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PHYSICS FOCUS

Bethel University Physics & Engineering Newsletter

Spring 2014
Editor: Alyssa Hamre

Inside this issue:

Dr. Keith Stein Awarded Prestigious NSF Grant

Keith Stein, professor of physics, received a National Science Foundation research grant.

Physics professor Keith Stein recently was awarded a $143,557 National Science Foundation (NSF) grant to support his project "Collaborative Research: Inspiring undergraduate engagement in advanced laboratories through web-based interactive video."

For a few decades now, the physics department at Bethel has encouraged students to work in open-ended advanced labs, or non-traditional labs with projects based on real-world scenarios, Stein explains. In traditional labs, lab assignments are commonly written such that every student is supposed to do the same exercises to get a known result – something Stein classifies as "cookie cutter." In the Bethel labs, students work on more extensive projects without known solutions,

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Dr. Nathan Lindquist Awarded Prestigious NSF Grant

Assistant Professor of Physics Nathan Lindquist has been awarded a $252,393 grant from the National Science Foundation (NSF) for his project, "Super-resolution plasmon-enhanced imaging and spectroscopy with patterned metallic surfaces and dynamic illumination."

Nathan Lindquist, associate professor of physics, received a National Science Foundation research grant.

"We want our microscope to take chemical images so – instead of just identifying what something 'looks like' – we can identify what it is made of, too," explains Lindquist. "There are several ways to do this, but we are mostly interested in taking chemical images of surfaces, like cell membranes." In graduate school at the University of Minnesota, Lindquist studied the peculiar form of light waves that allow precise imaging of surfaces. These light waves, called plasmons, are stuck

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Dr. Keith Stein's NSF Grant

"This project is all about engaging undergraduate students in the upper-level physics laboratory ." –Dr. Keith Stein

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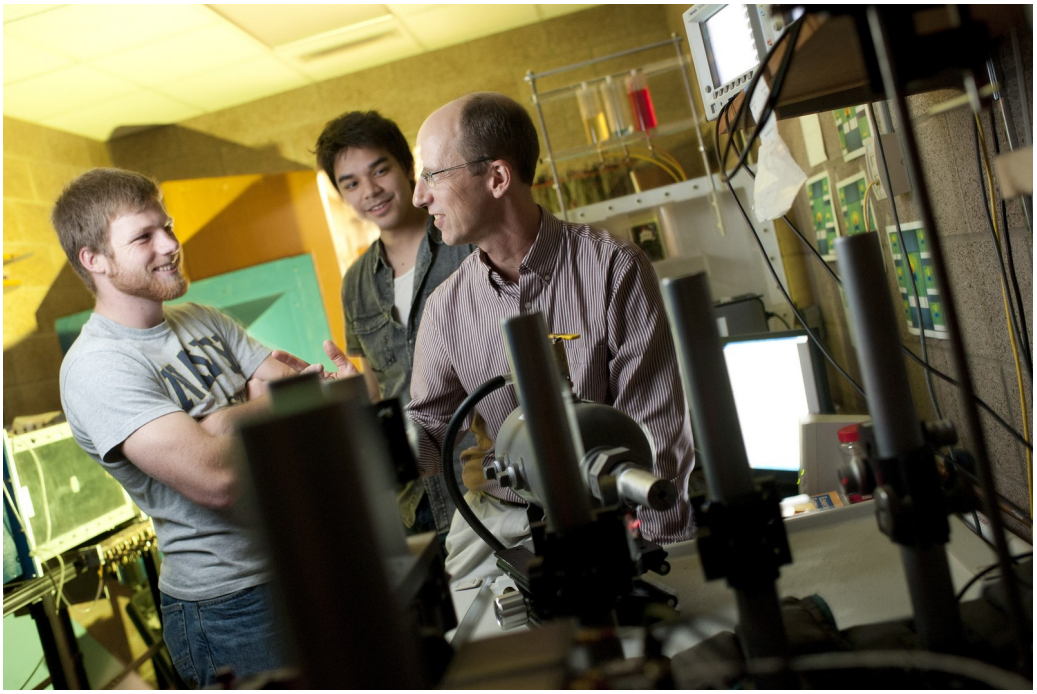
he says. "They are driven by a scientific question and it involves real-world experience. It is a creative learning experience that involves genuine problem solving."

The NSF-funded project will allow Stein and his team to develop web-based activities with interactive videos to inspire undergraduate students in physics and engineering by showing them the exciting things that can be done in an advanced lab setting. "This project is all about engaging undergraduate students in the upper-level physics laboratory," says Stein. "The activities will be designed to provide an interactive lab-like environment that focuses on the essence of the lab topic. We anticipate that they will enrich learning and student enthusiasm in the advanced lab topics, provide a solid introductory framework to the physics, and lead to more meaningful experiences inside the laboratory." The interactive videos will be available to the broader physics education community through ComPADRE.org, a digital library of resources for physics and astronomy communities.

The funding will also provide for three undergraduate student researchers during the next two summers.

The project is jointly directed by Stein, Associate Professor of Physics Chad Hoyt and Assistant Professor of Physics Nathan Lindquist, all from Bethel, and in collaboration with Robert Teese, a professor at the Rochester Institute of Technology in New York. Assistant Professor of Biology Sara Wyse will lead the activities associated with the project assessment. Hoyt and Lindquist were also awarded NSF grants this past year, and the three grants have totaled more than $625,000 for Bethel research.



Dr. Stein in the Fluids lab with students Alex Wiedmann and Nate Gessner. Their collaborative work on shock diamonds is an example of the open-ended lab project that Stein's grant supports and was recently presented at the COMSOL conference (see pg. 14 for more details).

Article first appeared in October 2013 at ***http://www.bethel.edu/news/articles/2013/october/nsf-keith-stein***.

Dr. Nathan Lindquists' NSF Grant

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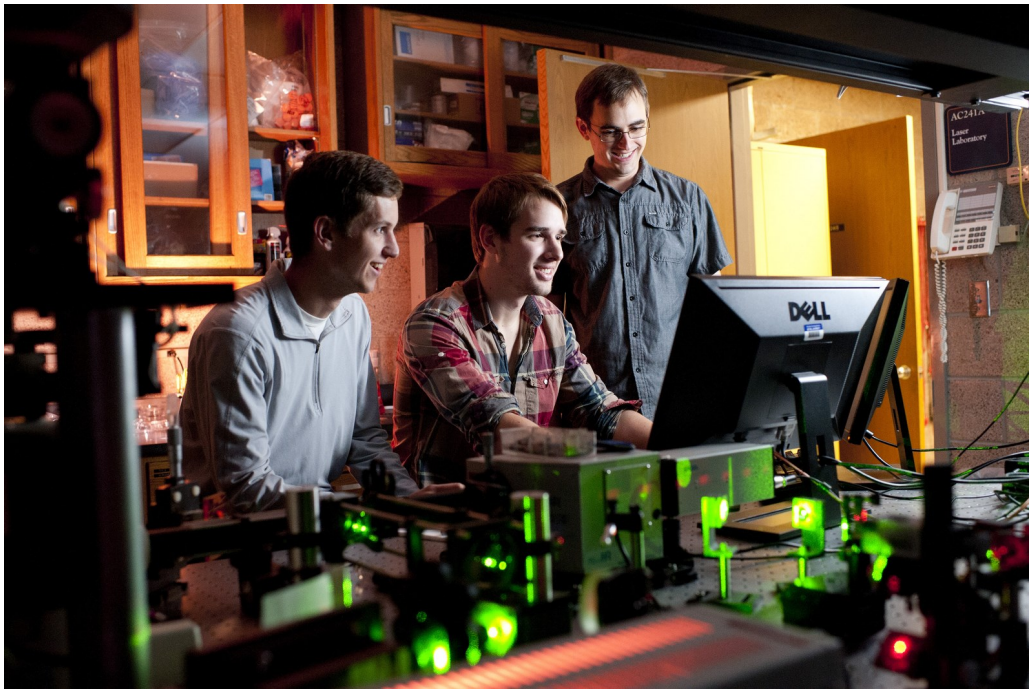
to surfaces, he explains. "To get these plasmons, the surfaces have to be nano-thin or decorated with nano patterns. Since we can make these nano-surfaces here at Bethel, thanks to some new equipment to furnish a little cleanroom, we will also be using this grant to explore better and cheaper ways for nanofabrication." Bethel's new "NanoLab" and cleanroom allow students to work in a contamination-free environment as they work with these tiny nano devices.

The NSF grant will support the development of new microscope imaging techniques to do just that. Such advanced research at a school like Bethel is unique, because there are no graduate students anchoring research initiatives. Instead, undergraduate students have gotten the unique opportunity to engage in this cutting-edge research in the field of nanotechnology and imaging.

According to Lindquist, undergraduates have in fact been integral to the development of this program. From the design process for the new microscope, to research integrated into existing coursework and senior and summer projects, the program has already allowed collaboration between students and faculty members like Lindquist. But now, he says, this grant will specifically fund undergraduate nano research projects for the next three years.



Dr. Lindquist in the Nanotechnology lab with students Luke Ness and Jared Wall.

The grant is awarded through the Research in Undergraduate Institutions (RUI) program of NSF, which supports research programs and instrumentation at institutions that have a majority undergraduate enrollment. Additional funding for this project has come from Bethel internally and a Bethel Alumni Faculty Grant during the 2012-2013 academic year. "This support helped lay the groundwork to get the preliminary results necessary for a good grant proposal," explains Lindquist. "I also need to acknowledge our physics department as a whole. Without its great labs, my great colleagues, and our great students, this sort of research would be pretty difficult."

Lindquist is the third Bethel physics professor to be awarded an NSF grant in the last year, and the grants have totaled more than $625,000. "The three NSF grants currently being awarded to physics principal investigators represent an extraordinary achievement in the current funding climate in Washington and the hyper-intense and bitterly competitive peer reviewing process that results," explains Dick Peterson, university professor of physics emeritus, who had a two-year appointment to NSF as a program director. "Going 3 for 3 for a small Science, Technology, Engineering and Mathematics (STEM) department must be unique in the U.S."

"The three NSF grants currently being awarded to physics principal investigators represent an extraordinary achievement in the current funding climate in Washington..." -Dr. Richard Peterson

Article first appeared in October 2013 at ***http://www.bethel.edu/news/articles/2013/october/nsf-nathan-lindquist.***

Physics Alumnae Awarded National Science Foundation Research Fellowship

"This recognition affirms anew the wonderful mentoring within Bethel STEM areas..." -Dr. Richard Peterson

The National Science Foundation (NSF) has selected two Bethel University alumnae to receive graduate research fellowships. Kayse (Lee) Maass '12 and Lauren Otto '12 were awarded NSF grants, which are among the highest in national recognition and support for graduate work in all STEM fields including science, technology, engineering, and mathematics.

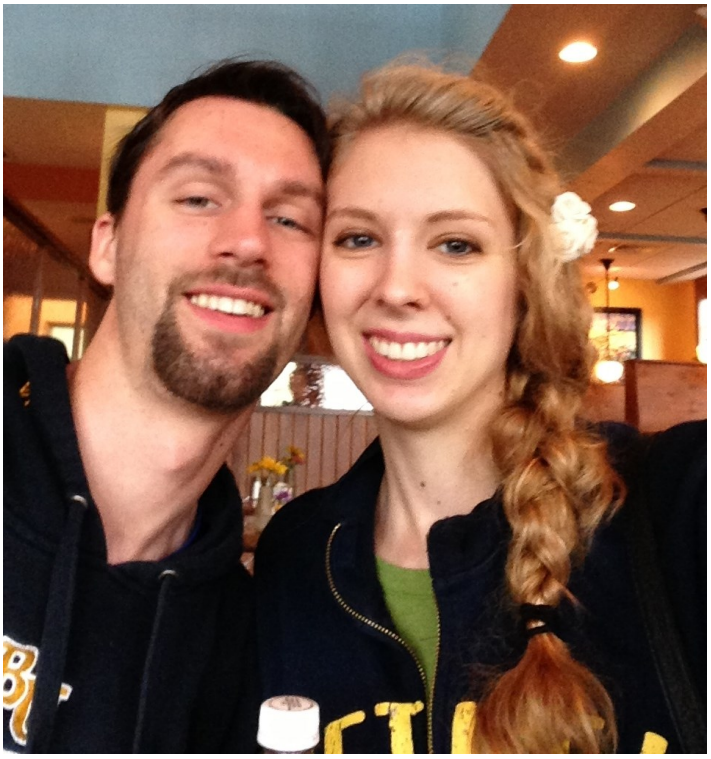
The NSF graduate research fellowships provide Maass and Otto with three-year annual stipends of $32,000 along with a $12,000 cost of education allowance for tuition and fees, opportunities for international research and professional development, and the freedom to conduct their own research at any accredited U.S. institution of graduate education they choose. They are expected to become knowledgeable experts in order to contribute to research, innovation, and teaching in engineering and science.

Both Maass and Otto graduated summa cum laude; Maass with double majors in mathematics and physics and a minor in business, and Otto with double majors in mathematics and physics. Maass is now in industrial and operations engineering, with initial emphasis in operations research and healthcare, at the University of Michigan. Otto is now in electrical engineering, concentrating in nanotechnology and photonics, at the University of Minnesota, and still contributes to the Bethel community by helping to edit Bethel's physics/engineering newsletter. She was back on campus last spring for the Society of Physics Students banquet. University Professor of Physics Emeritus Richard Peterson notes, "This recognition affirms anew the wonderful mentoring within Bethel STEM areas—in this case [Assistant Professor of Physics] Nate Lindquist who led her [Otto's] senior research last year. Lauren has used her many gifts and self-discipline to profoundly impact Bethel University."

Lauren Otto '12 [left] and Kayse (Lee) Maass '12 [right] at their graduation.

Article first appeared in May 2013 at ***http://www.bethel.edu/news/articles/2013/may/alumnae-fellowship.***

Sometimes Romance happens in the Physics Department



Bryan '13 & Cassie '13 in Bethel gear

When Dr. Beecken asked me to write this article, I wasn't quite sure where to start. I learned many things from the Physics Department. The Bethel professors taught me everything from kinematics in General Physics to Thermodynamics years later. They taught me about the theory and mechanics of physics, yes, but they also taught me how to be an effective learner as well. However, I took something out of that department that I never expected to. I get to spend the rest of my life with someone just as nerdy as I am; all because sometimes romance happens in the Physics Department.

For those of you who have experienced the Physics Department first hand, you know that when you sign up for that major, you aren't just signing up to take Physics classes. You are signing yourself up to be adopted into the physics family. The students do homework together, eat together, go to class together, and occasionally cry together over the latest killer test. As a Physics student, you really get used to leaning on people and being leaned on. That ability to lean and be leaned on is really what bound us together as a group. You could say Physics students are driven together by a common desire to learn. Every once and a while, people stick. My husband, Bryan, was one of those people.

It all started when I was working as a Lab Assistant in the sophomore electronics class. The Lab I assisted consisted of entirely male students, and Bryan was one of them. He is one of the most intelligent people I know, so I have no idea how I ended up always helping his lab group. He insists it had something to do with his lab partner, but we all know the truth. We started hanging out a lot more. By "hanging out" I mean staying in the building hallway till the wee hours of the morning either doing physics homework or watching "The Office." I'm not exactly sure when it happened, but we started being more than just friends.

As the typical Bethel love story goes, we fell in love and got engaged the summer before my senior year. The winter before I graduated with a double major in Physics and Computer Science was when I started looking for jobs that would start in the spring, and that's when I happened upon a listing for a Garmin Software Engineer. I had a couple of interviews and ended up getting the job. So I started working for Garmin in July doing web development for their Aviation Navigation Division. What does that mean? Well, I construct and maintain the website called fly.garmin.com which allows pilots who own Gar-

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"...you know that when you sign up for that major [physics], you aren't just signing up to take Physics classes. You are signing yourself up to be adopted into the physics family."
-Cassie Doehrmann

A fairy-tale ending to romance in the physics department—Bryan and Cassie on their wedding day.

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min Aviation Navigation devices to keep track of and update the maps that they have on them.

As I started my new job, Bryan and I prepared for the wedding, and Bryan started a Software Engineering Co-op at a company called LasX. LasX is a company that makes laser cutting machines which cut thin materials such as papers, plastics, and metals. The types of companies that they make these machines for are companies like medical companies and food processing companies. Bryan's job at LasX was to create a database system of laser parameters which optimized cutting performance.

We got married in a whirlwind of tulle and lights, and, next thing we knew, we were getting Bryan ready for his final semester at Bethel. It was the hardest semester of his life, taking 18 credits with all Physics and Computer Science classes to finish up his double major. But he made it; with blood, sweat, and tears, but he made it. Now he is a Bethel alum and will be continuing his Software Engineer Co-op position at LasX at the beginning of February. When the Co-op ends in May, Bryan plans on becoming a Software Engineer in the field of Graphics.

So there you have it. The story of a Physics Department which changed two nerds' lives by bringing them together, of how that same department made them into hard workers and good learners, and how they used those skills to achieve careers in Engineering. Sometimes more than just romance happens in the Physics Department.

Article submitted by Cassie Doehrmann

Physics Student J.D. Mehlhorn named to national "Good Works" Team

"It's a humbling thing and an honor to be nominated for this award because I know there are so many deserving people out there."

Earlier this fall, senior defensive back J.D. Mehlhorn was selected to the Allstate AFCA Good Works Team. In order to be selected for this team, a player has to display exceptional work in the community as well as in the classroom. According to the Allstate Good Works Team criteria, "Nominees have to be actively involved and committed to working with a charitable organization, service group or community service and maintain good grades. Candidates have to display sincere concern and reliability, while also having made a favorable impression on the organizations with which they are involved."

Needless to say, Mehlhorn goes above and beyond when it comes to meeting these standards. Over the past few years, Mehlhorn has volunteered at Feed My Starving Children, Adopt-A-Park, and the Neighborhood Care Program in Lakeville – an organization that helps citizens in need. Mehlhorn's most impactful volunteering came this past summer when he traveled to Slovakia for a short-term missions trip with Good Sports International. During his time there, he helped by serving the kids through sports.

"There are a lot of kids who come from broken homes, so we just spent time with them, developed connections and relationships, and loved on them," Mehlhorrn said.

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According to the American Football Coaches Association (AFCA), there were a record 150 nominees for the 2013 Good Works Team.

"This year's nominees uphold impressive service resumes detailing several unique and inspiring stories of servitude," Executive Director of the AFCA Grant Teaff said.

After the AFCA receives nominees from all over the country, a selection committee sorts through the résumés to determine who is the most qualified for the team and selects 22 players. To put these numbers in perspective, there are 366 Division III football programs in America. If the average roster holds 75 players, there are roughly 27,450 Division III football players. That doesn't even factor in the Division II players who are also eligible for the team.

When asked about Mehlhorn, Head Coach Steve Johnson said, "He's a great player, a good kid, and a godly man. That's what makes a good citizen." Bethel doesn't nominate a player every year. The coaching staff gets together at the beginning of the year and deliberates as to whether or not they have anybody that stands out in the community and classroom.

"We don't just nominate somebody every year," Johnson said. "He's got to be a ridiculously exceptional guy, and J.D. fits that description."

J.D. Mehlhorn's extensive charity work includes volunteering at a neighborhood care program in Lakeville and traveling to Slovakia on a missions trip with Good Sports International. Photo courtesy of Sports Information

With his selection, Mehlhorn joins five former Bethel football alumni to make the team. The most recent member of the team was Reid Veilo, a 2010 graduate of Bethel.

Mehlhorn has found himself a part of an elite group of football players. In joining this year's Good Works Team, he is in the company of NFL Superbowl Champions Peyton and Eli Manning who were a part of the Good Works Teams in 1997 and 2002, respectively. Not only that, but members of the selection committee include current University of Texas Head Coach, Mack Brown, and current ESPN sportscaster, Lou Holtz.

Later this fall, Mehlhorn will join the rest of the Good Works Team at the Sugar Bowl in New Orleans, La. to do a service project for youth in the area. There he and the rest of the team will partake in a pep rally and will be honored at halftime of the game.

"I've never been to New Orleans, and I've never been to a bowl game, so I'm pretty excited," Mehlhorn said. Mehlhorn feels honored to be recognized. He will look to represent not only the Bethel community, but also selfless athletes everywhere.

"I do what I can to serve my community, but there are still so many deserving guys out there. Now it's my job to honor all those guys by continuing to serve.

"He's a great player, a good kid, and a godly man. That's what makes a good citizen."
-Steve Johnson

Article first appeared in October 2013 at ***http://www.bethel.edu/news/clarion/articles/2013/october/mehlhorn-good-works.***

Physics & Engineering Department hosts Open House

The Physics & Engineering Department hosted an open house on Saturday, November 23rd, 2013 to celebrate the exciting things happening in the department, including three National Science Fellowship (NSF) grants and the development of new laboratories. This event was the first of its kind, and the department was thrilled to have a very substantial attendance of around 100 alumni and family members.

Alumni had the opportunity to tour the department and see developing lab facilities, including the NanoLab, Atomic and Molecular Optics Lab, and Fluids Lab. The new NanoLab hosts a clean room, microscopes, single molecule spectroscopy, atomoic force microscopy, and nano-fabrication equipment. The Atomic and Molecular Optics lab showcases a mode-locked erbium laser, four frequency tunable diode lasers, a sub-picometer wavelength meter, and a magneto-optical trap at 500μK atoms, which is the coldest measured spot in Minnesota. The Fluid Dynamics lab continues to develop as well, including two wind-tunnels, a water tunnel, and a Mach 3 Supersonic Shock Tunnel, plus 100,000 frames/sec videos of fluid interactions.

In addition to taking tours of the department while enjoying coffee and pie, alumni enjoyed watching Dr. Peterson do resonance demonstrations in the gen-

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eral physics lab, with most notable of them being the flame tube. This was followed by Dr. Peterson firing off the ping-pong cannon in the science demonstration hall, during which real-time high-speed video footage of the ping-pong ball was recorded by Dr. Stein.

Following the demonstrations, there was a program which included an opening by Troy Kopischke, Jason Sheard, and Jennifer Schommer from Invenshure, who were instrumental in contacting alumni and coordinating the open house. The program also included presentations by Dr. Keith Stein, Dr. Chad Hoyt, and Dr. Nathan Lindquist on their research. At the end, a few lucky alumni won the drawing for some vintage SPS t-shirts (where else would you get a t-shirt that says "Here, kitty, kitty…" with Schroedinger's equation on the back?).

Overall, the open house had an impressive turnout and many alumni and families were excited to be back in the physics department. Many commented that this would be a good tradition to continue. The department would again like to acknowledge the folks from Invenshure for their help getting the open house ready and contacting alumni, and the Alumni Services office for their support.

Dr. Peterson Returns from Teaching in Pyongyang, North Korea

"[Fellow faculty] desire that their offspring may someday be able to take a bus from Seoul to Pyongyang, and that many families and churches will see unification."
-Dr. Peterson

As described in *Christianity Today* in 2012 [http://www.christianitytoday.com/ct/2012/september/teaching-the-dragon.html] an unusual opportunity encouraged my teaching over 6 weeks in Pyongyang during May and June of 2013. To give some background, Pyongyang University of Science and Technology (PUST) is a Christian-founded university in North Korea which seeks to break down walls separating the Korean peninsula by teaching (in English) high quality courses within engineering, business, and science disciplines. It is the only private university in North Korea. Its founder, Korean-American businessman James Kim, has also founded a similar university in China (Yanbian University of Science and Technology [YUST]). Though it is not technically a Christian university, most of the faculty and administrators are Christians, and it relies on outside Christian support. In particular, Korean Christians and churches throughout the world have given generously and worked long hours to enable this private institution to exist, and North Korea (DPRK) has accepted this support and added some of its own. The school is located on the south side of the city and is administered by a parallel structure of English-speaking foreign professors and academics along with other academic leaders that represent the DPRK. Students have been at PUST for about 2-3 years, with campus construction happening over the last decade. At the opening of the university in 2010, it had 160 students, and the enrollment had almost doubled by 2012. The university intends to add other programs of study in the near future.

Location of PUST (courtesy of Google maps)

I flew into Beijing on May 1 and after receiving a DPRK entry visa was able to venture on to Pyongyang. I taught a class of Junior level Electricity and Magnetism for students enrolled in Electrical and Computer Engineering (ECE) programs. The students had excellent backgrounds in physics and mathematics and had all previously taken university-level physics and math classes. In addition, all of them had taken a year of intensive English during their first year at PUST.

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Dr. Peterson teaching his Electricity and Magnetism class

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There were 32 in my class and attendance was perfect during the weeks of class. Since I do not usually teach this subject beyond Freshman/ Sophomore level, I was kept quite busy in trying to stay ahead of the students. We met 1.5 hours every day, five days per week, for the six weeks.

Faculty members grow quite close during such an experience. Fellowship thrived, and I became much more familiar with the heritage of the well-recognized Korean/English hymnal. We ate most meals together in the cafeteria (modest, but quite sufficient Korean food), and typically weekly we went from the closed campus in a small bus into Pyongyang for miscellaneous shopping for breakfast, fruit, and snack foods at internationally oriented stores and from an open market (Tongil market – rather like a "farmers market", only much bigger and with a huge diversity of things for sale). We also went a few times into Pyongyang in the evening for an interesting mix of Korean food and pizza, and we also went by bus once to one of the four state-sanctioned churches in Pyongyang. While on such off-campus outings we were always with DPRK "minders," we were usually quite free to take pictures, and I believe we did get a fairly genuine picture of Pyongyang and its people – especially at the huge market and pizza place. On campus we stayed in single rooms of a motel nature that were sufficient. In June it was quite hot in this climate – a bit warmer than Minneapolis.

Farewell from Bongsu Church in Pyonyang

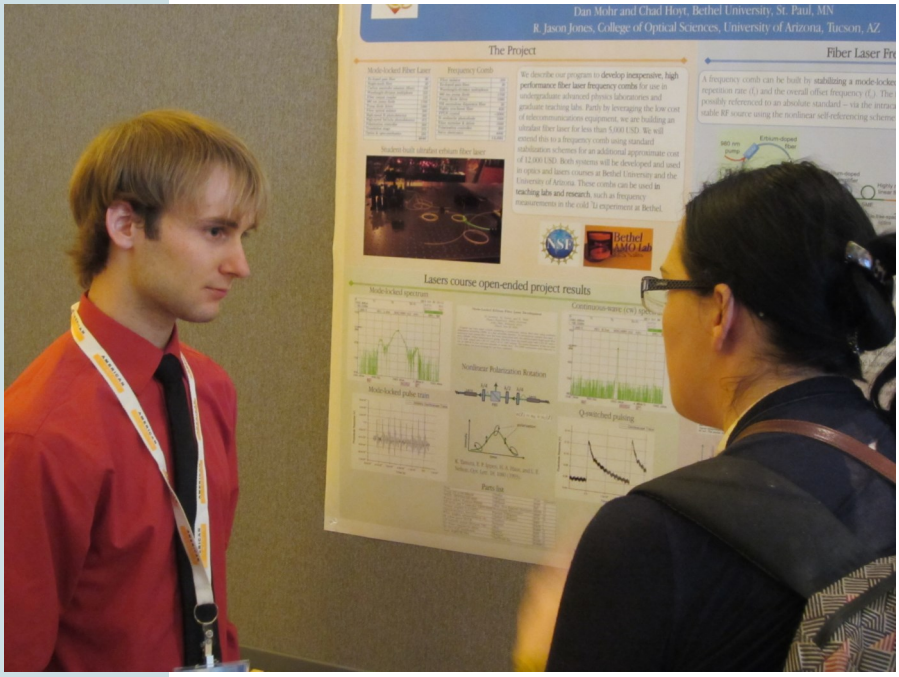
There is an interesting and growing engineering venture spinning off of PUST that seeks to provide solar stored energy lamps to many locations of the DPRK that are short on electricity and lighting options. There is some lamp information available at: http://www.brighterworldmovement.org/projects.html.

Much more could be said personally about this experience, and I can say six months later that the images and memories from that time still come up almost daily in my thoughts. Fellow faculty members (most having a close Korean heritage) are naturally very much in touch with the situation(s) of those of faith within the DPRK. They desire that their offspring may someday be able to take a bus from Seoul to Pyongyang, and that many families and churches will see unification.

"Much more could be said personally about this experience, and I can say six months later that the images and memories from that time still come up almost daily in my thoughts. "
-Dr. Peterson

Article courtesy of Dr. Richard Peterson. Additional information from Christianity Today *(www.christianitytoday.com/ct/2012/september/teaching-the-dragon.html?start=1), Wikipedia (en.wikipedia.org/wiki/Pyongyang_University_of_Science_and_Technology), and (money.cnn.com/2009/09/14/magazines/fortune/pyongyang_university_north_korea.fortune/index.htm).*

Senior physics major Dan Mohr presents laser cooling and trapping results at DLS meeting in Orlando



Dan Mohr explaining his poster to a fellow DLS conference student

Dan Mohr, a senior physics major doing research in Bethel's atomic, molecular, and optical (AMO) physics lab, recently presented his laser cooling, trapping, and spectroscopy results in a talk in Orlando, FL in October 2013. The Symposium on Undergraduate Research was a part of the annual meeting of the Division of Laser Science of the American Physical Society, co-located with the Optical Society of America annual meeting (FiO/LS XXVII). He presented "Measurements using cold ^{7}Li atoms in a visible magneto-optical trap," to a group of outstanding undergraduates and their research groups from institutions such as JILA, Swarthmore, Cornell, Bates, Colgate, Vassar, and NIST. Dan and his Bethel team recorded the fluorescence spectrum of the unresolved D2 lines in cold ^{7}Li. They observed line shape effects due to probe and re-pump beam polarization, power broadening, and probe duration.

While at this Symposium on Undergraduate Research, Dan also presented a poster on his work with fiber laser frequency combs in the AMO physics lab. The NSF-funded project is a collaboration with a colleague at the University of Arizona's College of Optical Sciences, R. Jason Jones (Bethel Physics alumnus, 1994), whose research group Dan visited for a month earlier in 2013. While there, Dan built and studied optical frequency combs and the necessary stabilization techniques. His poster at the Symposium described a nonlinear polarization rotation mode-locked erbium laser that was built and characterized in the context of an open-ended project in the Lasers course at Bethel.

Article courtesy of Dr. Chad Hoyt

Dan Mohr, Dr. Chad Hoyt, and one of the other DLS conference participants eating dinner.

Bethel professor presents invited talk at Orlando AAPT meeting

Chad Hoyt gave a 30 minute invited talk in a session at the American Association of Physics Teachers (AAPT) Winter 2014 meeting in Orlando, FL on January 5th, 2014. The talk, "Open-ended Laboratory Projects in an Undergraduate Lasers Course," was in a session entitled "Optics Labs Beyond the First Year." Chad described the work that he, Nate Lindquist, and Richard Peterson have done with students in Optics and Lasers courses. Chad distributed compilations of project manuscripts from the Lasers course in spring 2013 and described the format and experience of the course. The course, which includes a standard, rigorous lecture portion, is built on open-ended research projects that have a novel aspect. It begins with four weeks of small student groups rotating between several standard laser laboratory exercises such as alignment and characterization of a helium neon laser. During the remainder of the course, student groups (two-four people) choose and pursue research questions in the lab. Their work culminates in a group manuscript typeset in LaTeX and a 20-minute presentation to the class. Projects in the spring 2013 Lasers course included ultrafast optics with a mode-locked erbium fiber laser, quantum optics, saturated spectroscopy of indium, nano-optics and plasmonics, and improvements to a lithium magneto-optical trap. The experience in Lasers is representative of other upper-level courses at Bethel, including Optics, Fluid Mechanics, and Computer Methods.

Article courtesy of Dr. Chad Hoyt

"The course, which includes a standard, rigorous lecture portion, is built on open-ended research projects that have a novel aspect."
–Dr. Chad Hoyt

Dr. Chad Hoyt in the Atomic & Molecular Optics lab with graduate Dan Klemme '13 and Sarah Venditto '14.

COMSOL Conference 2013 Boston: Student Presentations on Supersonic Flow Studies

"The close correlation between their experimental and computational data resulted in some "oohs" and "aahs" from the conference attendees.." –Dr. Keith Stein

Senior physics majors Nathan Gessner and Alex Wiedmann, accompanied by Professor Stein, attended the 2013 COMSOL Conference in Boston during October 2013 to present results from experimental and computational studies on the highly-transient supersonic flow from an axisymmetric converging-diverging nozzle. These studies originated as a project in the Fall 2012 Fluid Mechanics course and continued as a Summer 2013 student research project under the supervision of Stein and Professor Peterson. Gessner and Wiedmann gave poster and oral presentations at the COMSOL conference that were very well received by the audience, which was primarily made up of professionals and graduate-level researchers. The close correlation between their experimental and computational data resulted in some "oohs" and "aahs" from the conference attendees.

Flow from the nozzle is initiated by the rupture of a Mylar® diaphragm that is positioned between the nozzle and a 1-gallon pressurized air tank. Upon rupture, supersonic flow exits the nozzle into the atmosphere. The student research and presentations have taken a threefold approach to analyze the startup flow from the nozzle, including the initial shock wave and 100-200 microseconds of supersonic flow following the shock. The threefold approach is based on high-speed video (HSV) imaging, dual-beam interferometry, and COMSOL simulations:

1. HSV shadowgraph techniques are employed at rates up to 100,000 frames per second to image the initial flow formation from the nozzle. Features in the HSV images are the result of density gradients in the flow and clearly reveal the initial shock wave and other features of the compressible flow.

2. Heterodyne interferometry quantifies rapid density variations in the nozzle flow as a function of time. A versatile LabVIEW enhanced system (using a stabilized He-Ne at 633 nm) measures changes in optical path due to fast density fluctuations by recording phase shifts between two 80 MHz reference signals.

3. Simulations are carried out using COMSOL® to model the unsteady flow in the tank, nozzle, and exit flow region. The flow in the simulation is driven by an initial pressure condition that is representative

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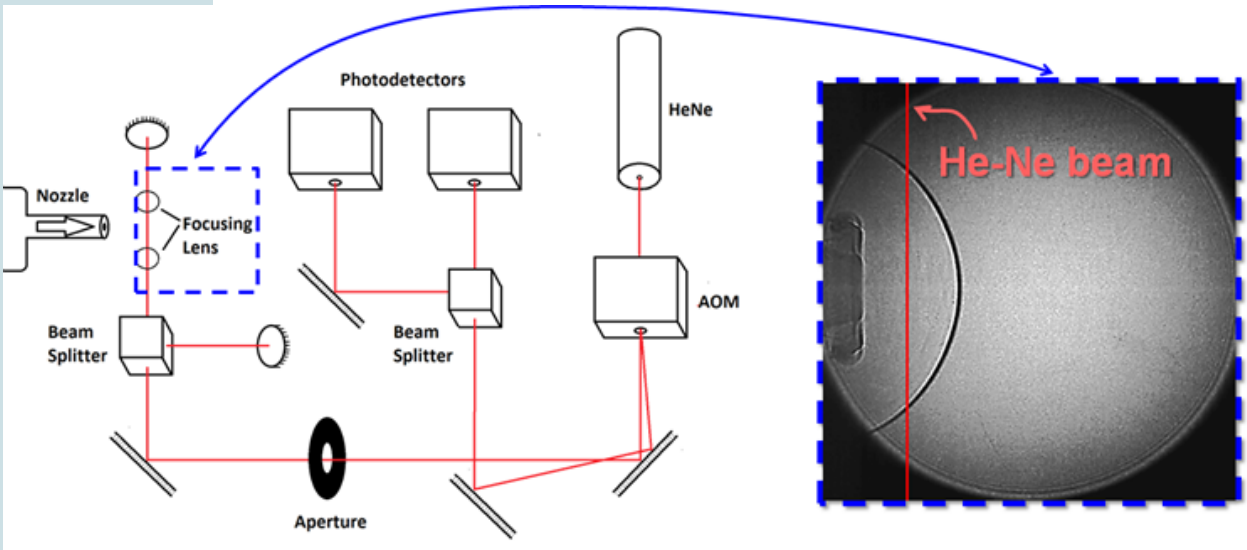

Experimental setup for the dual-beam heterodyne interferometer (left), with one arm of the interferometry passing through the nozzle flow field (right). An expanded view is shown at the nozzle exit, depicting the He-Ne laser passing through the leading shock wave.

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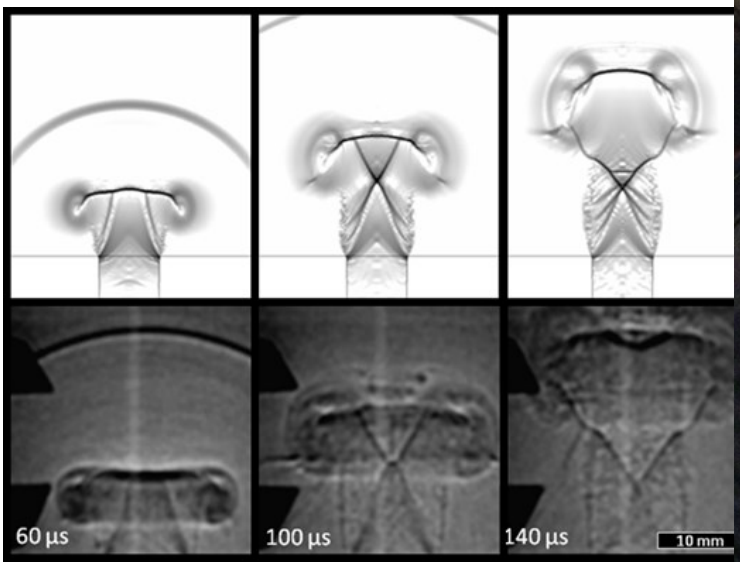
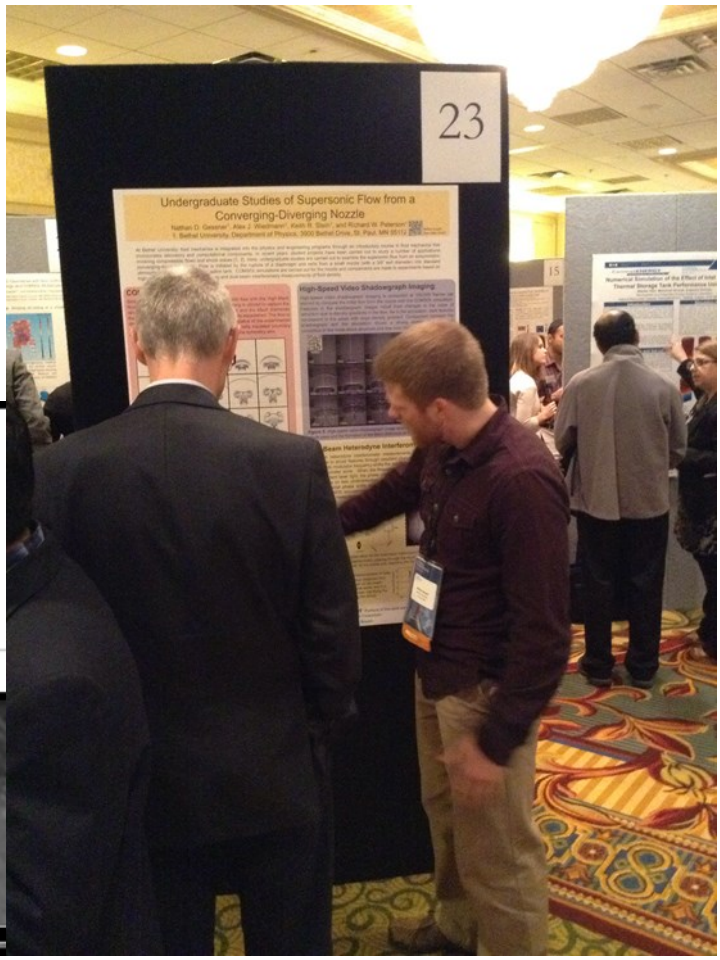
of the conditions in the physical experiments.

Qualitative and quantitative comparisons are made between the COMSOL simulation, HSV imaging, and the dual-beam interferometric measurements. The threefold approach in these experiments is complementary, providing a rich undergraduate advanced laboratory experience. Research and instruction on this project is ongoing and will be included as an NSF funded ALPhA laboratory immersion workshop hosted at Bethel this coming summer.

Article courtesy of Dr. Keith Stein.





Left: High-speed video shadowgraph image sequence (bottom) and corresponding numerical simulation results (above) showing the initial shock wave and the formation of the shock diamonds at the nozzle exit. Right: Nate Gessner discussing his poster with one of the conference attendees.

Annual Physics Department Christmas Party

This year, the Physics Department Christmas Party was hosted by the Stein family. We continued the tradition of singing both physics carols and traditional Christmas carols, as can be seen in the picture to the right.

The party also included pizza, home-made treats, and apple cider. Students kept busy working on a physics word find (it was hard!) and playing ping-pong in the basement. Overall, a good time was had by all.

Bethel University Physics & Engineering Newsletter

Newsletter article and photo submissions to Dr. Beecken (beebri@bethel.edu) are welcome and appreciated.

www.physics.bethel.edu

BETHEL UNIVERSITY

About Us

We normally graduate about 20 students each year, including both physics and engineering students. Most of the engineering majors earn a double major in physics.

Both physics and engineering courses strengthen students' problem-solving skills and analysis abilities. Engineering has a stronger emphasis on practical application of course material for solving real-life problems, whereas physics has a stronger emphasis on how the fundamental laws of physics undergird these problems. All students participate in open-ended lab projects which provide them with practical, hands-on experience geared toward preparing them for the real world. This nationally-recognized project-based learning begins in the first semester and continues throughout upper-level courses. Its effectiveness has been demonstrated in the employment and graduate school success of Physics & Engineering department alumni.

Class of 2013

Fall 2013 (not pictured)
Lucas Crestik, Curtis Heyda, Jacob Smith, Erik Smith, Bryan Wallin

(Above) Spring 2013 Back row from left: Andreas Copan, Dr. Lindquist, Dr. Beecken, Dr. Hoyt, Dr. Stein, Cassie Doehrmann. Middle row from left: Dr. Greenlee, Matt Robbins, Derek Leventry, Jonathan Lake. Front row from left: Joel Englund, Tony Burand, Stefan Jentoff, Ben Stein, Patrick Franzen. Not pictured: Seth Anderson, Karl Johnson, Chris Kleinhuizen, Dan Klemme, Geoffrey Schmalzer, Michael Tetzlaff, Laura Billiar.