions from eminent scientists from all over the world. This will inform the ZnO community of the latest developments and help define future research directions.

Marc Weber, **Kelvin Lynn**, and student **Narendra Parmar** are looking at this coloration of ZnO with metal vapor exposure, and are revisiting the role of hydrogen in the process. Hydrogen is omnipresent and a shallow donor and generally accepted to cause the n-type conductivity of as-grown ZnO in an interstitial state. Other states of hydrogen exist in ZnO, some of which are not detectable by IR spectroscopy. They are researching the annealing in the presence of titanium metal depleted of or preloaded with hydrogen. Ti forms a strong bond with oxygen. Annealing ZnO in the presence of titanium removes oxygen from ZnO just as in the case of Zn metal. Ti is known to absorb hydrogen very efficiently and is used to pump hydrogen in vacuum systems. In the presence of Ti with hydrogen ZnO turns reddish, very much like in the presence of zinc as reported by Selim. To deplete hydrogen from Ti the metal is heated repeatedly before it is sealed in an evacuated ampoule with the ZnO sample. With hydrogen-free Ti ZnO remains transparent. Furthermore, ZnO previously annealed with Zn metal present and hence red also turned transparent when annealing with Ti (H depleted). Their current interpretation is therefore: Hydrogen must be present to turn ZnO red. The role of oxygen vacancies and their link to hydrogen is under further investigation. Potential defects are diatomic hydrogen or oxygen vacancies filled with hydrogen.

Our newest assistant professor, **Yi Gu**, has a strong interest in the physics and technology of nanostructures. Yi sees the tremendous potential for use of ZnO nanowires to capture solar energy [FACT: more energy from sunlight strikes the earth's surface in one hour (4.3×10^{20} J) than the world currently consumes in one year (4.1×10^{20} J); solar accounts for only 0.015% of the world's electricity production.] ZnO nanowires, configured as high efficiency dye-sensitized solar cells (DSSCs), have been proposed as a promising material due to their straightforward synthesis, environmental compatibility, high chemical and thermal stability, and low cost.

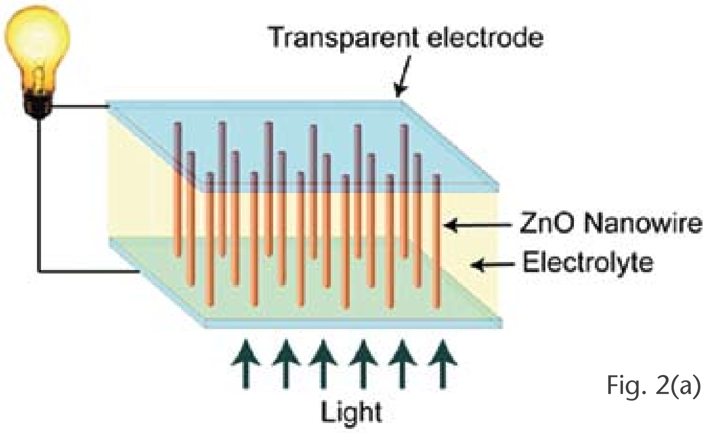

Fig. 2(a)

Fig. 2(a) shows a DSSC based on ZnO nanowire arrays. An electric current is generated when photogenerated electrons are transported through nanowires to the bottom electrode (photoanode) with photogenerated holes carried to the top electrode (photocathode) by the electrolyte inside the solar cell. In this type of solar cell, the expectation of efficient energy conversion stems from the theoretical prediction that electrons travel faster in nanowires than in bulk materials. This faster electron transport would enhance the electron collection and thus the solar energy conversion efficiency.

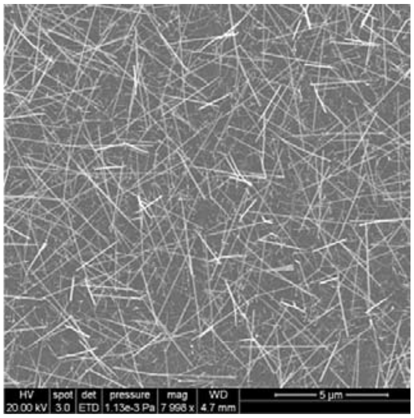

Fig. 2(b)

Yi's group is currently pursuing experimental studies on home grown ZnO nanowires (a Scanning Electron Micrograph (SEM) of large numbers of nanowires is shown in Fig. 2b) to provide insight into carrier transport properties and to establish a fundamental understanding of transport-limiting mechanisms. Yi's methods include various nanometer scale scanning probe microscopy techniques that combine electrical and optical probing capabilities.

Matt McCluskey is also interested in ZnO as an electronic material and the pesky p-type conductivity roadblocks. Both first-principles calculations and experimental studies, including those of Farida above, have confirmed that hydrogen acts as a shallow donor in ZnO, in contrast to hydrogen's usual role as a passivating impurity. Given the omnipresence of hydrogen during growth and processing, it is important to determine the structure and stability of hydrogen donors in ZnO. The McCluskey group has focused on hydrogen donors in ZnO, using infrared spectroscopy to determine their structures. The hydrogen bonds they observe are unstable, decaying into an unknown, "hidden" species after a few weeks at room temperature. The identity and potential importance of this hidden species is still under study.

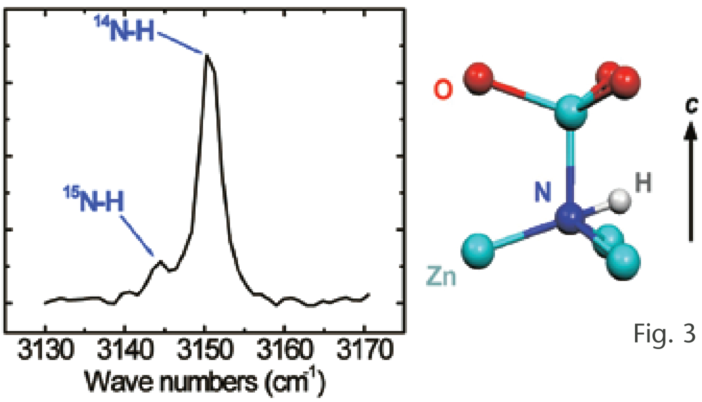

Fig. 3

They are also investigating nitrogen as a possible acceptor dopant. Recently, they reported the successful incorporation of nitrogen-hydrogen (N-H) complexes in ZnO during growth, using ammonia as an ambient. This could be an important first step toward p-type ZnO. Figure 3 is an IR spectrum of N-H pairs in ZnO, showing the isotope shift due to nitrogen. Next to the spectrum is a ball-and-stick model of the N-H complex in ZnO.

Tom Dickinson, **Steve Langford**, and student **Enam Khan** are examining zinc oxide as part of their focus on defect production in transparent, wide bandgap materials by laser radiation. This work is being done in collaboration with **Dr. Lynn Boatner**, Oak Ridge National Laboratory, who specializes in growth of single crystals.

In most of the materials studied, ultraviolet laser radiation creates excitations that decay to yield defects, such as chlorine vacancies in sodium chloride (table salt), easily seen by visible coloration of the crystal. Photoexcitation of ZnO with nanosecond pulses and energies just across the bandgap does not produce lattice defects. However, using a bigger hammer—using photons whose energies (6.3 eV) are nearly twice the band gap--was seen to generate visible coloration: namely a gray to black darkening. The first question was (i) WHERE: that is, was the actual coloration in the bulk or on the surface); (ii) second WHAT caused the darkening; and (iii) third HOW did it form. A photo in white light of three exposed spots is shown in Fig. 4(a).

To make a long story very short, Dickinson's group has found: (i) the coloration originates strictly on the surface – there is no bulk coloration detected. At low laser intensities, this coloration is limited to the laser spot; at high laser intensities, the inner spot is bleached and a ring surrounding the laser spot grows very black. (ii) The darkening is caused by the generation of huge numbers of metallic zinc nanoparticles (~20 nm in size—see Fig. 4(b)) sitting on the surface [for example, within Spot 1 we estimate a total of more than 4 x 108 nanoparticles]. For the high intensity exposures, most of the nanoparticles have been removed from the irradiated region and the surrounding surface consists of extremely dense Zn structures generated by aggregation of nanoparticles—this leaves behind a very dark "bathtub" ring. (iii) Briefly, mass spectroscopy shows that very intense atomic and molecular oxygen, O and O_2, are removed by the laser irradiation. Although Zn emission is also seen, strong preference for oxygen removal is leaving metallic Zn behind. Dickinson's group is working on a model which starts with hot electron hole pairs generated by the laser and leads to the observed crystal modification and mobile Zn. Also, interesting electronic properties of these exposed regions are being studied using conductivity and Hall Effect measurements in collaboration with **Yi Gu** and **Matt McCluskey**.

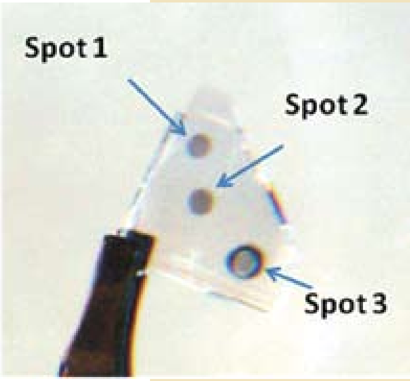

Fig. 4(a)

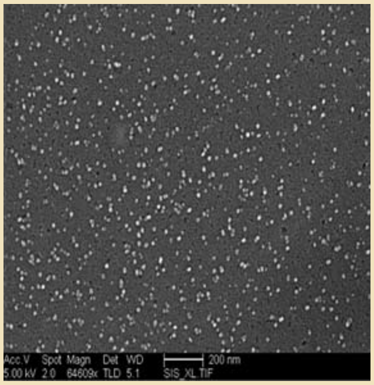

Fig. 4(b)

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