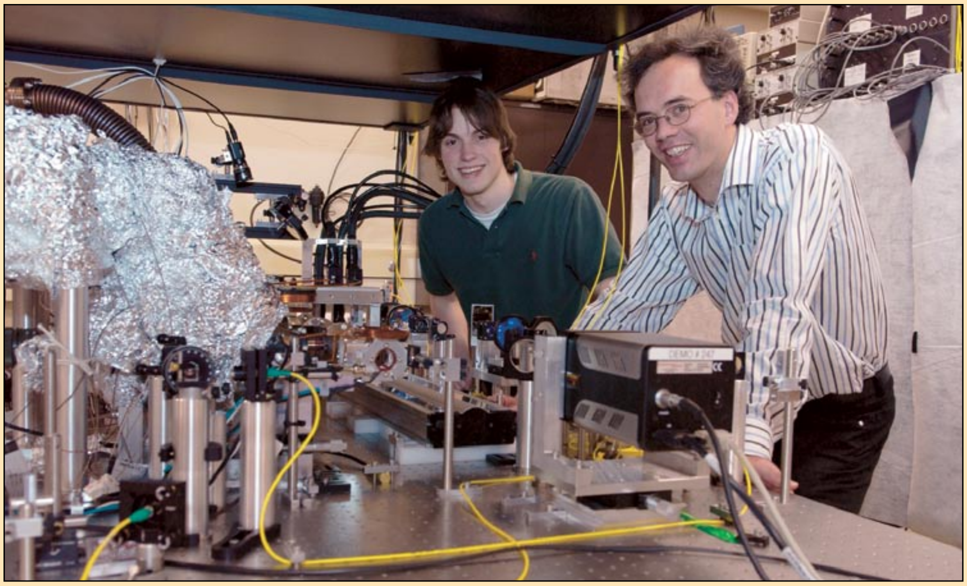
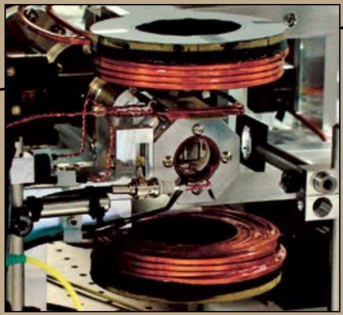
Physics Matters

Department of Physics and Astronomy

Winter 2006–2007





Atom trap used to create Bose-Einstein condensates. Strong magnetic fields produced by an assembly of coils confine atoms in the center of a vacuum cell. The vacuum insulates the ultracold BEC from the room-temperature environment.

WSU Physicist First in the Northwest to Produce Rare Form of Matter

Dozens of lenses, mirrors, lasers, and vacuum chambers sprawl across two large tables, linked by electrical cables, optical fibers, and water lines. Physicist **Peter Engels** flips switches and adjusts dials. The machine clicks through its procedure, and a minute later a computer screen flares with a pencil-shaped bright patch on a field of gray.

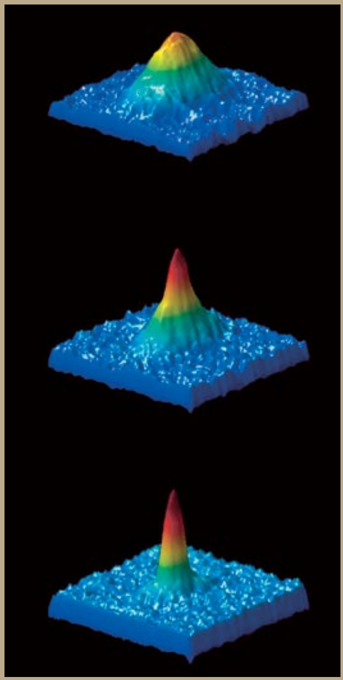
"It's the coldest thing in the universe," said Engels, nodding toward the bright image.

He has just produced Bose-Einstein condensate (BEC), a rare and, as Engels calls it, "weird" form of matter in which atoms behave like waves rather than like particles. The ability to produce BEC is something of a holy grail in modern atomic physics; Engels' Washington State University lab is the first in the Pacific Northwest to accomplish it.

Engels, an assistant professor in the Department of Physics and Astronomy, says being able to make BEC opens a wide range of experimental possibilities in such areas as nuclear physics, astrophysics, and quantum optics. Comprised of gaseous atoms that are cooled nearly to absolute zero (-459 degrees Fahrenheit), BEC has potential applications in ultrasensitive sensors of gravitational fields and in powerful new computing systems known as "quantum computers."

Bose-Einstein condensates are even colder than the deep reaches of space, which register about three degrees above absolute zero. They were named for physicists Satyendra Nath Bose and Albert Einstein, who in the 1920s theorized that gases would condense into the unusual form if temperatures that low could be attained. The feat was accomplished for the first time in 1995, by Eric Cornell and Carl Wieman of the University of Colorado and independently by Wolfgang Ketterle of MIT. These three researchers shared the Nobel Prize for Physics in 2001 for their pioneering work.

Continued on page 3



BEC images from Peter Engels' lab: Experimental images showing the emergence of a condensate from a cloud of classical atoms as the temperature approaches absolute zero. Upper image: classical atoms before BEC transition. Middle image: A narrow density peak emerges as atoms condense into a BEC. Lower image: pure BEC.

Washington State University

World Class. Face to Face.

Greetings from the Chair

The Department of Physics and Astronomy had an incredible year. We saw Buckyballs made of gold, molecules designed to speed up the Internet, a novel pulsed-power facility to study shock physics, pictures of ancient galaxies from the Hubble Space Telescope, and the creation of Bose-Einstein Condensate. In addition to publications in top-tier journals, our research breakthroughs were featured in *WSU Today*, the *Spokesman Review*, and the *New York Times*. The hard work of the faculty, staff, and students was recognized by a shower of awards and scholarships (see pages 9 and 12). **Steve Tomsovic** was awarded the 2006–2007 Martin-Gutzwiller Fellowship by the Max-Planck Institute for the Physics of Complex Systems—which is why I'm the acting chair this year.

Amazingly, all of these achievements were carried out by a relatively small department. We have only sixteen full-time-equivalent tenure-track and tenured professors, all of whom are engaged in vigorous research programs. Simply put, we are *lean* and *mean*. The department is ideally positioned to grow. Over the next two years, we will hire three new faculty: two theorists, including the endowed William Band Chair of Theoretical Physics, and one experimentalist. At the same time, we are actively identifying strategic areas where we plan to expand in the long term. Along with the growth in faculty numbers, the graduate student population is increasing, fueled by new fellowships and a major recruiting push by the faculty, students, and staff. This fall, we welcomed nineteen graduate students to our department, a level not seen since 1991.

Our undergraduate enrollments have increased 60% since 1998, when I arrived at WSU. To help support the increased enrollment this year, we hired an office assistant, **Jana Vitamanti.** We also hired a new instructor, **Nicholas (Nick) Cerruti,** who started teaching this fall and **Ralph Aeschliman,** who coordinates Project ASTRO. In addition to providing high-quality, face-to-face instruction, we are a leader when it comes to involving undergraduates in research. To enhance these research opportunities, we have established an endowed fund, the Tom Dickinson Undergraduate Research Stipends (see page 14). This is our top fundraising goal for 2006–07; please consider making a donation today. Your gift will provide student stipends and pay for special equipment.

In summary, our department continues to make breakthroughs in research and scholarship, with faculty and students who are truly "World Class." Enjoy reading about their numerous accomplishments.

Sincerely,

Matt McCluskey

Continued from front cover

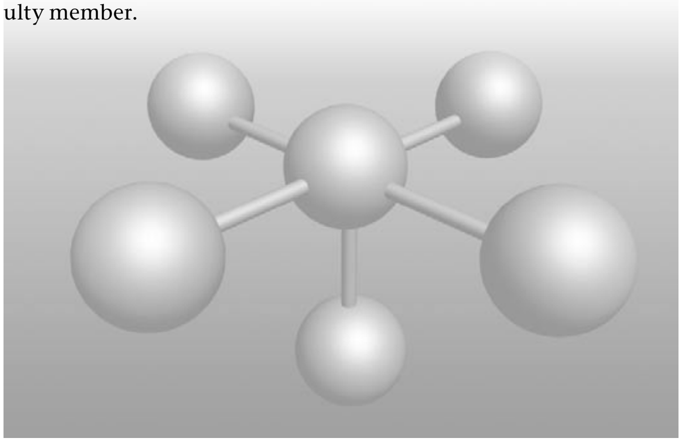
Usually, once a technical breakthrough has been made in a scientific field, other researchers are able to repeat the accomplishment more easily. But Bose-Einstein condensate remains notoriously difficult to produce. Engels says the main obstacle is achieving low enough temperatures while retaining enough atoms to form a condensate. Some of the chilling procedures cause atoms to be lost from the sample.

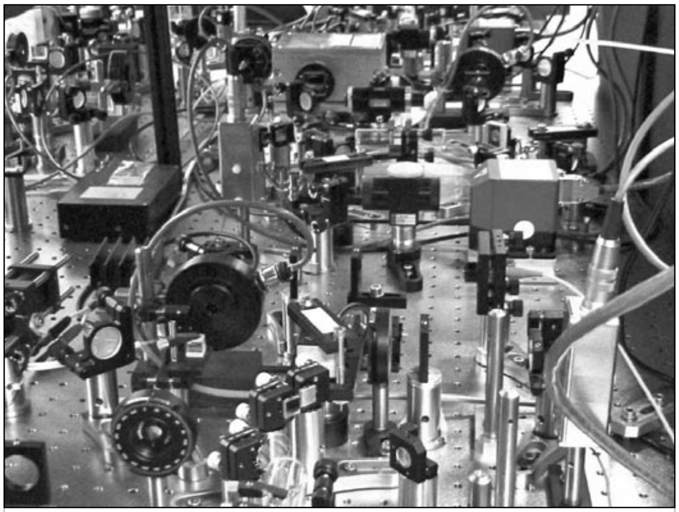
Engels, who worked in Eric Cornell's Nobel Prize-winning lab from 2001 to 2004, drew on his experience there in devising his own system for producing BEC. He and WSU's Technical Services team designed and built more than 200 parts and purchased nearly 300 more to create his experimental set-up. The project spanned a year and a half and was accomplished with the help of **Collin Atherton,** a physics major who just completed his sophomore year.

To cool a cloud of rubidium atoms to just a few billionths of a degree above absolute zero, Engels and Atherton combine sophisticated laser cooling and atom trapping techniques. First, they confine the atoms in an ultrahigh vacuum chamber by using six intersecting laser beams and a magnetic field. This arrangement traps the atoms in the center of the vacuum chamber and cools them to a few millionths of a degree above absolute zero in a few seconds. The vacuum provides thermal insulation that allows the cloud to reach ultracold temperatures while the instrument as a whole can be housed in the lab at normal room temperature.

A second cooling step removes the fastest-moving (most energetic, highest temperature) atoms from the sample, allowing the remaining atoms to cool further. Eventually they reach a low enough temperature—just a few billionths of a degree above absolute zero—to condense into a BEC. The entire trapping and cooling process takes about a minute. The resulting condensate persists for over a minute—more than long enough to perform experiments on how the atoms interact with each other in this highly unusual state.

Steve Tomsovic, chairman of the Department of Physics and Astronomy, said Engels' ability to generate BEC "gives us the opportunity to get into the forefront of a whole new area of physics." He said Engels' experimental work is complemented by theoretical research on BEC being done by **Doerte Blume**, also a physics faculty member.





Laser system used to trap and cool rubidium atoms during the creation of a Bose-Einstein Condensate.

"The development of quantum mechanics has been one of the most important achievements of modern physics. Quantum mechanics constitutes the basic foundation of nature on an atomic length scale. However, quantum mechanics is often at odds with our classical world, seemingly contradicting everyday experiences. Certainties are replaced by probabilities. A single atom, for example, can be in different states or even at different positions at a given time. Furthermore, quantum mechanics poses fundamental limits: We cannot know an object's position and momentum at the same time. For nearly a century, it has been a dream of physicists to realize a macroscopic object that behaves purely quantum mechanically. A BEC is exactly this—its realization gives physicists direct access to the quantum mechanical world."

–Peter Engels

Molecular Design:
Breakthrough May Unleash Full Speed of Internet

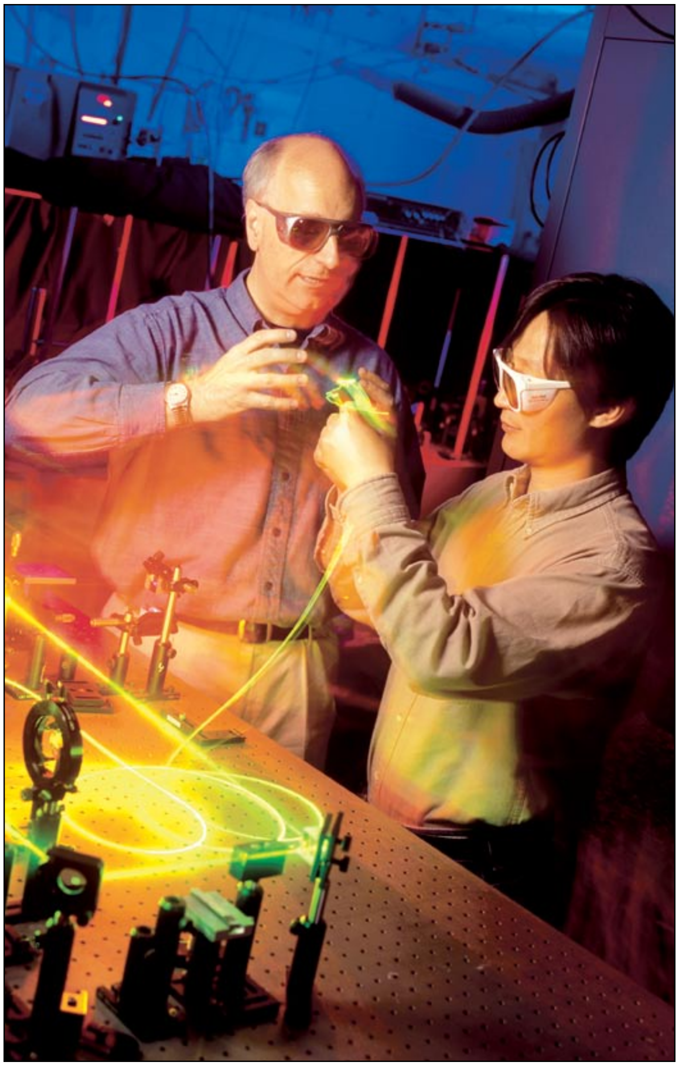
WSU researchers have created design guidelines for new molecules that could enhance the speed of Internet communications and other optical technologies. Physics graduate student **Juefei Zhou,** physicist **Mark Kuzyk** and mathematician **David Watkins** used computer simulations to design molecules that will interact very strongly with light. The vigor with which a material interacts with light affects high-tech applications such as the speed of the Internet, the amount of information that can be stored in a hologram, and the efficacy of some cancer therapies. “These molecules can be built up into materials to make tiny electro-optical switches to manipulate light the way a transistor manipulates electricity,” said Kuzyk.

Their results are published in the journal *Optics Letters*. A preprint is available online at Physics Archives. Ever since optical technologies became prominent in the 1970s, researchers have tried to improve the materials used to handle light. In 1999, Kuzyk discovered a fundamental limit to how strongly light can interact with matter. He went on to show that all materials ever examined fell far short of that limit. Even the best molecules had 30 times less “optical brawn,” as he calls it, than was theoretically possible.

He also showed that certain widely-publicized molecules, such as the soccerball-shaped “buckyballs,” interacted strongly with light because they tended to gather in large clumps, not because they inherently responded to light well. Kuzyk said that, to date, efforts to create materials that interact strongly with light have assumed the best molecules will have long stretches where electrons can move freely from end to end. By contrast, in his team’s new work constituents such as carbon, nitrogen, sulfur, and various ring structures are interspersed in a uniform molecular chain.

“Our results show that you need to place some obstacles along the way,” he said. “An electron in a molecule can be viewed as the metal ball in a pinball machine. The nuclei are the bumpers and hazards that knock the ball around.” The WSU team developed a computer program that Zhou then used to test different configurations of “bumpers” for their effect on a virtual molecule’s interaction with light. Their work found molecular designs that should reach within about 30 percent of the fundamental limit—a drastic improvement over the best molecules previously tested.

Ted Sargent, holder of the Canada Research Chair in Nanotechnology at the University of Toronto and author of the book *The Dance of Molecules,* praised the findings. “The work of Kuzyk and colleagues ushers in a new strategy to maximize the nonlinear optical behavior of materials,” Sargent said. “To do so is of critical importance to realize ultrafast optical switches—building blocks of a new, blazing-fast, all-optical Internet.”



Mark Kuzyk and Ph.D. candidate, Juefei (Jeff) Zhou

Koen Clays of Belgium’s University of Leuven and a leader in the characterization of optical materials said the WSU results have led him to examine molecules he previously might have overlooked. “Their paradigm is giving us lots of new ideas,” he said. Kuzyk is the Boeing Distinguished Professor and associate chair and Zhou is a graduate student. Watkins is a professor in the Department of Mathematics and Statistics.

Seeing Stars Inside:
The WSU Planetarium Lights Up Sloan

Story by Shannon Bartlett. Reprinted from the *Daily Evergreen,* March 28, 2006.

The University holds a universe with the stars shining inside Sloan Hall. "The planetarium helps in learning how to find your way around the sky," said **Guy Worthey**, WSU associate professor of physics and astronomy. Aided by a series of charts, a large sphere with a powerful light bulb inside projects the stars onto the 24-foot dome. "Where a star is in the real sky, there's a hole punched in the ball," Worthey said. "The number of stars [shown here] is only a few hundred. [But] there are about 6,000 stars you can see with your eyes." The planetarium is a valuable teaching tool for astronomy classes, as well as other interested groups. "By sitting under the night sky, you can communicate concepts of motion and position that no diagram in a textbook can do, and no night sky software can provide," said **Michael Allen**, instructor of physics and astronomy. Worthey agrees, especially with teaching concepts such as the seasons. "It's an immersing environment," he said. "It's useful for astronomy class—you can come in here and it's much more visceral. For example people have trouble visualizing why the tilt of a ball creates seasons." Because the sun's path is different from what is known as the celestial equator—the true equator—by 23 and a half degrees, the seasons change when the sun's path crosses this celestial equator, Worthey said. At the spring and autumn equinox, the sun rises due east and sets due west. "The reasons the dates of the equinox sometimes change is mostly our calendar jumping around," Worthey said.

Originally, the planetarium was designed to be part of the observatory when the project was proposed in 1948 to then-University president Wilson Compton. But funding for the observatory came first and the planetarium project was put on hold. In 1957, a small planetarium within a 14-foot dome was constructed in Dana Hall. However, space was tight—the room was crowded and the astronomy classes were too large. In 1959, the University purchased a 24-foot plastic-laminated glass-fiber dome, choosing to design a room in Sloan specifically for the dome. The new planetarium opened in 1962 and its projector was upgraded in 1966. However, the equipment has not been upgraded in the past 40 years and both Worthey and Allen would like to go digital. "Digital projectors are more compact," Allen said. "In the current set-up, the optical apparatus can block the view of some visitors of some part of the sky. With a digital projector, such a blockage would not occur." Worthey said digital equipment is also more efficient. "With a digital projector, the maintenance is much, much easier," Worthey said. "We'd also be able to show movies with a digital projector."

Digital or not, both professors agree the planetarium is a useful asset to the University and community. "I like the fact that WSU is a unique resource locally. The same is true of any university, anywhere, but especially in a rural setting," Allen said. The physics and astronomy department speaks to between 1,500 and 2,000 people a year at the planetarium. "Most visiting groups are school-aged children, grades four through six, which is a terrific age group to work with. They have a lot of energy, and they can be very smart," Allen said. Tera Ray, a senior English education major, attended a presentation for her science fiction literature class. "It was cool to hear about all the mythological connections to the constellations," she said. "I liked seeing how [the constellations] are all connected to each other." Worthey said the planetarium is a good experience for visitors from urban areas. "Remember, some city kids are never completely in the dark," Worthey said. "When you turn out the lights, and there's a bunch of kids sitting in the room, each one of them gasps every single time. Of course, the pitch of the gasp changes, depending on the group." Fundraising efforts for an updating of the planetarium are underway. If you would like to support this project, please contact Gabe Brannon, assistant director of development, College of Sciences, at 509-335-5917.

Michael Allen making a presentation in the planetarium located in Sloan Hall on WSU Pullman campus.
Photo courtesy of Kevin Quinn, *Daily Evergreen.*

All That Glitters

The shimmering nano-alchemy of Lai-Sheng Wang.

Lai-Sheng Wang places a tinker-toyish thing onto a visitor's palm. Many such toys line the physics professor's Pacific Northwest National Laboratory office in Richland. The object at hand—12 steel balls hinged to red plastic tubes twisted this way and that—form a perfectly symmetrical, 20-sided icosahedron.

Wang also displays a daughter-fashioned Father's Day card that testifies to his paternal greatness: he spends time with the family, washes dishes, cooks, and is always kind. Mixed in there is a gilded item that truly separates Wang from all other pops on earth: he fathered the gold buckyball.

The word "buckyball" derives from "Buckminsterfullerene," a hollow cluster of 60 carbon atoms discovered by Richard Smalley at Rice University. Wang worked with Smalley until joining WSU in 1993. He is also an affiliate senior scientist at the Department of Energy laboratory.

The "hollow gold cage," as Wang calls it, is the official reason for today's visit, but Wang is full of surprises.

The cluster's practical use is unknown, though gold is valued as a catalyst and component of advanced electronics. What truly excites people is the cluster's status as the first buckyball-like structure made of metal.

Because of their tendency to clump, metals have presented a special challenge to architects of the very small. One group in Europe theorized that 32 atoms was the hollow-cage gold analog to carbon 60. But Wang's team elicited what is called the photoelectron spectra—a physical signature—of the gold 32 cluster and found it just another compact clump.

Wang's group already knew that at 20 atoms gold assumed a 3-D pyramid shape and that clusters of 15 atoms or fewer remained flat. So they concentrated on the clusters between 16 and 20 and, buttressed by theoretical calculations that tease out specific geometry, found that all but one possible configuration of 16, 17, and 18 atoms were open in the middle.

After they published this finding last May, in *Proceedings of the National Academy of Sciences*, the news escaped the arcane world of materials science to engage a larger cultural conversation. The *New York Times* carried a story that prompted a Princeton mathematician, a New York playwright, students, and other readers from all over to bombard Wang with helpful suggestions for an original name. Wang thanked them but resisted.

Why? Wang explains that the gold is lovely but unstable; it can maintain its shape only while free-floating in a vacuum or in pressurized gas. It is the metal-cluster equivalent to a sickly but adorable puppy in a pet store window that you have no intention of buying.

Back to the toy with 12 atom balls. Shouldn't it have 16 to 18 atoms? No. Wang announces, "It is tin!" A second hollow metal cluster!

Wang quietly slipped the tin findings into a chemistry journal a month after the gold study. This cluster he actually named: Stannaspherene, after the Latin word for tin. After what happened with gold, he says, he'd have felt uncomfortable making a big deal out of this one.

Still, he can barely contain his excitement. Tin's perfect mini-buckylike symmetry suggests it is more robust than gold at holding its shape. And like the gold cluster, tin is more than 6 angstroms across, roughly a ten-millionth the size of a comma, large enough to contain other metal atoms. Such configurations, according to Wang, can act as "chemical building blocks for cluster-assembled nanomaterials."

Time to cross the hall between Wang's office and his lab in the sprawling W.R. Wiley Environmental Molecular Sciences Laboratory. Off to one end is a large, U-shaped apparatus that performs the photoelectron spectroscopy. Photoelectrons carry all of the structural information, a physical-chemical fingerprint, about the clusters from which they came.

On one side of the U is a laser that vaporizes atoms from a metal sample affixed to a tiny drum inserted into the machine. This creates a hot plume, tens of thousands of degrees, of distinct atoms that are cooled by a high-pressure helium gas. The material condenses into clusters of a few atoms to a few hundred atoms, swept along by the helium and sorted according to how fast they make it across the bottom of the U to the far side. There the clusters, each with a known number of atoms, are pulsed with another laser to shake loose their atoms' electrons.

The other fork of the U is the end of the line, a 12-foot tube Wang calls "a race track" that the photoelectrons must traverse to reach a detector that will yield the spectra for calculating their structure. First, though, the quarry must be coaxed along by a strong magnetic field, or "magnetic bottle," that keeps all these photoelectrons that have been flying off the clusters in all directions on the race track and moving toward the detector.

Of the handful of U.S. groups performing photoelectron spectroscopy, Wang says, "we have the best magnetic bottle, which allows us to detect 99 percent of the electrons. Since there are so few, we don't have the luxury of throwing any away." Wang frequently refers to what he does as "alchemy," an "intellectual curiosity." "If you want to make it big," he says, "you have to make material, come up with a sample"—something you can see in bulk, rather than isolated clusters. "Look at the Buckyball. It's very stable in air. Any idiot can make it—even a physicist." A nickname might help, too. Stannaspherene? Hard sell. How about Haleyball, for Jack Haley, the actor who played the hollow Tin Man in *The Wizard of Oz*? The alchemist will take it under advisement—maybe save the nickname for when he puts another atom inside the cluster and gives the Tin Man a heart.

Discovery of Galaxies:
WSU Astronomer Researches Early Universe Galaxies

Hundreds of galaxies dating back to the time of the Big Bang have been discovered through an analysis of the two deepest views of the cosmos ever taken by NASA's Hubble Space Telescope. The research was performed by a team of four astronomers that included **John Blakeslee**, assistant professor of physics.

John Blakeslee, assistant professor of physics

The researchers report finding some 500 galaxies that existed less than a billion years after the Big Bang—a time when the cosmos was less than seven percent of its present age of 13.7 billion years. Their findings constitute the most comprehensive compilation of galaxies in the early universe.

The discovery is considered a significant leap forward in developing an understanding of the origin of galaxies, given that little was known of early galaxy formation just a decade ago, when astronomers had not seen even one galaxy dating back to the first billion years of the history of the universe.

The early universe galaxies are smaller than today's giant galaxies and quite bluish in color, indicating they are ablaze with star birth. They appear red in the Hubble images because of their tremendous distance from Earth. The blue light from the galaxies' young stars took nearly 13 billion years to reach Earth. During the long journey, their shorter wavelength blue light shifted to longer wavelength red light due to the expansion of space.

"Finding so many of these dwarf galaxies, but so few bright ones, is evidence for galaxies building up from small pieces—merging together as predicted by the hierarchical theory of galaxy formation," said Rychard Bouwens, University of California, Santa Cruz, an astronomer who led the Hubble study.

The researchers discovered the early galaxies in an analysis of the Hubble Ultra Deep Field, a patch of sky observed in unprecedented depth by Hubble in 2004, and the Great Observatories Origins Deep Survey, begun in 2003. Their results are scheduled for publication in the *Astrophysical Journal*.

The astronomical data used in the study came from an instrument called the Advanced Camera for Surveys (or ACS) on board the Hubble Space Telescope. Blakeslee was part of a large team of scientists and engineers that developed the ACS and he wrote much of the software that processes the images used in identifying the early galaxies.

"Since its installation on Hubble in March 2002, the ACS instrument has been giving us spectacular views of the universe, from the most distant galaxies to nearby stars forming in our own Milky Way galaxy, and even the familiar planets within our solar system," Blakeslee said. "Finding so many primordial galaxies in one study demonstrates the combined power of Hubble and the ACS. Nothing else in space or on Earth compares to it."

The researchers' findings show that early dwarf galaxies were producing stars at a furious rate, about ten times faster than is happening now in nearby galaxies. Astronomers have long debated whether the hottest stars in early star-forming galaxies, such as those in this study, may have provided enough radiation to reheat the cold hydrogen gas that existed between galaxies in the early universe. The gas had been cooling since the Big Bang.

"Seeing all of these starburst galaxies provides evidence that there were enough galaxies one billion years after the Big Bang to finish reheating the universe," said team member Garth Illingworth of the University of California, Santa Cruz. "It highlights a period of fundamental change in the universe, and we are seeing the galaxy population that brought about that change."

Because the evolution of galaxies and stars occurs over billions of years, astronomers rarely witness dramatic, relatively brief transitions that changed the universe. One such event was the universe's "reheating."

Driven by the galaxies' ultraviolet starlight, the reheating transformed the gas between galaxies from a cold, dark hydrogen soup to a hot, transparent plasma over only a few hundred million years. With the aid of Hubble and the ACS, astronomers are now beginning to see the kinds of galaxies that brought about that reheating.

"This research provides some answers to questions about the earliest stages of galaxy formation, but it also hints at how much more we have to learn," Blakeslee said. "Five hundred primordial galaxies may seem like a lot, but those were found over a tiny fraction of the sky. There are likely billions more out there, even at these great distances and early cosmic times. We need bigger, more representative, samples to truly understand the formation and evolution of galaxies in the universe."

For electronic images and additional information about this research, visit hubblesite.org/news/2006/12 or www.spacetelescope.org/news/html/heic0603.html.

Good News from Around the Department

- In addition to **Michael Allen's** teaching and outreach responsibilities, he has accepted the assignment to serve as the department's pre-majors advisor. Meeting with incoming freshman and others interested in our program is an important aspect of student recruitment and retention. We appreciate Michael's involvement.
- Research professor emeritus and associate director of the Institute for Shock Physics **James Asay** retired in May 2006. Jim and his wife, Pat, moved back to New Mexico to be near their family. Jim remains affiliated with the Institute.
- **John Blakeslee** has been awarded a $98,000 NASA grant based on research entitled, "Measurements of Surface Brightness Fluctuation Gradients in Normal and Peculiar Early-type Galaxies." As a result of this funding, John has hired postdoc **Michele Cantiello**, who will reside at WSU on a one-year leave from Teramo Astronomical Observatory in Italy. John has also received $36,500 for a proposal entitled "Calibration of ACS F814W Surface Brightness Fluctuations." He will use Hubble observations of eight galaxies in the Fornax cluster to calibrate the surface brightness fluctuations technique in an important optical bandpass. This approved observational program is also supported by NASA funding.
- **Doerte Blume** was elected to serve a three-year term on the executive committee of the Topical Group on Few-body Physics of the American Physical Society. As for research activities, she has been awarded a three-year National Science Foundation (NSF) grant totaling $195,000 to study the "Monte Carlo Treatment of Bose and Fermi Gases." Doerte is currently on sabbatical leave at the Bose-Einstein Condensation (BEC) Center in Trento, Italy, and JILA, an institute jointly run by the University of Colorado and National Institute of Standards and Technology. She received a JILA Visiting Fellowship, a prestigious and highly competitive award, allowing her to do research on the theoretical description of atomic many-body systems.
- The Laser Interferometer Gravitational-wave Observatory (LIGO) has selected **Sukanta Bose's** research group from among 43 institutions to receive their 68 rack-mounted Pentium-4 nodes towards the construction of a Beowulf computing cluster here at WSU. The original cost of the cluster was about $75,000. Each node is a rack-mounted 2GHz Penitum-4 unit with 512MB of RAM and 220GB of disk space. These will supplement Sukanta's existing cluster, Pleiades, to form a 96-node supercomputing Beowulf cluster. The cluster will model and search for astronomical and cosmological sources of gravitational waves and play a role in testing Einstein's theory of gravity and its predictions of the behavior of space-time around pulsars, supernovae, and black holes.
- **Gary Collins** received an unsolicited $35,000 donation in support of his research in nuclear solid state physics from former student **Praveen Sinha**, who graduated from WSU in 1995 with a doctorate in physics and a master's degree in computer science. These funds have been used to support a number of students to carry out research in Collins's group. Professor Collins is highly honored by this support. (Read more about Dr. Sinha in "Where Are They Now?")
- This past summer **Tom Dickinson** chaired his third Gordon Research Conference. The topic this summer was tribology (the science of wear, friction, and lubrication) and emphasized the underlying nanoscale phenomena. Tom was also recently named a fellow of the AAAS, the American Association for the Advancement of Science. This is in addition to being a fellow of the American Physical Society and the American Vacuum Society.
- **Sue Dexheimer** gave an invited talk at the American Physical Society's March 2006 meeting entitled "Dynamics of photoexcitations in quasi-one-dimensional systems." She has also received an additional $7,000 from a NSF-REU grant. The Research Experience for Undergraduates program supports active research participation by undergraduate students in any of the areas of research funded by the National Science Foundation. REU projects involve students in meaningful ways in ongoing research programs or in research projects designed especially for the purpose.
- **Fred Gittes** has developed a new course in biological physics. Taught for the first time in fall 2005, Fred's student evaluations were very positive. In addition to his regular teaching load in spring 2006, he found time to co-teach an Honors integrated science course, Sci 199. Much of the material covered was new to him: genetics, weather and climate, and geology. Fred found that in teaching the course he was able to navigate a path through each subject that touched on ideas from physics. And if all of this were not enough, Fred served as the advisor to the Physics/Astronomy Club last year and has recently assumed the role of majors advisor for the department.
- Late last spring, physics recruiter **Mary Guenther**, along with **Ron Newton** (ret. chemistry), Associate Dean of College of Sciences **Mary Sanchez Lanier,** and a host of other College of Sciences and College of Engineering and Architecture personnel hosted the second annual WSU Future Scientists and Engineers visitation to campus. Students from schools in the Yakima Valley, Tri-Cities, Moses Lake, and Chelan areas participated in lab demonstrations, performed hands-on experiments, and visited various science and engineering related facilities at WSU. The high school sophomores and juniors, along with some of their parents, stayed on campus for the two-day event.
- **Mark Kuzyk** is the author of a new book entitled *Polymer Fiber Optics: Materials Physics, and Applications,* published through CRC Press, Taylor & Francis Group. On the grant front, Mark was awarded a one-year NSF Research Experiences for Undergraduates (REU) grant for $6,000. Mark's group is investigating "Fundamental Quantum Limits of Nonlinear Susceptibilities and Devices."
- **Mike Miller** spent his summer in Linz, Austria, in collaboration with the quantum many-body physics group in the Institute for

Theoretical Physics at Johannes Kepler University. They have been studying the properties of superfluid helium films. In one recent work, they showed that the mobility of electrons absorbed onto film surfaces oscillate in tandem with film layering. In a second work, they employed time-dependent variational methods to examine the thermodynamic phase of helium films near monolayer completion. Both studies were in excellent agreement with the experimental data.

- **Steve Tomsovic** is currently on a one-year leave after receiving the Martin-Gutzwiller Fellowship by the Max-Planck Institute for the Physics of Complex Systems. In addition to his award he recently was granted a three-year NSF grant for a total $195,500. He will be doing research on wave field evolution, random media, chaos, and interactions.
- **Guy Worthey** received financial support for his proposal of "A Seminar Series in Astrobiology" for the Office of Research Initiation of Collaboration Program for the amount of $5,000 and another $5,000 of matching support from five WSU departments. This series is anticipated to draw interested WSU scientists for future internal collaborations that would have been impossible otherwise.
- Congratulations to faculty members **Doerte Blume, Sukanta Bose,** and **Guy Worthey**, who all received tenure and promotion to the level of associate professor.

New Astrobiology Seminar Series Will Explore Life in the Universe

Top researchers in the field of astrobiology have been recruited to speak Friday afternoons in a new interdisciplinary seminar series. "The seminars will focus on aspects of life in the universe," said **Guy Worthey,** an associate professor of physics and one of the organizers. "Astrobiology touches on many universal questions such as 'What is being alive?' 'Where and how did life arise?' 'How extreme can conditions get before life becomes impossible?' 'What are the possibilities for life on other planets?' 'What is the ultimate fate of life?'"

Among the outside speakers is planetary scientist Jonathan Lunine, who is an interdisciplinary mission scientist on the Cassini Huygens mission to Saturn, which succeeded in soft-landing cameras, sensors, and radar gear on Titan, one of Saturn's moons. Lunine's lecture will include a report of this project and be illustrated with photos from the mission. His lecture is scheduled for January 26, 2007. Check the seminar schedule at astro.wsu.edu/astrobio.

We Welcome Three New Members to the Department

Ralph Aeschliman is the department's new head coordinator for Project ASTRO Appaloosa, an outreach effort to facilitate the teaching of astronomy in grade, middle, and high schools. A self-professed "case of attention deficit disorder run rampant" coupled with a vast interest in amateur astronomy and planetary cartography, helped land him a position working with Professor **Guy Worthey**. For more on Project ASTRO, visit astro.wsu.edu/appaloosa.

The department is pleased to present a new physics instructor this fall. **Nicholas Cerruti** ('00 Ph.D.) earned his undergraduate degree in physics and mathematics from Lewis & Clark College, Portland, Oregon. He went on to earn a master's and doctorate in physics from Washington State University. Nicholas continued at WSU as a postdoctoral research assistant and an assistant research professor, where he studied many aspects of quantum chaos with **Steven Tomsovic**. His research involved various areas including conductance in quantum dots and acoustic propagation in the deep ocean. Recently, Nicholas spent one year teaching at Whitman College in Walla Walla. Since returning to campus he has participated in WSU's summer *ALIVE!* orientation program where incoming students are introduced to an array of study and research opportunities.

Jana Vitamanti is a welcome addition to the physics office support staff. Her main responsibility is to input the myriad of data regarding student recruitment and retention. Jana grew up in Almira, Washington, 90 miles west of Spokane, and after high school attended a business college in Spokane before starting her career in the secretarial field. Married with one daughter, Jana and her husband enjoy spending time at their cabin in the woods in Sandpoint, Idaho. Jana has worked at WSU since 1998.

Alums: Where Are They Now?

William Arnott ('88 Ph.D.), a resident of Reno, Nevada, has received a patent for his Photoacoustic Instrument for Measuring Particles in a Gas. This instrument measures carbon black particles emitted in the exhaust gas of a vehicle traveling on a road or being tested on a dynamometer or engine stand. The sensor includes an acoustic waveguide and a pump mounted to an outlet of the waveguide. A microphone is attached to the waveguide and detects an acoustic signal generated by absorption of the light by the particles in the gas. The acoustic signal is proportional to the mass concentration of particles in the gas and the microphone then generates an electrical signal proportional to the acoustic signal. Arnott's advisor was **Phil Marston.**

WSU alumni **Frank Barmore** ('60 B.S.) visited campus in July. While in Pullman he met with a number of individuals in the physics area, including professor emeritus **Ed Donaldson, Yogi Gupta,** and **Steve Tomsovic.** Barmore studied physics under the tutelage of **William Band** (dec.) and **Ed Donaldson.** After graduation Barmore earned a doctorate from the University of Wisconsin-Madison and worked in New York before joining the physics faculty at the University of Wisconsin-LaCrosse. Barmore's roots in Pullman are deep; his father was a WSU faculty member and Frank graduated from Pullman High School in 1956.

Christopher Brooks ('04 M.S.) and **Paul Hoffman** ('02 M.S.) landed jobs at Aculight Corporation after graduation. Aculight is based in Washington state and specializes in laser products, including solid-state and fiber lasers. Recently we talked to Paul and are happy to report he is continuing his tradition of making specialty beers and wines. We understand his graduate cohort never lacked libations. Chris's advisor was **Yogi Gupta** and Paul's advisor was **Mark Kuzyk.**

Dean Casey ('73 Ph.D.) retired from Verizon in late 2003 and started a consulting company called Ngenet Research. Ngenet provides consulting services to the telecommunications and data networking industries in areas critical to the deployment of next-generation, broadband networks. In addition, he has been working at Princeton University for the computer science department on a large networking project.

Innovation seems to be **Joshua (Josh) Clearman's** ('99 B.S.) middle name. Since leaving WSU, Josh has been a busy man. He spent two years in the Middle East teaching at the American School of Kuwait during 9/11 and Gulf War II. He currently teaches physics and marine science (SCUBA) at Key West High School in Key West Florida. He built the school's physics program from the ground up and has almost 1,300 kids involved in his programs. In his spare time Josh spear fishes and hunts for lobsters. Josh notes that he plans to pursue a master's degree at Arizona State University sometime in the near future.

Michael Feise ('01 Ph.D.) has been working for an IT consultancy in London producing trading systems for investment banks. Although his first interests were in optics research, Michael notes, "Physicists are supposed to be very flexible in what field they work....My current job is quite interesting and a very different mind set."

Dennis Grady ('71 Ph.D.), one of **George Duvall's** students, has just published a book, *Fragmentation of Rings and Shells: The Legacy of N.F. Mott* (Springer 2006). According to Yogi Gupta, "Although the book has an excellent account of Mott's seminal work in the field, the book is really based on Dennis Grady's outstanding work spanning 20-plus years on dynamic fragmentation. I cannot think of a better reference than Dennis Grady's book for learning about this field." Grady, who is a world-recognized leader in the field of dynamic fragmentation, is a Fellow of the APS.

Rizal Hariadi ('02 B.S.) is currently a graduate student at Caltech in Pasadena. He is a member of the DNA and Natural Algorithms group that studies biomolecular computation—how systems of biomolecules, such as DNA and enzymes, can process information and carry out algorithms. Rizal worked in **Tom Dickinson's** group as an undergraduate.

Richard H. Lindsay ('62 Ph.D.), physics professor emeritus, is enjoying retirement in Bellingham, Washington.

Shurong (Sherry) Liu ('99 Ph.D.) is working at the University of Utah's chemistry department. She says her graduate training with professor **Lai-Sheng Wang** has served her well since she is currently performing research in cluster sciences.

Lieutenant **Bryan Morgan** ('04 B.S.) served our country in Iraq as a platoon leader of around 30 soldiers this past year. The department sent him and his fellow soldiers a care package over Christmas to brighten their spirits and keep them busy with physics trinkets and goodies. Bryan made it home safe and sound in January 2006.

Praveen Sinha graduated from WSU in 1995 with a doctorate in physics and a master's degree in computer science. He carried out his dissertation research as a member of **Gary Collins'** research group. In December 2005, Praveen started a fund to support Collins' research through a generous, unsolicited $35,000 donation. While at WSU, he first synthesized nanocrystals of indium metal and studied their properties, finding indirectly that the axial ratio of this tetragonal metal becomes more cubic as crystal size decreases. Later, in his dissertation research, he studied types of point defects produced by quenching or plastic deformation of intermetallic compounds and measured defect concentrations. Praveen left WSU to accept a position as N.I.H. postdoctoral research associate in radiation oncology at the University of Wisconsin. Praveen went back to school and earned an MBA in 2000. At about the same time, he co-founded UltraVisual Medical Systems to develop software products for medical image management for hospitals. After merging with another company, Emageon, the company went public in early 2005. Currently, he is co-founder, president, and CEO of Securitas Technologies, Inc., a start-up company developing products for computer security.

Charles (Bonner) Walsh ('01 B.S.) recently graduated from the Southern Methodist University Dedman School of Law. Bonner spent eight months as intern working for the U.S. Citizen and Immigration Services. He is interested in working for the Department of Homeland Security, which is affiliated with the United States Citizenship and Immigration Services.

The following is an excerpt from an account written by Washington State College alumnus Walter Morgan ('54 B.S. '59 M.S.).

I had selected physics for my major at WSC before I graduated from Omak High School. The choice of school was a no-brainer: my father, two of his brothers, and my oldest sister were graduates, and my other two siblings were in attendance. The choice of major was a result of my high school science experiences. The science teacher was very good, and I related well to both physics and chemistry, but chemistry just didn't have the appeal for me…

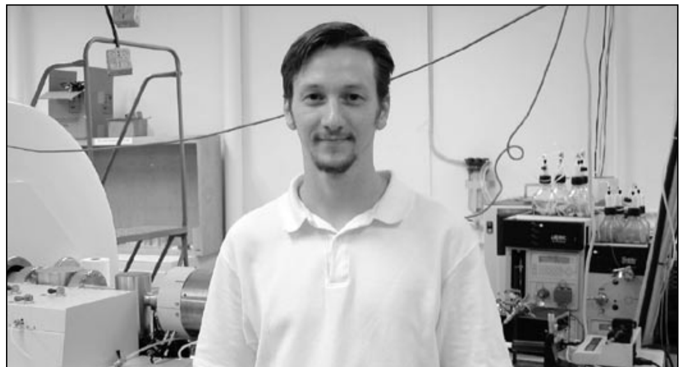
Engineering physics was routinely required for all engineering and physics majors in the sophomore year. It was a two-semester, five-hour course: three lectures, two tutorial sessions, and one three-hour lab each week. The course was taught by **Al Butler,** and he did a great job. (He was also known campus-wide as "Physics Butler," thereby being distinguished from "Math Butler.") Al had been a high school physics teacher in the Tri-Cities and Spokane, and had come to Pullman just before WWII. Most of his early students at WSC were in an Army Air Corps program.

The number of students enrolled in engineering physics was something over 100 in 1949, and the lecture room in the Mechanical Arts building [now Carpenter Hall] had a theatre-type arrangement, seating about 200. The ceiling at the front of the room, over the demonstration table, was about 15 feet high. (Let's see: sometime after 1949 we were supposed to undergo a major shift to the metric system, so let's pretend that we did. The ceiling must have been 5 metres high.) The height played a significant role in the demonstration. (Maybe everyone currently in the Physics Department has seen it, but I can only say that the way he did it made a big impression on me.)

At the beginning of one class, a bucket was hanging from the ceiling over the demonstration table, and professor Butler busied himself with what resembled a B-B gun, except that he inserted a dowel-like arrow into the barrel. Then, commenting that the equipment had been loaned out to another department, and he had just gotten it back, leaving him no time to practice, he knelt on the floor and took careful aim at the bucket. The elevation was about 45 degrees. I was watching the alignment carefully, and when he squeezed the trigger I was dismayed to see not an arrow zinging toward the ceiling and punching a hole in the bucket, but rather a stick that hardly seemed to clear the muzzle, probably going no more than two meters above the floor. In following its arc I was astounded to see that it hit the bucket a fraction of a metre before the bucket hit the floor. He hadn't told us that the bucket was hanging from an electromagnet, with a switch in the trigger, or that the purpose was to demonstrate summation of forces. That was 55 years ago, and I haven't forgotten the lesson. To polish things off, he re-hung the bucket and climbed a ladder at the side of the room, so that his elevation was nearly equal to that of the bucket. That time we were not surprised when the arrow made contact with the bucket just before it hit the floor."

Scholarship Recipients 2005–2006

Many of the gifts from our alumni and friends support scholarships for department's most deserving students. For the 2006–07 academic year, the following scholarship awards were made.



Gunnar Skulason, project associate, Department of Chemistry. Winner of the Physics Transfer Student Scholarship

The Physics Transfer Student Scholarship
Gunnar Skulason

Physics Textbook Scholarships
Ben Arthurs
Christopher Bates
Morgan Emerson
Carl Estes
Brice Kosnik
Jonathan Leiner
John Leraas
Peter Means
Jeff Noel
Ben Norman
Steve Pearce
Philip Peterman
John Renshaw
Urszula Szafruga

The Claire May Band Scholarship in Physics
Katrina Epperson, Stanwood High School, Stanwood, Washington
Christina Ellis, Knox College, Galesburg, Illinois

Paul A. and Dian Bender Freshman Physics Scholarship
Kent Evens

Paul A. Anderson Prize
Juefei Zhou

Granted Degrees, Fall 2005–August 2006

Bachelor of Science
Benjamin Horton
John Renshaw

Master of Science
Krittika Kanjilal
Shawn Seader
Lai Wang

Master of Science Opto-Electronic Certificates
Xi Chen
Jay Jeffers
Xiaorong Li
Yao Sun
Lai Wang
Ye Zhu

Doctorate
Jeong-Joon Park

Awards and Recognition

Kudos to Regents Professor **Tom Dickinson** who was awarded the 2005 Sahlin Faculty Excellence Award for "enriching the lives of students and elevating their experience through excellence in research of physics and materials science." For the past 37 years Tom has invited undergraduate students to work with him in his lab, many of whom are now researchers in some of the nation's top research universities.

Among the recipients of the College of Sciences Thirteenth Annual Dean's Recognition Awards were **Doerte Blume** for the Young Faculty Performance Award, **Tom Cowger** for the Outstanding Administrative Professional Staff Award, and **Krittika Kanjilal** for the Outstanding Graduate Student. Congratulations for jobs well done.

We are especially pleased to announce that **Tom G. Johnson**, the department's scientific instructional technician supervisor, was the recipient of a 2005–2006 President's Employee Excellence Award. Chair Steve Tomsovic said, "Tom Johnson is highly valued by the Department of Physics and Astronomy. His work is superb, he is constantly solving problems in innovative ways, and his contributions have greatly increased the quality of education for students taking physics and astronomy courses."

John Paznokas, Director of SMEEC/SLIC (Science, Mathematics, Engineering Education Center/Science Learning Instructional Center), presented **Joel Lonzaga**, a physics graduate student, with a NASA Space Grant Science Opportunity Scholarship from the College of Sciences at WSU. The $5,000 award is in recognition of Joel's "outstanding academic achievements" in the space sciences.

Last April the Spokane office for U.S. Senator Maria Cantwell notified **Steve Tomsovic** that the department's GAANN grant proposal had been approved. The prestigious three-year GAANN, which stands for Graduate Assistance in Areas of National Need, covers areas such as biology, chemistry, computer and information sciences, engineering, geological and related sciences, mathematics, nursing, and physics.

The U.S. Department of Education program provides fellowships, through academic departments and programs in institutions of higher education, to assist graduate students with excellent records who demonstrate financial need and plan to pursue the highest degree available in a field designated as an area of national need. The department's GAANN budget for fall 2006 is $126,672.

Materials Science graduate student **Christopher Dudley** received the "Second Place Best Student Paper Award in Structural Acoustics and Vibration." The $200 award followed his presentation at the June 2006 Acoustical Society of America meeting. Chris, who has been working with Professor Phil Marston, presented a talk based on their research entitled, "Liquid-filled focusing cylinders and the caustic merging transition," J. Acoust. Soc. Am. 119, 3418 (2006).

Second-year physics graduate student **Jennifer (Jennie) Schei** is a recipient of the Poncin Scholarship for the academic year 2006–2007. This prestigious renewable scholarship is awarded to graduate students with an interest in biomedical research who are attending Washington State schools. Jennie is one of ten recipients this year, which includes some renewals. Jennie is working with Professors **Matt McCluskey** and **David Rector** (VCAAP) on the optical imaging of neural activity.

Undergraduates **Jonathan Leiner** and **Stephanie Lage** were awarded $2,500 for their submissions to the COS Undergraduate Student Minigrant competition. Jonathan Leiner is working with Sukanta Bose on a project entitled, "Probing the existence of extra-spatial dimensions in the Universe." Stephanie's proposal, "Unique Lattice Locations in Cr_3Si," is being supervised by **Gary Collins**.

And finally, **Tom Dickinson** reports that two of our physics majors received prizes at the Pacific Northwest Division of the American Vacuum Society 2006 Symposium Undergraduate Research Poster Competition: first place to sophomore **Nathan Moore** and third place to senior **Christopher Bates**. Tom recently submitted a paper to the *Physical Chemistry Journal Langmuir* based on Chris' work. Chris made the first observations of the phenomena while working on another project and realized their significance. Tom is proud of the thought and effort that Chris put in the work to see it to its completion.

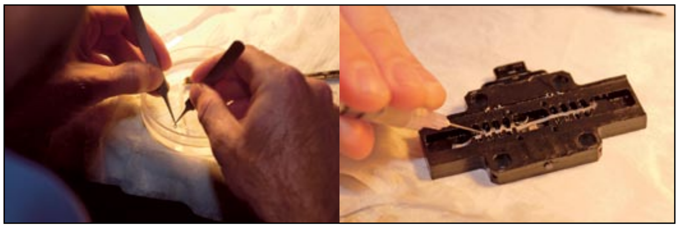
We Are Growing!

Our graduate program is growing at an impressive rate. New enrollments bring our total count up to 59 students this fall, a 35 percent increase over last year's total. This dramatic increase was due to an intensified recruitment effort on the part of the whole department, including faculty, staff, and our graduate council members, coupled with several new attractive graduate stipends. Largely through the efforts of associate professor **Sukanta Bose**, the Graduate School is providing funds for five Millennium Fellowships, one-year appointments that allow students to do research instead of teaching. Thanks to the tireless efforts of the department chair, **Steve Tomsovic**, the Department of Education awarded us five federally funded GAANN (Graduate Assistance in Areas of National Need) Fellowships. The GAANN program provides a generous stipend and is designed to enhance teaching and professional development. We welcome student referrals and promise to follow up on all submissions. To learn more about our offerings, visit our Web page at **www.physics.wsu.edu**. Pass the word!

Neuro, Micro, Opto

For most of us, sleep is time to rest and a chance to dream. For others such as biochemists, sleep offers a window into how the brain is organized, and how its trillions of cells coordinate their actions to create a perceiving, reflecting, inventing human mind. In his ground-breaking work, **David Rector**, WSU assistant professor in Veterinary and Comparative Anatomy, Pharmacology, and Physiology, has collaborators who are not just new to sleep research, they're new to any form of biology. WSU physicist **Matt McCluskey** spent the past year doing a sabbatical in Rector's lab studying how nerves transmit or reflect infrared light when they are transmitting impulses. "The weirdest thing about this is working with stuff that's alive," says physicist **Matt McCluskey**. In his own research Matt uses optics to explore the structural properties of crystals and semiconductors. The result, he and Rector hope, will be a portable easy-to-use way to track human brain activity.

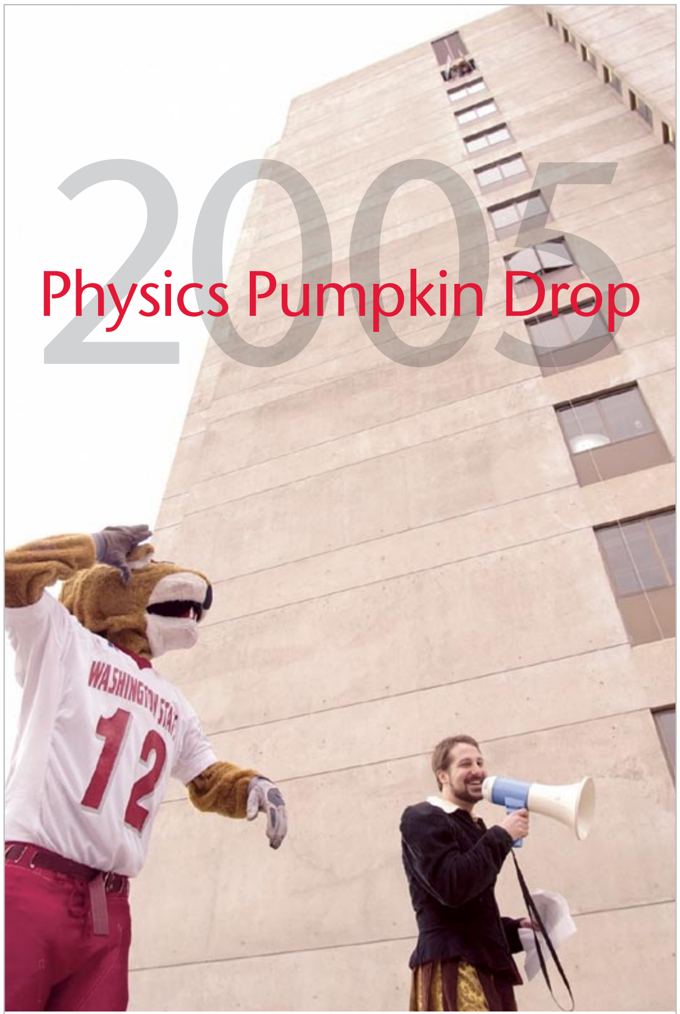
McCluskey's initial tests were done with nerves from lobster legs. Learning how to dissect out the stringy white nerves without mangling them required a whole new set of skills. "Part of the challenge, which I'm finally used to, is that you're up against a clock," says McCluskey. "The thing will die in just a few minutes. Ten, 15 minutes, the nerve just degrades. A semiconductor sample can wait around for weeks and weeks. You can always do it 'tomorrow.'"



Matthew McCluskey teases out the nerve from a lobster leg and then seals the nerve into a chamber with petroleum jelly.
Photo by WSU photographer Robert Hubner.

Regents Professor Tom Dickinson delivered a speech welcoming all new students, parents, faculty, and staff to the University during the President's 2006 Convocation.

2005 Physics Pumpkin Drop



The 2nd Annual Pumpkin Drop was a smashing success during Dad's Weekend 2005. More than 150 guests, including WSU's mascot Butch and "Galileo" (physics graduate student Fran Morrissey), shared in the fun as the Physics and Astronomy Club demonstrated the laws of falling objects.

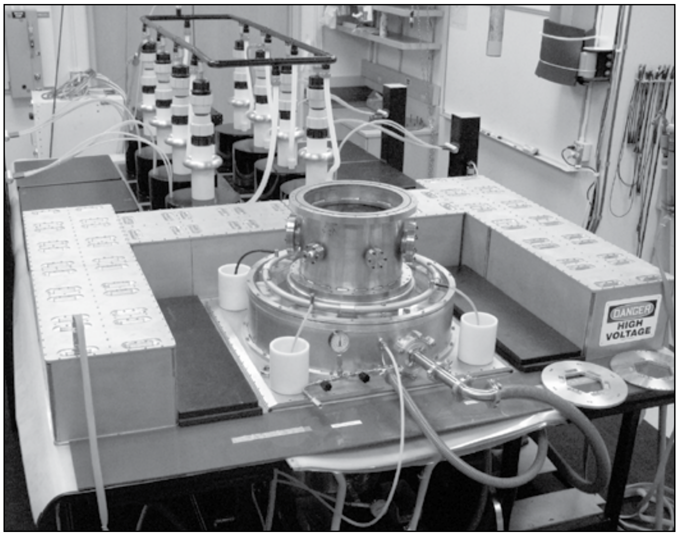
A bird's-eye view of the 3rd Annual Pumpkin Drop held on WSU Dad's Weekend, Saturday, November 4, 2006.

Large-Amplitude Ramp Waves Produced by Compact Pulsed Power Facility at the Institute for Shock Physics

How does a material respond when it is very rapidly compressed, but not shocked, to high stresses? This and other related questions will be addressed in the next several years in experiments at the new Compact Pulsed Power Facility (CPPF) at the Institute for Shock Physics. This facility has been developed with assistance from Sandia National Laboratories (SNL) and is one of only two such facilities in the United States. The other facility is located at SNL. Research professor emeritus **James R Asay** ('71 Ph.D.), who retired recently after four years at WSU, is playing an important role in the development and installation of this facility.

The CPPF releases energy stored in eight high voltage capacitors in a single pulse, providing a large electrical current (up to 4 million amperes) to the load (metallic panels) in the test chamber. This current pulse produces a strong magnetic field which, in turn, launches a large-amplitude stress wave into the sample. Up to four different samples can be simultaneously subjected to the same stress wave loading. To obtain experimental results, stress wave loading histories are measured using optical interferometry at various locations in the sample. Also, time-resolved optical spectroscopy measurements can be performed on the dynamically compressed samples.

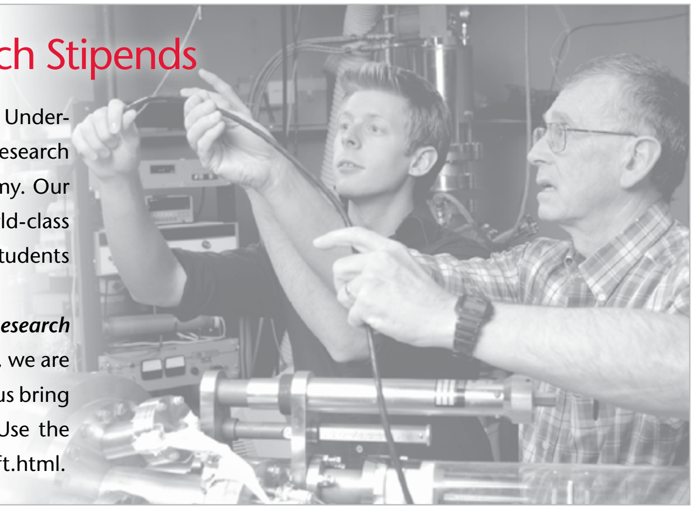
Unlike shock waves produced by traditional means of impact loading at the Institute, in which wave risetimes can be as small as a few picoseconds (10^{-12} seconds), the stress waves produced by the CPPF are ramp waves with risetimes of approximately 500 nanoseconds (10^{-9} seconds). The longer risetime of these ramp waves results in several important features and efficiencies relative to shock wave loading: 1) the ramp waves produce less entropy than shock waves, resulting in a lower temperature in the compressed material, 2) for ramp wave loading, the wave profile is sensitive to small changes in mass density, such as those that occur in phase transitions, 3) ramp wave loading permits determination of the full dynamic stress-strain loading path of the sample material in a single experiment, compared to the shock loading process where many experiments would be required to obtain the stress-strain response, and 4) the ability to conduct experiments on several samples simultaneously.



Compact pulsed power facility. High voltage capacitors are in the rear and the sample test chamber is front and center.

The CPFF will be used for investigating the role of temperature and loading rates in determining and understanding material response to dynamic loading, detecting and characterizing stress-induced phase transitions, and efficient characterization of the dynamic compressive response of materials. Thus, the experimental results made possible by the CPPF provide a valuable complement to the existing shock wave experimental capabilities. In addition, the CPPF will be used for applied research in association with the Institute's Spokane-based Applied Sciences Laboratory.

Tom Dickinson Undergraduate Research Stipends



We are pleased to announce the establishment of the Tom Dickinson Undergraduate Research Stipends. This endowed fund will support summer research by undergraduate students in the Department of Physics and Astronomy. Our department is committed to getting undergraduates involved in world-class research. The Dickinson Fund will give financial support to outstanding students and give them the means to succeed.

Our goal is to raise $25,000 for the Tom Dickinson Undergraduate Research Stipends. Thanks to generous gifts by Tom Dickinson and Ed Donaldson, we are already at 20 percent of this goal. By donating to this fund, you will help us bring outstanding research experiences to a new generation of scientists. Use the enclosed envelope or donate online at www.supportscience.wsu.edu/gift.html.

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