Department of Physics NEWSLETTER
NDSU

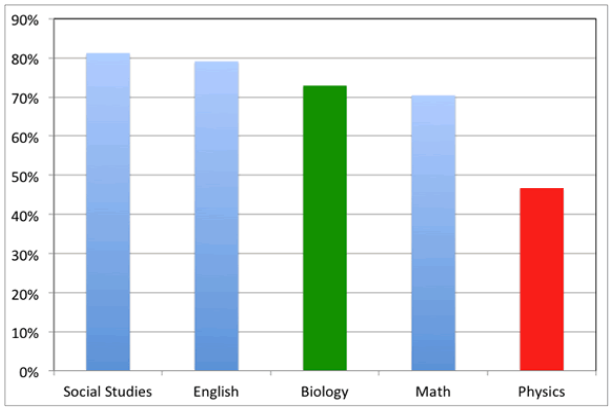
NORTH DAKOTA STATE UNIVERSITY Summer 2012 http://www.ndsu.edu/physics

The Challenge of Small Physics Enrollments

We have all heard the refrains "America isn't educating enough of our people well enough to get American-based companies to do more of their high-value-added work here" and "Our K-12 school system isn't nearly up to what it should be. American students continue to do poorly in math and science relative to students in other advanced countries. Japan, Germany, South Korea, Canada, Australia, Ireland, Sweden, and France all top us." These statements are certainly true, and the solution is rather clear. As Robert Reich has noted, "The way we get good jobs back is with a national strategy to make Americans more competitive – retooling our schools, getting more of our young people through college or giving them a first-class technical education…" In spite of this, federal and state funding for higher education is being reduced, and a college education is becoming unaffordable for many middle-class families.

Universities have been hard hit by budget cuts, and in some states officials are looking for ways to cut or reduce programs in an attempt to save money or at least be seen as saving money. Late last year the Texas Higher Education Coordinating Board (THECB) decided to cut 60% of the undergraduate physics programs in the state, including those at its two largest historically black institutions. In an attempt to make the system more efficient, the THECB reviewed all of its public universities' undergraduate programs that produced a small number (fewer than five per year) of graduates, and recommended a number for termination. If these standards were applied throughout the country, this would lead to the closing of undergraduate physics programs at 49% of all public institutions and 100% of all historically black public colleges and universities. Unfortunately, this is not just Texas politics; similar measures are already in progress or being considered in California, Florida, Idaho, Louisiana, Maine, Mississippi, Missouri, and Tennessee. In North Dakota, the State Board of Higher Education (SBHE) recently approved similar enrollment criteria (fewer than 5 BA/BS Degrees, 3 Master's Degrees, and 1 PhD Degree per year) for low-enrollment program review. Our department currently graduates approximately four undergraduate physics majors per year. It is still too early to say how the SBHE decision will impact our program.

There is also little doubt that low numbers of physics majors are related to the shortage of highly qualified secondary school physics teachers. The accompanying figure shows that fewer than half of all US high school physics classes are taught by teachers with a degree in physics. We cannot expect students entering college to be excited about physics if they have not had the opportunity to take physics from a highly qualified teacher. *North Dakota graduates the lowest percentage of high school students who have taken Advanced Placement (AP) Physics courses of all states in the country.* Indeed, the only high schools in the state that offer AP Physics courses are located in the Fargo and Bismarck metro areas!



The percentage of high school classes taught by teachers with degrees in the fields they teach. The annual national demand for physics instructors is roughly three times the supply of teachers with undergraduate majors in physics. (Figure reproduced from the American Physical Society website.)

Increasing enrollment and the number of qualified high school physics teachers are critical issues that we are currently trying to address. Compared to Physics Departments at many public institutions, we are in a comparatively good position because of the strong state

economy, our low tuition, and two faculty members with expertise in Physics Education. The next couple of years will be interesting; we will keep you informed of what happens!

Two other things have happened this last year that deserve mention. First, our current Dean of the College of Science and Mathematics, Kevin McCaul, decided to “retire” after six years in the position. Dr. McCaul joined NDSU in 1978 and will return to the Psychology Department to continue teaching. Kevin had several qualities which made him an exceptional and effective Dean. Personally, I will miss him.

Following a national search, Scott Wood was recruited as the new Dean of our college and joined NDSU in late July. Dr. Wood had previously been with the University of Idaho since 1991 as a faculty member in geochemistry. He became Associate Dean of the College of Science in 2006, Interim Dean of Science in 2007, and Dean of Science in 2008. Dr. Wood’s area of expertise is aqueous geochemistry, specifically how minerals interact with various types of aqueous solutions with applications toward mineral deposit exploration, geothermal energy exploration, nuclear waste disposal, health effects of asbestos and other minerals in the lungs, and the environmental geochemistry of acid-mine drainage. He is particularly well known for his expertise in the geochemistry of rare earth elements and platinum group elements.

Secondly, we would like to congratulate Dr. Darrell Strobel, a 1964 graduate of our program, on being awarded the 2012 Gerard P. Kuiper Prize for outstanding contributions to planetary science; see the following article.

Finally, I would like to personally thank all of you who have contributed to one of the department funds that have enabled us to recognize outstanding undergraduate scholarship. Further information regarding these funds and scholarships are provided in the body of this newsletter. Please continue to provide support for these scholarship funds. I also encourage all of you to send us a note about your life after NDSU and to come by the department when you are in the area. We would enjoy showing you around and sharing stories about physics and NDSU.

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FEATURE ARTICLES

NDSU Physics Alumnus Awarded Kuiper Prize

Daniel Kroll

The Division for Planetary Sciences of the American Astronomical Society awarded the 2012 Gerard P. Kuiper Prize for outstanding contributions to planetary science to Darrell Strobel, of the Johns Hopkins University Departments of Earth & Planetary Sciences and Physics & Astronomy. Dr. Strobel was a 1964 graduate of the NDSU Department of Physics; he received his Ph.D. from Harvard in 1969. The Gerard P. Kuiper Prize was established by the Division for Planetary Sciences to recognize and honor outstanding contributors to planetary science. It is to be awarded to scientists whose achievements have most advanced our understanding of the planetary system.

Strobel. © JHU

As stated in the press release from the Division for Planetary Sciences of the American Astronomical Society, “Dr. Strobel is one of the very best experts on many aspects of planetary atmospheres and magnetospheres, on which he has made fundamental contributions over nearly 40 years. In the mid-70s he laid out the fundamentals of atmospheric photochemistry, playing a leading role in establishing the general methodology for this then emerging field, and opening the way to study and solve a rich suite of problems related to photochemistry throughout the diversity of planetary atmospheres. After crucial work

on the photochemistry of the Earth's atmosphere that addressed the modeling of mesospheric nitric oxide, he pioneered the study of hydrocarbon chemistry in Jupiter's atmosphere, and his predictions were brilliantly confirmed by the Voyager measurements. As a co-investigator on the Ultraviolet Spectrometer (UVS) experiment on Voyager, he was the intellectual force in that team. He was a leading player in the interpretation of the UVS data in terms of energetics, density and thermal structure of the Giant Planets and Titan, and the discovery and characterization of Triton's tenuous N_2 atmosphere. He was also a key member of the team that used the Hubble Space Telescope to discover oxygen atmospheres of Europa and Ganymede and to characterize the SO_2 atmosphere of Io and its plasma torus. Being currently an Interdisciplinary Scientist on the Cassini mission, he continues to be a driving force in mission science planning and many investigations of Titan's atmosphere.

"Through an exceptional scientific breadth, Dr. Strobel led seminal studies in fields such as atmospheric thermal structure and energy balance, neutral and ionospheric structure of upper atmospheres, and plasma interactions with extended atmospheres and mass loading in magnetospheres, addressing virtually all questions related to aeronomy in outer planets. In most of these areas, his physical grasp and novel work outlined new concepts and established gold standards for subsequent studies. In recent years, his unabated intellectual vigor and inextinguishable appetite for new challenges has led him to successfully attack seemingly intractable problems such as the quantitative modeling of hydrodynamic escape from weakly bound atmospheres, or the role of gravity and tidal waves in driving atmospheric dynamics.

"Darrell Strobel is undoubtedly one of the most insightful and influential scientists in the field of planetary aeronomy, for which he clearly appears as one of the founding feathers. He has attracted to the field, and guided with dedication, many young planetary scientists, almost all of whom moved to very successful careers. For his many and impressive achievements, the Division for Planetary Sciences is proud to award the 2012 Gerald P. Kuiper Prize to Darrell Strobel."

Gecko Inspired Stickiness

Andrew B. Croll

Why do things stick? This seemingly simple question has both practical importance and forms one of the biggest limitations for nanotechnology. At its root, the answer has been available for centuries and is the same physics that occurs in all classical systems – things stay together if this arrangement reduces the system's total free energy. As is usually the case, the devil is in the details. What are the relevant energies anyway? And why is it that a gecko can run up a wall and hang upside down when even with really great boots I cannot?

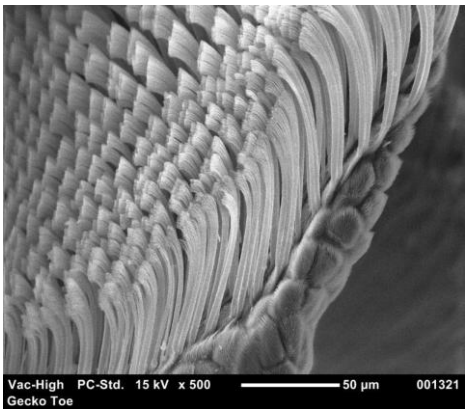
A Tokay Gecko. Photo courtesy of Michael Bartlett.

Before we look at something as complex as a living organism, let's back up and think of something simpler. Let us consider two very rigid, atomically flat blocks in a vacuum. Will these stick? The intuition might be that they will not; for example, when I touch something rigid like a glass window, it does not feel sticky. The reality is contrary to this intuition, and the two blocks do feel an attractive force (a good example of why it is important to do experiments every now and then). The root of the adhesion lies in the ubiquitous van der Waals forces that occur between all atoms. Atoms are made of positive and negative charge, distributed according to the details of quantum mechanics. This means that most atoms have a polarization (e.g., a space between the centers of positive and negative charge), which allows one to think of the atom like a little bar magnet. Now, as most of you recall, there is an attraction between opposite poles of a magnet, and so there can be an analogous attraction between polarized atoms. The exact details are of course more complicated, due to the motion of the charge, relativistic effects, and quantum effects, but hopefully we can see that there will be an attraction between the two bodies and that the exact chemical details might not be very important. The latter point is necessary for a gecko only if it only climbed one particular kind of tree, because it would have evolved a particular chemical interaction between its foot and the tree bark. The reality is that a gecko must stick to many chemically different surfaces, so it cannot rely on chemistry.

Our question now changes to why our intuition was wrong – why does glass not feel sticky if there are van der Waals forces between the glass and our finger? The answer here is related to the geometry of the attraction. Using the magnet analogy, one might recall that the magnetic force changes with the separation (R) of the two magnets. In fact, one might even recall that it falls as one over the separation squared ($1/R^2$). The same is true with van der Waals forces, except the force falls much more quickly ($1/R^6$). In effect, the atoms will only feel a force if they are (almost) touching. Another important detail is that real surfaces also contain many atoms, and therefore we must add the effect of a single atom many times. To summarize: the force for large bodies must depend on the total area of contact (which now sounds familiar – more duct tape can hold up larger weights). The reason the glass does not stick to our finger is that there is not much truly contacting area between a finger and a piece of glass. Again this might be surprising, but our finger is not really that smooth. Nor, as it turns out, is the glass. If we examine the glass on a fine scale, we would find that it is rough as well – and because it is rigid we can't easily flatten the roughness to increase contact area.

To make something stick to the glass, we have two options. We can increase the size of the (macroscopic) contact area, or we can make the adhesive much softer (to increase microscopic contact). Ignoring the triviality of increasing macroscopic contact, let us imagine softening the window glass. If we did, the glass would deform around the bumps and ridges on our finger and create a much larger degree of real – molecule on molecule – contact between the two. This would feel sticky, like touching the glue side of duct tape. As a limit of softness, we might think of a fluid like water or air which would have quite a lot of contact with our finger. There is a problem with soft things, though; soft things tend to fracture much more easily (for example, it is very difficult to pull on water). So how does that gecko do it?

The gecko has a clever adaptation to defeat the surface roughness and increase contact area. Its toes are covered with several 'skin flaps' (scansors), which can drape over larger scale roughness (like a piece of fabric). On each scansor there are thousands of tiny features called setae. Setae are long thin projections made of keratin (a relatively rigid material, similar to many plastics like plexiglass, for example). Each setae branches out into a collection of tiny 'spatulae' at its end (like a tree or broccoli). A spatula resembles a spatula – it has a long thin handle which connects to the satae, and a flat 'flipper' on its top. The flipper is a very smooth pad of about 100 nm in radius and is the only part of the structure that touches another surface. And here is the trick: keratin is rigid and difficult to fracture, but the setae are long and thin, which means that the whole structure is very deformable. Think of the difference between a copper pipe and a copper wire; it is easy to bend a long thin wire, but not a thick pipe. Geometry can make a thing soft! The gecko's specialized anatomy does exactly what is needed to be sticky; it can deform around surface roughness to create a large microscopic contact, but is strong enough to support the weight of the animal. A remarkable adaptation, indeed.



A scanning electron micrograph of a gecko toe. Bottom right shows part of a scansor from which many satae extend. The tips of the setae break up into many spatulae (below the resolution of this image). Courtesy of Michael Bartlett.

What NDSU Physics Has to Offer

The Department of Physics at North Dakota State University provides a rigorous education in physics and its applications. Students acquire knowledge and skills that provide a deeper understanding of nature, ranging from the physical laws' inherent beauty to the latest technological opportunities. We foster a climate of creativity, critical thinking, and investigational curiosity, where students thrive and instructors care. Being part of a research university allows our students to become involved in first-class research projects; i.e., design and perform experiments, develop modeling concepts, and perform computer simulations. Our threefold departmental research focus on soft condensed matter, polymer physics, and physics education research provides a unique environment that students and faculty alike find inspiring and fulfilling.

DEPARTMENT NEWS

Faculty & Staff Awards

Bladow Receives 2012 College Ambassadors Excellence Award

Daniel Kroll

The Bison Ambassadors is an NDSU public relations student organization sponsored by the Alumni Association; Ambassadors are actively involved with prospective, current, and past NDSU students, as well as increasing Bison Pride on campus. This last year, Assistant Prof. Landon Bladow of our department was the recipient of the prestigious Ambassadors Excellence Award – the only student-sponsored award in the College of Science and Mathematics. Ambassador Derek Miller explains why Landon was chosen in an address given during the College's Honors Day event:

Bladow. © NDSU

"Each year, the College of Science and Mathematics Ambassadors have the privilege of nominating and selecting a recipient for the Ambassadors Excellence Award. The award, given by students, recognizes a faculty or staff member of the College of Science and Mathematics who has a profound impact on students. This year, we had six nominations from three different departments across the College. Each nominee was well-deserving; however, after much discussion a consensus was reached. By chance, I personally nominated this year's recipient and will share just a little about why I feel he is very deserving of this award.

"This past fall semester, I had the privilege of taking University Physics I from Dr. Landon Bladow. Although I, like many other Physics students, was initially apprehensive, I realized very early in the semester that Landon has an uncanny ability to both motivate and engage his students. Although I may have nominated Dr. Bladow, several other Ambassadors had similar experiences and also spoke highly of his ability to relate difficult course material to students in a more understandable manner. Overall, I would like to personally thank Dr. Bladow for transforming the way that many other students and I think about the subject of Physics. Because of this, I would like to invite him up here to receive the Ambassadors Excellence Award."

Omernik Receives Staff Recognition Award

Warren Christensen

The title "Laboratory Technician" only begins to describe Paul Omernik's many roles within the Department of Physics. Whether overseeing teaching labs, building new demonstrations, maintaining servers, building/ salvaging computers, or snapping photos at outreach events, Paul helps to keep the Physics engine humming. For his many outstanding achievements, Paul was honored this spring with an NDSU Staff Recognition Award in the Administrative/Professional category. He was nominated by Dr. Warren Christensen, with the backing of the Physics Department faculty.

Routinely going above and beyond his official duties, Paul is an essential component of the Department. In addition to helping to make daily life run smoothly for faculty and students, he was a key player in putting on last summer's Discrete Simulation of Fluid Dynamics conference. Paul contributed hundreds of hours to setting up the conference server, designing the conference web page, and assembling submitted abstracts. So successful was the conference that the lead organizer, Dr. Alexander Wagner, won a Heartland Pride Award from the Fargo-Moorhead Convention and Visitors Bureau (see http://www.ndsu.edu/news/view/ article/12673/ and the related article in this newsletter).

Research, Education, & Events

International Physics Conference Held in Fargo

Alexander Wagner

As we announced in the last newsletter, we organized the 20th International Conference on Discrete Simulation of Fluid Dynamics (DSFD.org) in Fargo last summer. This was a week-long conference held August 8-12, 2012, in NDSU's new Barry Hall downtown. About 90 researchers from 20 countries converged on Fargo for this event, and we worked hard to make this a memorable event for the participants. The local organizing committee consisted of Andrew Croll, Alan Denton, Erik Hobbie, Thomas Ihle, Daniel Kroll, Taehun Lee (CUNY), Sylvio May, and Alexander Wagner. We had a lot of support from Paul Omernik and Patty Hartsoch. A special thanks goes out to my graduate students Eric Foard (now in Bari, Italy) and Goetz Kaehler for their hard work, as well as to the international organizing committee.

The organization was both exciting and arduous. Since not many international conferences of this scale have been held at NDSU, there was little in terms of existing structures to facilitate the local organization. But from the President down, we received a lot of encouragement and support at all levels from NDSU as well as MSUM, which let us use their Science Center at Buffalo Rive State Park for the conference outing. There were some challenges as well. For refreshments and lunches, I wanted to make sure that I would be able to provide the best quality available in Fargo, but NDSU Dining Services is typically granted a monopoly position in providing food for events held at NDSU. I had gotten a waiver for using outside catering from the Provost's Office, but when Dining Services became aware of this three days before the start of the conference, they wanted this decision overturned. Fortunately, the President of NDSU intervened, ensuring that we could honor our contracts with Nichole's Fine Pastry for the refreshments and Green Marked Catering for the lunches. Both of them outdid themselves and provided an excellent quality of food that was at least as good as the catering at previous DSFD events in Rome and Beijing. We received many compliments on the food by the participants, particularly those who required vegetarian cuisine.

The scientific presentations, however, were the real core of the conference. We selected some of the best people to invite to give presentations at the conference. The overwhelming majority accepted our invitation and came to Fargo. We had 13 invited presentations as well as five tutorial presentations, which focused on explaining the fundamentals to a more general audience.

The subject of this conference series is a class of numerical methods that originate from lattice gas models. A lattice gas model consists of particles that move on a lattice, and when two or more particles coincide at a lattice point they undergo a collision. If these collisions conserve mass and momentum, we should expect from kinetic theory that they should represent a very simple fluid. Van Neumann already had proposed lattice gas models, but on a Cartesian grid they lacked rotational symmetry to reproduce the Navier-Stokes equations that describe fluid flow. In the first conference of this series, held in 1986 in Los Alamos, Frish, Hasslacher and Pomeau proposed and presented a lattice gas model that used a hexagonal lattice (in two dimensions). This model had a sufficient symmetry to recover the Navier-Stokes equations. This caused quite a stir in the Physics community and beyond. The Washington Post stated in a front-page article that the potential of the lattice gas method was "one thousand to one million times faster than previous methods," and even reported that the United States Department of Defense had to consider whether the method "should be classified to keep out of Soviet hands."

In the 20th edition of this conference, which we held here in Fargo, researchers presented new descendants of these early lattice gas models. The most prominent derived models are lattice Boltzmann methods, where continuous densities move along the lattice, stochastic rotation dynamics models, where particles take on

continuous positions, but still collide if they are within a range determined by a lattice, and dissipative particle dynamics, a cheaper version of Molecular Dynamics where the low quality of the time evolution of the particles is compensated for by a stochastic force. These methods are now being used for a very large variety of applications. At the conference we saw a wide variety of applications from liquid crystals to the aerodynamics of cars, and from protein diffusion in cells to relativistic fluid dynamics.

On the Tuesday, we had a conference outing. We deliberated for a while on what to do for this outing, since it should give the participants a lasting memory of their stay here. The aspect of our local culture that most fascinates visitors from abroad is Native American culture and the beautiful natural environment of the wide-open prairie. So we organized an outing to one of the last remaining parts of unplowed prairie in and next to Buffalo River State Park, just outside of Moorhead. Adjacent to this is MSUM's science center, which also has some adjacent prairie. They mowed a part of their property for us, a half mile walk from the parking lot. Malcolm Butler of the NDSU Biology Department let us use two tepees he owns, and we set them up at this site. For the first part of the outing, Clifford Canku, Dakota Studies Professor at NDSU, gave a presentation on his translation project for the Dakota Prison Letters, letters written by Dakota men describing their life and suffering in a Minnesota concentration camp, a part of our history that is seldom highlighted. It was remarkable that nearly all the participants that made it to this outing were non-US citizens. For the second part of the outing, renowned Native American flute player Keith Bear (from the Mandan tribe) came and gave a memorable performance. We were extremely lucky that the weather cooperated with our open-air plans with a dry, partly overcast sky that kept the temperatures moderate.

During the conference, many participants expressed their sincere appreciation of both the scientific quality of the conference and the local organization. Fargo was also well-received as a quiet and pleasant venue off the beaten track.

In all, the conference went about as well as it could have. It remains for me to thank the following for their financial support: the National Science Foundation, the North Dakota Department of Commerce, ND EPSCoR, Intel, NVIDIA, NDSU's College of Science and Mathematics, NDSU's Vice President for Research, NDSU's Provost's Office, NDSU's Department of Physics, and the Fargo-Moorhead Convention and Visitors Bureau. You can learn more about the conference at http://dsfd.physics.ndsu.nodak.edu.

Graduate Student from Germany Visits Physics Department

Sylvio May

Kathrin Kaess is a graduate student in the Department of Pharmaceutical Technology at the Friedrich-Schiller University, Jena, Germany. Her first visit to the US brought her to Fargo, where she spent two weeks in October/November working in our Physics Department together with Sylvio May on modeling the fluorescence of drug molecules. This visit was part of a collaboration between Sylvio May and Kathrin's advisor in Germany, Alfred Fahr. Kathrin also gave a presentation at our 5th Annual Undergraduate Research Poster Session on October 27 (yes, that was already number 5). Kathrin's activities in Fargo included attending a Science Café as well as theater and concert performances. She was not only impressed by Fargo's cultural life but also liked the friendliness of its people (and that people don't push while waiting in line).

Learning Assistants Program

Warren Christenson

The 2012-2013 academic year will be a transformative one for hundreds of students in the physics classrooms at NDSU. For the first time, top-notch physics majors are being recruited to serve as Learning Assistants (LAs) in the introductory calculus-based sequence of physics classes.

LAs are present every day in the large lecture classrooms, helping the instructor to engage students in more interactive activities. For example, imagine an instructor posing a question up on the board: "A car drives over a curved hill at constant speed. How does the normal force acting on the car compare to its weight?" Students use electronic clickers to select one of four possible answers. Then it gets exciting. Students are directed to turn to their neighbors and defend the choice they selected and share their reasoning. Picture a classroom of 180 students simultaneously discussing and challenging each other's thinking about physics, with multiple experts (the instructor and several LAs) circulating about, facilitating discussions and asking leading questions to guide student thinking. This type of classroom activity requires significant preparation on the part of the LAs and the instructor. Weekly meetings create a space for LAs to thoroughly examine that week's content, ask challenging questions, and have an opportunity to practice facilitating student discussions before class. In addition, Physics LAs, along with other LAs serving in Biological Sciences and Biochemistry, will learn fundamental principles of the research on student learning through a course on *The Science of Learning*, taught by Biochemistry Education Researcher Erika Offerdahl.

Our LAs will not only promote greater learning gains for the undergraduate students enrolled in the physics courses, but will also significantly improve their own understanding of the most challenging physics content. LAs will enter advanced courses with a superior understanding of the material and be better prepared for graduate admissions and coursework, as well.

Members of the STEM Education Research Group (Warren Christensen, Physics; Erika Offerdahl, Chemistry and Biochemistry; Jennifer Momsen, Biology; Mila Kryjevskaia, Physics; and Lisa Montplaisir, Biology) at NDSU received funding for the LA Program through an unsolicited proposal to the Dean of Science and Mathematics. Our proposal is modeled on the LA Program at the University of Colorado, which has built up capacity throughout their University to over 100 LAs since its inception a decade ago. Our five-year plan sees us building further capacity for the LA Program at NDSU as well, reaching out to more instructors in our College and across the University, particularly into Engineering.

Physics Outreach: Home and Away

Alan Denton

Here follows a brief chronology of another fun year of science outreach events.

June 2011: During the NATURE Summer Camp, Andrew Croll and Alan Denton mentored four tribal college students in a week-long research experience. NATURE (Nurturing American Tribal Undergraduate Research and Education) is a North Dakota EPSCoR-sponsored education and outreach program that aims to improve science, technology, engineering, and mathematics education among North Dakota tribal college and high school students. In two related projects, the students explored the unusual properties of soft matter. In one project, the students built a giant bubble machine and tested the stability of soap films. In the second project, they studied pattern formation in a mixture of corn starch and water poured onto a vibrating audio speaker (only a physicist would dream of doing this).

October 11, 2011: On the heels of the Nobel Prize announcements, we staged our second annual "Science Fun Night" at Longfellow Elementary School in Fargo. With kind support from the school staff and PTA, and a dedicated team of NDSU faculty and student volunteers, the event drew about 100 students (plus parents). Students rotated through a variety of stations, each with several hands-on activities based on a common theme, e.g., "Cool Colors," "Charged Up," "Light Show," "Pulley Power." Demonstrations included old favorites – liquid nitrogen, superconductors, and electrostatics – as well as the new giant bubble machine.

January 26, 2012: Thanks to the tireless efforts of science teacher Nandini Katti, we were able to put on our first Science Fun Night at Horizon Middle School in Moorhead. With generous support from the school, the event drew almost 150 students. Stations included "Force and Motion," "Under Pressure," "Soapy Science," "Making Waves," and "What Goes Around." For the first time, activity facilitators included students enrolled in our University Physics Recitation, who earned credit (and free pizza) for their teaching and outreach experience. This approach is based on the philosophy that one learns a subject best by teaching it. A grant from the NDSU Development Foundation will further support the involvement of Physics students in next year's Science Fun Nights.

April 14, 2012: As part of NDSU's "Expanding Your Horizons" program for middle school girls, Alan and Anne Denton led a workshop entitled "Fun with Physics and Computers." About 20 keen junior scientists attended, bravely navigating the winding path from magnets and relays to logic gates and binary numbers.

April 21, 2012: The Department of Physics turned out in force for the ND State Science Olympiad. Andrew Croll led "Storm the Castle," an event in which teams must design and construct a device capable of accurately launching a previously unknown projectile the farthest distance possible using a counterweight of previously unknown mass. Physics graduate student Stephan Loew led two of the "hottest" events: "Keep the Heat" and "Thermodynamics." Physics/Music major Brandon Johnson led the "Technical Problem Solving" event, in which teams gather and process data to solve problems. Mila Kryjevskaia and Alan Denton, assisted by Physics majors Wei Kang (Ken) Lim and He Gao, and Chemistry postdoctoral research fellow Delwar Hossain, facilitated the "Optics" events, in which students explore geometric and physical optics using lenses, mirrors, and lasers.

Physics Education Expert Visits NDSU

Landon Bladow

On October 6-7, 2011, Prof. Edward "Joe" Redish of the University of Maryland Department of Physics visited the NDSU campus. He is one of the leading experts on Physics Education Research. In addition to visiting with science faculty across campus, Prof. Redish gave two presentations. The first, "Thoughts on teaching while listening to Ravel's *Bolero*: Implications of research on learning and knowing," was given as part of the NDSU Pedagogical Luncheon series, which was attended by faculty from across the university. As part of his talk, Redish related his story of how he became interested in Physics Education Research. Originally a nuclear theorist, he began teaching the algebra-based sequence of physics courses. Although his ratings as an instructor were good and his students were able to perform well on traditional numerical physics problems, he was surprised at their lack of conceptual understanding of basic physical principles. He switched his research focus to Physics Education (roughly 30 years ago), and has become an advocate for a more active-learning, student-centered approach to teaching. His presentation discussed how education research has suggested that instructors focus not only on the "melody," or course content, but also the "orchestration," or how the content is delivered to effectively promote student understanding.

Redish's second seminar, presented to science and education faculty, focused more on the details of the reforms he has made in the algebra-based physics sequence at the University of Maryland. Realizing that many students taking the course were majoring in the life and health sciences, he developed a version of the course that focuses on biologically-relevant problems, among other modifications. As NDSU has recently become a hub for Science, Engineering, Technology, and Mathematics education research, Prof. Redish's visit was timely and appreciated.

2nd Conference on Transforming Research in Undergraduate STEM Education

Warren Christensen

Scientific study of the teaching and learning of STEM (Science, Technology, Engineering, and Mathematics) disciplines is playing an ever-increasing role in the discussion of solutions to educational challenges and our country's growing need for students majoring in the STEM disciplines. Assistant Professor Warren Christensen worked with three investigators across multiple institutions to organize the second of two conferences on Transforming Research in Undergraduate STEM Education (TRUSE) to facilitate discussion and nurture research across these discipline-based education research programs, including mathematics, chemistry, physics, and biology. Along with Marcy Towns, Purdue University (Chemical Education Research), Chris Rasmussen, San Diego State University (Mathematics Education Research), and John Thompson, University of Maine (Physics Education Research), Dr. Christensen brought together nationally recognized researchers as plenary speakers and over 120 participants to the beautiful University of St. Thomas campus in nearby St. Paul, MN. The 2nd TRUSE Conference took place June 3-7, 2012. The conference allowed special time for viewing the Transit of Venus on Tuesday, June 5th. Additional information can be found on the TRUSE website: http://www.chem.purdue.edu/Towns/TRUSE/.

Student News

Physics Undergrad Recognized by AAPT

Mila Kryjevskaia

The American Association of Physics Teachers (AAPT) is the world leader in promoting physics education. Each year the Association recognizes outstanding teaching assistants and grants them a one-year gift membership. This year, Cody Gette has been selected as the Outstanding Teaching Assistant from the NDSU Department of Physics. Department Head Daniel Kroll presented Cody with a certificate of achievement and a gift AAPT membership.

Gette. © NDSU

Cody is an outstanding student who graduated this May with a double major in Physics and Mathematics. Cody will pursue his graduate degree in Astrophysics at the University of Bonn, Germany. He received the prestigious Astronaut Scholarship Foundation Scholarship for both the 2010-2011 **and** 2011-2012 academic years. He was nominated for the award by Dr. Orven Swenson of our department; at the time, Cody was working under the supervision of Dr. Swenson at the NDSU Center for Nanoscale Science and Engineering. His research involved the laser processing of silicon-containing precursor films for flexible photovoltaic applications.

More recently, Cody became interested in Physics Education Research and started working with Dr. Mila Kryjevskaia. Cody served as an undergraduate teaching assistant in small group recitation sessions for physics majors. As a TA, Cody demonstrated an excellent understanding of introductory physics as well as a high level of maturity, professionalism, and a genuine commitment to helping students learn. In the beginning of the 2011-2012 academic year, Cody became involved in one of the research projects on teaching and student learning conducted by the Physics Education Group at NDSU. Cody investigated conceptual and reasoning difficulties that introductory physics students have while interpreting and applying multi-variable expressions in the contexts of electric fields, electric potential differences, and capacitance. Cody presented the preliminary results of this investigation at the 5th Annual Undergraduate Research Poster Session at NDSU and as a seminar to the Department of Physics at NDSU. Cody also reported the results of this investigation in an oral presentation at the National AAPT Winter Meeting, February 2012. Because of Cody's exceptional performance as a teaching assistant and his strong interest in the research-based approach to teaching, Cody was awarded the AAPT Outstanding Teaching Assistant Award.

Physics Students Win Bronze Medal in International Competition

Sylvio May

Senior physics majors Marne Johnson from Rugby, N.D., and Brandon Johnson from Hazen, N.D., and Junior physics and math double major Ahis Shrestha from Nepal won a bronze medal in the 2011 University Physics Competition.

The University Physics Competition is an international contest for undergraduate students, who work in teams of three at their home colleges and universities all over the world. They spend a weekend in November, 48 hours, analyzing a real-world scenario using the principles of physics and writing a formal paper describing their work. The 2011 contest started on November 4 and had 77 participating teams from around the world, including China, Singapore, Mexico, and the United Kingdom. The NDSU team wrote a paper about three-point shooting in Olympic basketball, calculating the ball's initial velocity, launching angle, and spin that would result in a successful shot. Success in this competition requires teamwork and enthusiasm, excellent analytical and numerical skills, and good time management. As Brandon Johnson put it, "Through the competition, I learned some of the value of teamwork in physics. The time limit was intense, to say the least." The success of the NDSU team was featured in *It's Happening at State* and on NDSU's home page (archived at http://www.ndsu.edu/news/banner_stories/basketballandphysicscompetition/). More information about the competition can be found at http://www.uphysicsc.com.

High School Student's Summer Research Experience Leads to Publication in Major Scientific Journal

Erik Hobbie

As many of you may know, North Dakota Governor's School is a tuition-free summer program for high-achieving North Dakota high school students. Attending Governor's School can be a formative experience for some of North Dakota's best students. The following excerpt from an NDSU press release describes the experience of Anna Bernhardt of New Salem, N.D., who worked in Prof. Erik Hobbie's lab last summer as part of the program:

When 16-year-old Anna Bernhardt of New Salem, N.D., filled out papers to attend North Dakota Governor's School, she didn't know it would jump-start her journey to become a young scientist in a major way, leading to a significant research discovery in nanotechnology.

Bernhardt attended an intensive six-week program on the North Dakota State University campus in Fargo this past summer. The Governor's School program provides selected academically-driven North Dakota high school sophomores and juniors an opportunity to learn about science, mathematics, English, business and performing or visual arts at the university level.

The science portion of the program pairs students with a mentor scientist and a research group to further develop laboratory skills. Bernhardt wrote "physics" as her lab preference. That led to the opportunity to work with Erik Hobbie and his research team in a lab in NDSU's Research and Technology Park.

"I had never worked in this type of setting before and didn't really know what to expect on my first day," Bernhardt said. "The biggest benefit of working in the lab was getting a taste of the true research experience. Without North Dakota Governor's School, I would never have been able to have this experience, and surely wouldn't be so certain that I would like to do more research in the future. Also, it was wonderful to meet and work with the people in my lab."

While working in the NDSU lab, Bernhardt prepared single-wall carbon nanotube samples and participated in testing of the samples. "The experience of working in a research setting has helped me to decide that I would love to do more research in the future," the young scientist said.

The daughter of Marlys and Leon Morgenstern, Bernhardt has grown up on a farming and cattle operation near New Salem, N.D. There are 28 students in her class at New Salem-Almont High School. Bernhardt said while farming operations and single wall carbon nanotubes may not be directly related, "the work ethic and having a persistent attitude definitely applied to my experience in the lab." When she graduates from high school, Bernhardt currently plans to major in physics.

“Anna is a very hard working and focused young woman,” Hobbie said. He notes that participating in such advanced research is an unusual opportunity, not typically available to teenagers. “I would say it is highly unusual, but it was a great opportunity for everyone involved; and as a young student interested in science and engineering, it gives her a great jump on her career.”

The first day in the lab was eye opening. “Before my first day, I had absolutely zero knowledge regarding nanotubes. My first day was mostly a crash course on the research taking place, and then an assignment to read up more on what I would be working with,” Bernhardt said. “Nothing in my high school setting had brought me close to what I was dealing with here. But I adjusted, and was soon doing experiments on my own. Working in the lab was unlike anything I had done before, and was altogether a pleasant experience.”

A few things were unexpected. “The most interesting thing I learned was probably how much time and thought are put into each experiment done, and how much time is spent waiting,” Bernhardt said. “I quickly learned that research involves much waiting around. For instance, I spent many hours waiting for acetone puddles to dry.”

Bernhardt explains some of her highly technical work in the lab, using examples. “Single-wall carbon nanotubes are basically a hexagonal lattice structure of carbon, rolled up into a tube. This is not how they are actually made, but it is a good way to envision their structure,” she said. There are several different types of carbon, including graphite and graphene. “Graphite is pencil lead, and graphene is a two-dimensional hexagonal lattice of carbon atoms. A piece of graphite is put into the middle of a vacuum chamber and then a laser beam is focused on it. The pulsed laser beam hits it with high intensity and gives it so much energy at the contact point that it causes carbon atoms to fly off the graphite and the particles condense on the walls of the chamber. As these particles condense, they build up single-wall carbon nanotubes one layer at a time.”

Bernhardt notes that the driving force behind the research she did is to replace expensive materials that are essential to today’s electronics. “Indium tin oxide is a transparent and highly conductive film used in phone, computer and television screens. ITO is very rare and therefore, extremely expensive. Since it is in such high demand, the resources are being depleted and are expected to be gone in 15 years.” Bernhardt’s exacting work measured the transparency of the films in the visible spectrum at different film thicknesses for each electronic type.

The research done by Hobbie’s team, including Bernhardt, could one day impact flexible electronic devices such as solar cells and wearable sensors. In addition to Bernhardt, the research team includes NDSU graduate student John M. Harris, postdoctoral researcher Ganjigunte R. Swathi Iyer, and researchers from the National Institute of Standards and Technology in Gaithersburg, MD.

Hobbie and grad student John Harris considered Bernhardt’s contribution to the research substantial enough to include her as a co-author of an article about their research results, now published in a major scientific journal. “I was absolutely thrilled,” Bernhardt said.

Results from the NDSU research team that included Bernhardt appear in “Electronic Durability of Flexible Transparent Films from Type-Specific Single-Wall Carbon Nanotubes,” published in *ACS Nano*, a major scientific journal of the American Chemical Society.

Bernhardt said her experience in Governor’s School made the opportunity possible.

ALUMNI NEWS

NDSU Researcher Uses Supercomputing Power to Study the Sun

Orven Swenson

The following is an excerpt from a spring 2012 press release from Carol Renner, Communications Manager for the Vice President of Research, Creative Activities, and Technology Transfer, regarding Cherish Bauer-Reich, who received her B.S. in physics from our department and is currently pursuing her doctorate in geophysics from the University of Minnesota:

Researcher Cherish Bauer-Reich wants to look inside the sun. More accurately, she wants to simulate the sun to study plasma flows associated with sunspot cycles. The cycles play a role in solar storms, which can affect satellites and disrupt a host of modern communication technologies, from cell phones to power grids.

Scientists recently warned about a series of solar storms in early March, concerned that it could affect global positioning systems, power grids, satellites and airplane travel. With the sun's normal 11-year cycle, these very active solar storms are expected to continue.

Bauer-Reich, a research engineer at NDSU's Center for Nanoscale Science and Engineering, is pursuing her doctorate in geophysics. She's using supercomputing power to create a model of the sun. "I need something that has a lot of computing power. Basically, when you're running these, you break the sun down into a big grid. And you have to compute all these variables at each node of the grid. When you're dealing with tens of thousands of grid points, you need a lot of computing."

The Center for Computationally Assisted Science and Technology (CCAST) at NDSU provides the power for Bauer-Reich's research. She looked at computing centers in Minnesota and Arizona to do the work, but found that CCAST in Fargo provided an easily accessible route to the supercomputing needed.

"I wasn't surprised that the university has a facility like this. I was actually more surprised at how easy it was to get in and work with them," says Bauer-Reich. "When I've talked with people that work with supercomputing, and I know some who are starting to go to places like China, because it's hard to get in to a lot of the super-computing facilities in the U.S., either there's no time available, or it's really expensive."

NDSU's supercomputing center (CCAST) is available to students, faculty and staff researchers, and available for researchers and industry that are partnering with NDSU. With secure facilities in NDSU's Research and Technology Park, CCAST provides 13 TFLOPS (trillion floating point operations per second) of peak theoretical computational performance to excel in today's competitive research arena.

"I could not do anything on my dissertation without having access to a computing center like this," says Bauer-Reich. "It would be a showstopper if I didn't have it because the emphasis is on the computational model."

While people have heard of sunspots, most aren't aware of what actually causes them. "It's a big tube of magnetic flux basically," says Bauer-Reich. "These things pop out of the top of the convection zone and then they pop back in. And where they pop back out and pop back in, they reduce the amount of heat and the amount of light coming out of the sun, which is why they look dark. It's because they're at different temperatures than the rest of the area around them," she explains.

Sunspots tend to work in cycles, starting at high latitudes and then migrating toward the equator. "Helioseismologists study vibrations in the sun and they image what's underneath the outer layer. What they've found is that when these sunspots are popping up, there's also a flow right next to them, so that the plasma is flowing at a different speed than on either side of them. What I'm trying to study is how strong that flow has to be," says Bauer-Reich. "These things can only be studied using computers because we can't really look inside the sun or go take measurements of the sun. So the only way to do it is to come up with these models that try to predict behavior."

Bauer-Reich expects running all the computer models on CCAST will take approximately a year, followed by the analysis of the data.

A native of Minot, N.D., who grew up in Bismarck and Fargo, Bauer-Reich earned her undergraduate degree in physics from NDSU and her master's degree in electrical engineering from NDSU. The availability of the supercomputing facilities at NDSU means she can be with her husband and children while completing her dissertation, rather than traveling much of the time. "It's nice that I was able to come back here and do research and have access to this computing."

More than 180 researchers engage in more than 50 projects using CCAST facilities at NDSU, according to Martin Ossowski, CCAST director. Projects include: renewable energy, multiprocessor electronic circuitry, modeling of atmospheric plasma, ways to monitor the health of bridges and vehicles, computational biology, tissue engineering, human bone modeling, and agroinformatics.

From her standpoint, researcher Cherish Bauer-Reich appreciates access to supercomputing available at NDSU CCAST. "I do think it's really cool that I get to be here to do my research."

AWARDS, SCHOLARSHIPS, & GRADUATES

Eivind Horvik Memorial Award: A cash award of $150 plus a recognition certificate for the best overall performance in the calculus-based physics sequence. The recipient's name is recorded on a permanent plaque in the Physics Department office. Funds are provided by friends and associates of Eivind Horvik.

2011 Horvik Award Winners: Marne Johnson & Elle Kvam

Sinha Family Scholarship: Initial funds to support this endowment in the amount of $5,000 were provided by Dr. and Mrs. Mahendra K. Sinha in memory of Mr. and Mrs. Pratap Narain, the parents of Dr. Mahendra K. Sinha, Emeritus Professor of Physics. It is understood that the recipient of this award will meet the following preferred criteria: (1) Be properly enrolled at North Dakota State University at the time of application and disbursement. (2) Be a Physics major with Junior or Senior standing. (3) Special consideration should be given by the selection committee to the applicant's academic merit and financial need.

2011 Sinha Scholarship Winners: Brandon Johnson & Ahis Shrestha

Physics Achievement Award: Up to four awards will be made annually to Physics majors based upon their academic performance. A minimum GPA of at least 3.3 is expected, but more emphasis will be given to excellence in Physics and Mathematics and distinction in undergraduate research. Awards may be extended for one additional year, subject to excellent performance and availability of funds.

The Department of Physics wishes to thank all donors who have contributed to our scholarship programs. You are making a significant difference in the lives of our students.

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Michael Reich and Cherish Bauer-Reich
Craig and Brenda Semler
Darrell and Carol Strobel
Dennis and Sandra Whitson

2011 – 2012 Graduates

Cody Gette (B.S. Spring 2012)
Cody will be pursuing a Master's Degree in Astrophysics at the University of Bonn, Germany, beginning in fall 2012. He plans to spend two years in Germany earning his Master's Degree, and then continue in Physics/ Astrophysics in pursuit of a Ph.D. He is undecided whether he will continue his studies abroad or return to the US at that time.

Micah Heppner (B.S. Spring 2012)
Micah has applied for graduate school in Physics at the University of North Dakota in Grand Forks for the fall 2012 semester. He desires to focus on his interests in condensed matter and particle physics while pursuing a higher level of education. Micah will be in Fargo for the summer working and studying for the Physics GRE.

Eric Foard (Ph.D. Spring 2012)
Eric successfully defended his Ph.D. thesis, "A Numerical and Analytical Analysis of the Physics of Phase-Separation Fronts," on March 28, 2012. His adviser was Dr. Alexander Wagner, Associate Professor of Physics. Eric has been awarded a postdoctoral fellowship from the Istituto Nazionale di Fisica Nucleare (INFN) to perform research on theoretical and computational fluid dynamics at Universita degli Studi di Roma Tor Vergata, Italy, beginning in the fall of 2012. There he will work on multiphase fluid dynamics and numerical method development as an extension of his Ph.D. research. Currently, Eric is a visiting researcher at Universita degli Studi di Bari, in the Puglia region of Southern Italy.

Deyan Mihaylov (M.S. Summer 2012)
Deyan successfully defended his M.S. thesis, "Hot Electron Effect in Ultrathin Photovoltaic Devices," on June 6, 2012. His adviser was Dr. Val Marinov, Associate Professor of Industrial and Manufacturing Engineering and Adjunct Professor of Physics. Deyan will remain at NDSU to pursue his Ph.D., working with Dr. Andrei Kryjevski, Research Assistant Professor of Physics, on the dynamics of photoexcited states in nanostructures, specifically on the description of exciton effects.

Your continued financial support is requested to keep the scholarship and awards programs growing.

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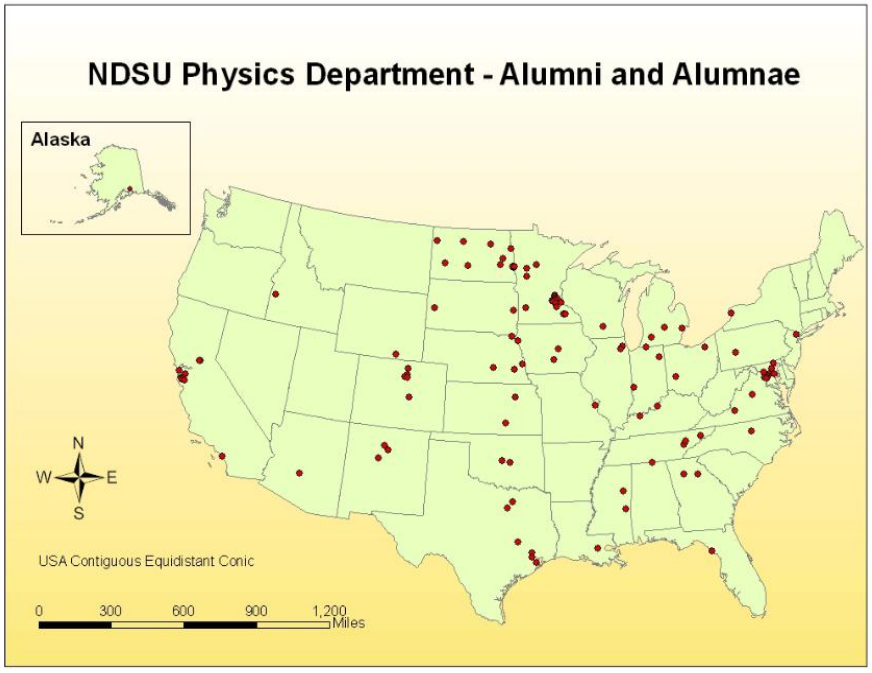

Graduates from the NDSU Physics Department are scattered throughout the United States and across the globe. We are eager to hear from our alums. Please send an email or note to update us on what's happening in your world.

Email updates to:
patty.hartsoch@ndsu.edu