An Alumni Newsletter from the Department of Physics and Engineering   Volume 9 | Winter 2015

The Ping-Pong Cannon Goes Global

Keith Stein

The ping-pong cannon (PPC) has been a beloved toy, demonstration gadget, and undergraduate research apparatus at Bethel over the past decade. It has captured the excitement of diverse audiences ranging from elementary school students to physics professors. It has been published on the cover of the *American Journal of Physics* (2006), the *Physics Teacher* (2005), and even the *Bethel Focus* magazine (Winter/Spring 2005). With the award of a recent National Science Foundation (NSF) grant "Inspiring undergraduate engagement in advanced laboratories through web-based interactive video," the cannon is about to go global, along with other Bethel physics advanced lab projects in the areas of compressible fluid mechanics, AMO physics, and nanotechnology and plasmonics. Through the support of this NSF grant, users across the globe will be able to interact with and experience the PPC and other advanced lab project work in the physics department.

The cannon (also referred to as an "expansion tube accelerator") can accelerate ping-pong balls up

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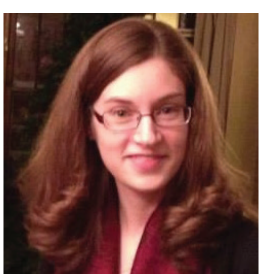
New Physics Instructor Alyssa Hamre



Professor Hamre is thrilled to join the Physics Department/Engineering Program full-time for the 2014-2015 academic year. She has been an adjunct in the department for the past two years, helping the department juggle increased student enrollment and the intensive work associated with the three NSF grants in the department.

Prof. Hamre received her M.S. in Physics at the University of Minnesota after completing her B.S. in Physics at Wheaton College, IL. Her research is in space plasma physics with a focus on the energy processes associated with the Northern Lights. She continues to monitor space weather and tends to be overly excited anytime there are large blobs of plasma coming off of the sun (a part of the energization process). She also holds a Minnesota teaching license in 9-12 physics completed through the graduate school at Bethel University. Within the department, she focuses on the exploration of new physics teaching methodology, and she heads the Women in Physics & Engineering events for the department.

Professor Hamre helping out the department by smashing a cement block over Keith Stein's chest while he is sandwiched between beds of nails. *Stein was not injured in the making of this picture.*

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to speeds of approximately 300 m/s over a distance of 2-3 meters using atmospheric pressure only. Numerous student projects at Bethel have studied the dynamics of the ping-pong ball and the role of shock waves in the cannon. The studies have included laser velocity measurement of the ping-pong ball, pressure measurements of the internal shock dynamics, interferometric measurements of the external shock dynamics, high-resolution pulsed-laser schlieren imaging of the cannon shock waves, numerical simulation of the compressible flow and shock dynamics, and more! In recent years, with the purchase of a state-of-the-art high speed video (HSV) camera, the ballistic speeds of the PPC have been "slowed to a snail's pace."

This summer, three students spent a portion of their summers collecting HSV that will be shared on the internet as part of the NSF advanced laboratory interactive video project. Peter Heppner ('15) and Matthew Fiscus (CAPS '14) constructed a clear PPC and collected video that will allow the user to take online measurement of ping-pong ball dynamics under various operating conditions (see Figure 2). Benjamin Copan ('15) utilized a shadowgraph imaging technique to collect video on the shock wave dynamics inside and outside of the cannon (see Figure 3).

After a decade, one can only speculate how long the PPC will continue to live at Bethel. However, it still draws an audience whenever it is about to be fired. With the construction of Bethel's first supersonic PPC as a fall 2014 fluid mechanics project, the cannon should remain alive and well at Bethel in the coming years.

Figure 1. Ping-pong balls exit the cannon at about 300 meters per second (or 670 miles/hour). The pictures above show the ball about to exit the cannon (left) and after taking the "short way around" two pop cans. **Check out the full video** at 25,000 frames per second to see the full sequence "at a snail's pace."

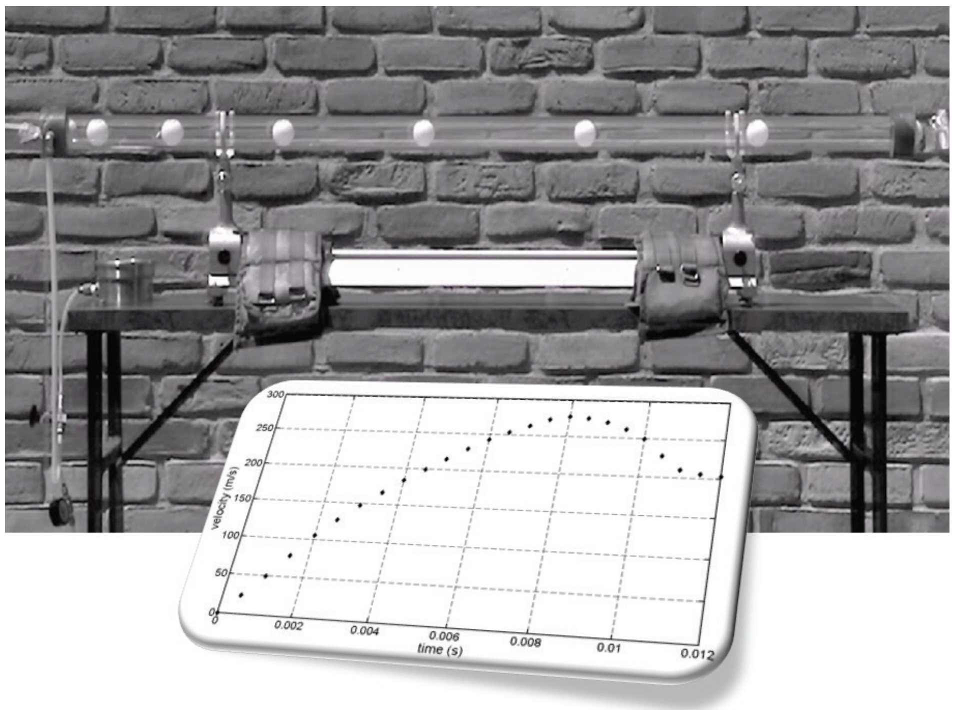


Figure 2. The photograph above is a multiple exposure image from HSV of the ping-pong cannon. The videos will allow online users to conduct frame-by-frame video analysis to study the dynamics of the ping-pong ball under various operating conditions.

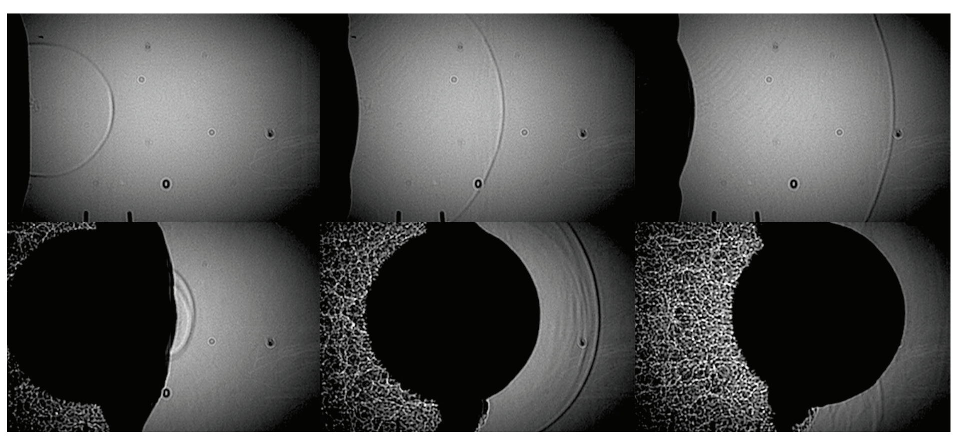


Figure 3. The sequence of images was obtained using a shadowgraph imaging technique at 50,000 frames per second and depicts shock waves at the exit of the cannon. The top frames show a shock wave produced by the release of the tape at the exit of the cannon. The bottom frames show a shock wave produced as the ball impacts the tape, along with the turbulent flow behind the ping-pong ball.

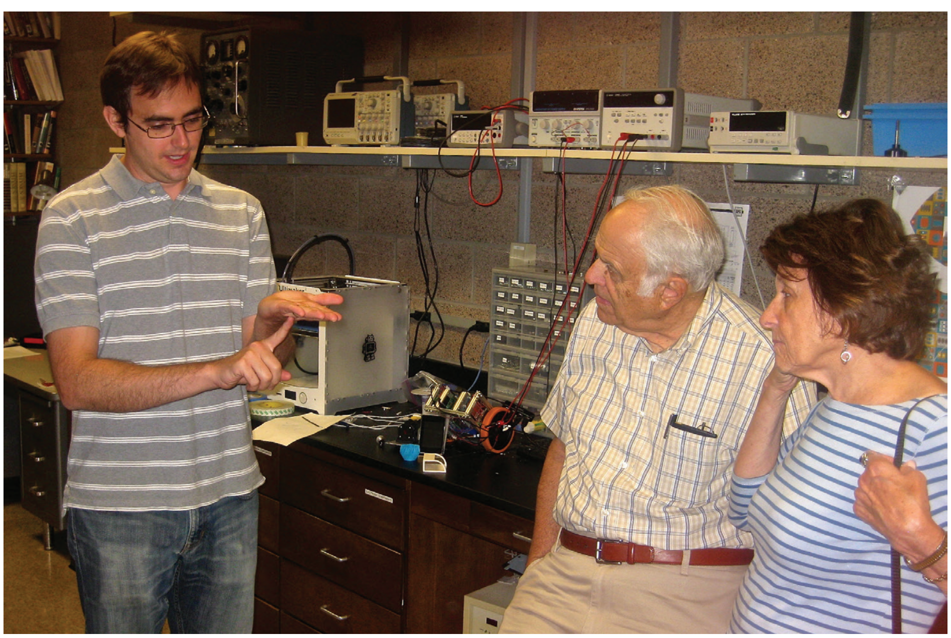
American Association of Physics Teachers Groups Tour Bethel Labs

Chad Hoyt

Bethel's physics department was actively involved in the American Association of Physics Teachers (AAPT) summer meeting, which was held in Minneapolis this year. This participation included Hoyt and Peterson contributing to a workshop on Advanced Labs and also hosting a tour of the department, as well as many of the other professors attending various parts of the conference. AAPT is the leading national organization devoted to physics teaching at all levels, which means that colleagues from all over the nation learned about the teaching methods used by Bethel professors and had the opportunity to see the labs where that teaching happens.

Chad Hoyt shows the AMO (Atomic, Molecular & Optical physics) lab to Jonathan and Barbara Reichert of *Teach Spin* during the AAPT Advanced Labs Tour.

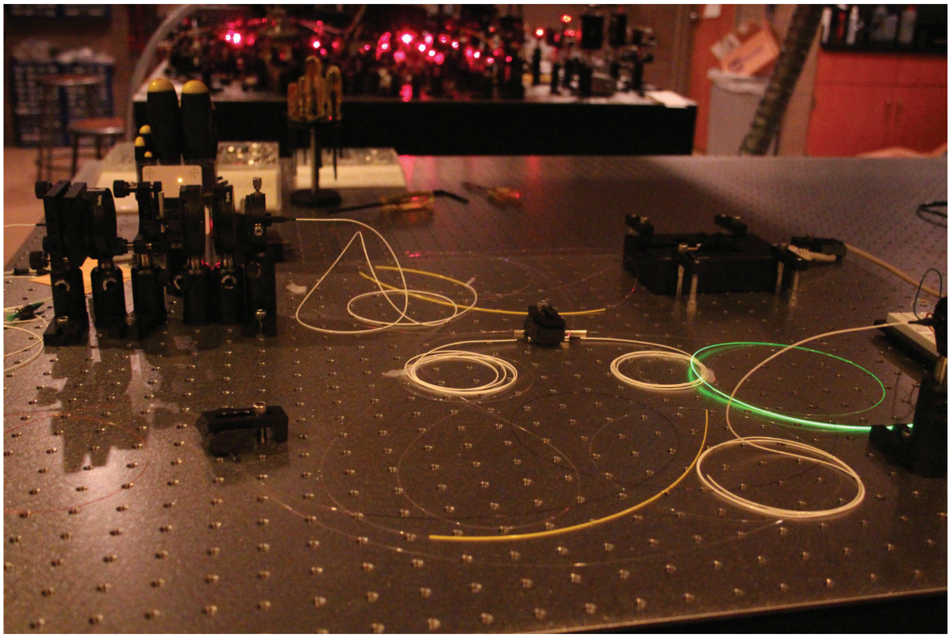
For the workshop, Hoyt and his research students brought the mode locked erbium fiber laser to present to other college and university instructional laboratory developers. Connor Fredrick ('15) and Peterson also brought the interferometric Faraday Effect apparatus that directly measures circular birefringence due to magnetic fields. The workshop included five stations at which presenters demonstrated an approach to an intermediate or advanced laboratory exercise. Presenters showed and discussed the apparatus and techniques used, and those at the workshop had a chance to use the apparatus. (General workshop description courtesy of AAPT.)



Nathan Lindquist with Jonathan and Barbara Reichert of *Teach Spin* in the Lasers lab during the AAPT Advanced Labs Tour. Note that the lab's new 3D printer is just to the right of Lindquist.

In July 2014, the Bethel physics department hosted approximately 12 AAPT summer meeting participants for a tour of its labs. When attendees registered for the AAPT meeting on the University of Minnesota campus, they could choose, as a free special conference event, the "Advanced Lab Tour at Bethel University." Participants, who were shuttled by Bethel faculty to and from Bethel's campus, included physics faculty and industry representatives. They were given lunch in the General Physics laboratory while Bethel faculty gave an overview of the department's advanced labs. After lunch the participants toured the Fluids labs, NanoLab, and the Atomic, Molecular and Optical physics lab.

One tour participant remarked afterward, "We were so impressed not only with the physics you are doing but also with the collegial warmth of both faculty and students. Even in Minnesota winter I have a feeling your physics department is a very warm place."



The erbium-doped fiber laser.

ALPhA Workshop

Chad Hoyt & Nathan Lindquist

With funding from the National Science Foundation (NSF) and the American Association of Physics Teachers, the Advanced Laboratory Physics Association (ALPhA) facilitates nationwide laboratory workshops for physics faculty and staff. ALPhA's Laboratory Immersion experiences provide participants with two to three days of intensive hands-on work with a single advanced laboratory experiment. Enrollment is limited to two to three participants per experiment to ensure a confidence-building experience.

Bethel University physics faculty began offering ALPhA Immersions in 2011, one year after the program started. Drs. Keith Stein, Richard Peterson, Nathan Lindquist, and Chad Hoyt have mentored faculty from around the world on Bethel's advanced labs. These have included studies of compressible flows, holographic measurements, nano-optics, laser diode construction, and ultrafast optics. A regular outing during the three-day intensive workshop has been a Twins game, a hit with both faculty and participants.

Bethel's most recent Immersion was July 23-25, 2014. Hoyt led a hands-on workshop entitled "Low Cost Ultrafast Optics with a Mode-locked Erbium Fiber Laser." Two participants—physics faculty from universities in New York and Wisconsin—modified, optimized and characterized an erbium-doped fiber laser (shown below). Short pulses from the laser were measured to be approximately 200 fs (0.000 000 000 000 2 seconds!). In order to measure such short durations, participants used a special interferometer called an auto-correlator that measured the interaction of a pulse with a delayed copy of itself. A sample of this data is shown in Figure 4. Participants also studied the effect of a series of gratings on the pulse, which affect the pulse's spectral content by spatially dispersing light according to wavelength.

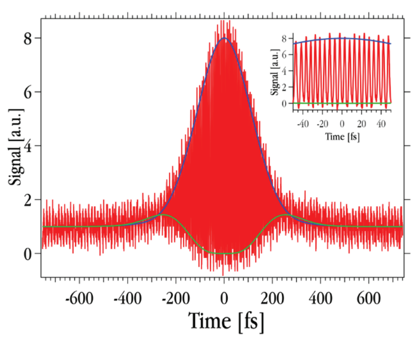
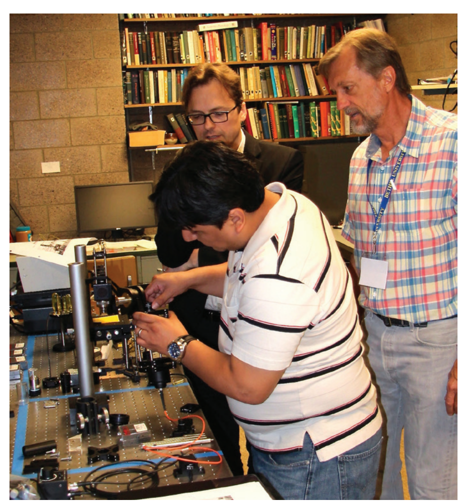


Figure 4. Data showing the interaction of a pulse with a delayed copy of itself, measured using the auto-correlator.

The use of ultrafast optics is widespread in science and technology. Ultra-short pulsed lasers can be used to study fast biological processes, for example. A stabilized version of the fiber laser in this Immersion can be used to make absolute frequency measurements of atomic transitions. With NSF support and a collaboration with Jason Jones at the University of Arizona, Hoyt and his student team are working toward this kind of a stabilized laser: an optical frequency comb. One of their goals is to build an ultrafast laser and comb at dramatically reduced cost, making it accessible to other undergraduate programs such as the ones represented in last summer's Immersion. Hoyt will offer another ultrafast optics Immersion during summer 2015.

Lindquist held a workshop on "Plasmonics and Surface Enhanced Spectroscopy." The field of "Plasmonics" deals with the optics, or how light interacts with nano-surfaces. For example, tiny nano-particles of gold that are only

ALPhA continued on p. 5



Lindquist's group at work on the microscope during the ALPhA workshop.

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50 billionths of a meter in diameter appear red in color. This comes from the fact that the electrons, which interact with light and give regular gold its yellow color, are now confined into a very small space, and can't interact with light as before, changing the color. This confined interaction of light and electrons is called a "plasmon." Interestingly, since these plasmons are so confined, the effective intensity of the light can increase by a factor of a million! This leads to many so-called "Surface Enhanced" effects. In particular, we studied an effect called "Surface Enhanced Raman Spectroscopy," wherein any molecules that are close to the nano-particle see this extremely large intensity of light and emit their own unique "fingerprint" Raman spectrum. This is useful for chemical identification.

There were three participants: one from Texas, one from Illinois, and another from Mexico. The first project participants worked on was building a homemade microscope, shown in Figure 5a. By carefully aligning lenses, mirrors, irises, a 3D printed custom eyepiece adapter, and a high-powered microscope objective lens, they were able to finish a basic upright microscope out of off-the-shelf parts. Finally, by shining a laser into the microscope, we were able to record our own Raman spectrum, shown in Figure 5b. Satisfied, the participants then took an extended coffee break.

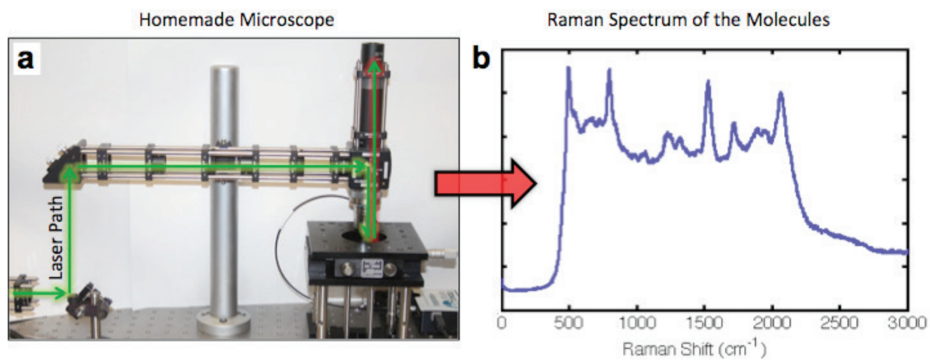

Figure 5. ALPhA workshop. (a) Participants built their own homemade microscope with off-the-shelf parts in order to explore (b) surface-enhanced Raman spectroscopy.

Seeing Super Small (with a new SEM) in the NanoLab

Nathan Lindquist

Due to many generous donations from alumni and friends of the department, this summer Bethel's NanoLab was able to purchase and install a new Scanning Electron Microscope (SEM). A SEM is a nano-imaging tool that uses a beam of electrons to create an "electron interaction" image of a sample of interest instead of a beam of light as a standard microscope would do. Since electrons have a much smaller "wavelength" than light waves do, SEMs are able to take images at much higher magnifications than even the most powerful microscope. For example, our new SEM can take great images at 100,000x magnification, whereas optical microscopes are limited to around 1000x of useful magnification. This is an equivalent magnification to being able to read from Bethel's campus the date on a penny sitting in Duluth.

Installation of the SEM.

Heating a tungsten filament "gun" and accelerating the emitted electrons with a large voltage, up to 30 kV, generates the electron beam. Several electromagnetic lenses collimate, focus, and steer the beam while a final set of deflection coils scans the tiny ~3 nanometer diameter beam spot across the surface of the sample. At every point in the scan (i.e. every pixel in the final image), detectors are used to collect both secondary electrons (SE) — low energy electrons that are ejected from the outer shells of the atoms of the sample — and backscattered electrons (BSE) — high energy electrons from the beam itself that are reflected backwards from the atoms in the sample. All of this happens under a vacuum so that collisions with stray air molecules are minimized. It also means that once the electron beam smashes into your sample, it better have a place to go. Otherwise, electric charge slowly builds up on the sample, eventually deflecting the incoming beam, and ruining the images. The SEM we purchased, however, is a variable pressure SEM that can also be used to image non-conductive samples

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at relatively high pressures while maintaining high-resolution capability. With a special two-stage vacuum system, most of the beam can still be under high vacuum while it is being collimated, pass through a small opening, and into the sample chamber that is kept at a relatively lower vacuum level. The residual air in the chamber has enough conductivity to then dissipate any charges accumulating on the sample. We've been having lots of fun imaging various interesting and useful samples for our research, shown in Figure 6.

There were five students working in the NanoLab this summer with Lindquist. One of the main projects — supported by a National Science Foundation research grant — was to develop a new optical microscope with "Super-Resolution" imaging techniques to complement our new SEM's imaging capabilities (see Figure 7). (This was a lot of fun since the 2014 Nobel Prize in Chemistry was just given to several scientists who were the first to develop another form of optical "Super-Resolution" a little over a decade ago.) Along with the amazing new SEM, an "Atomic Force Microscope" that we built last year, and our new super-resolution optical microscope, students in Bethel's NanoLab are able to work with cutting-edge instruments, do high-level research, publish in world-class scientific journals — for example, [C. T. Ertsgaard, R. M. McKoskey, I. S. Rich, and N. C. Lindquist, "Dynamic Placement of Plasmonic Hotspots for Super-Resolution Surface-Enhanced Raman Scattering," ACS Nano, Article ASAP, (2014)] — and have important learning experiences that will follow them into graduate school, high-tech industry, or any other amazing place they will end up.

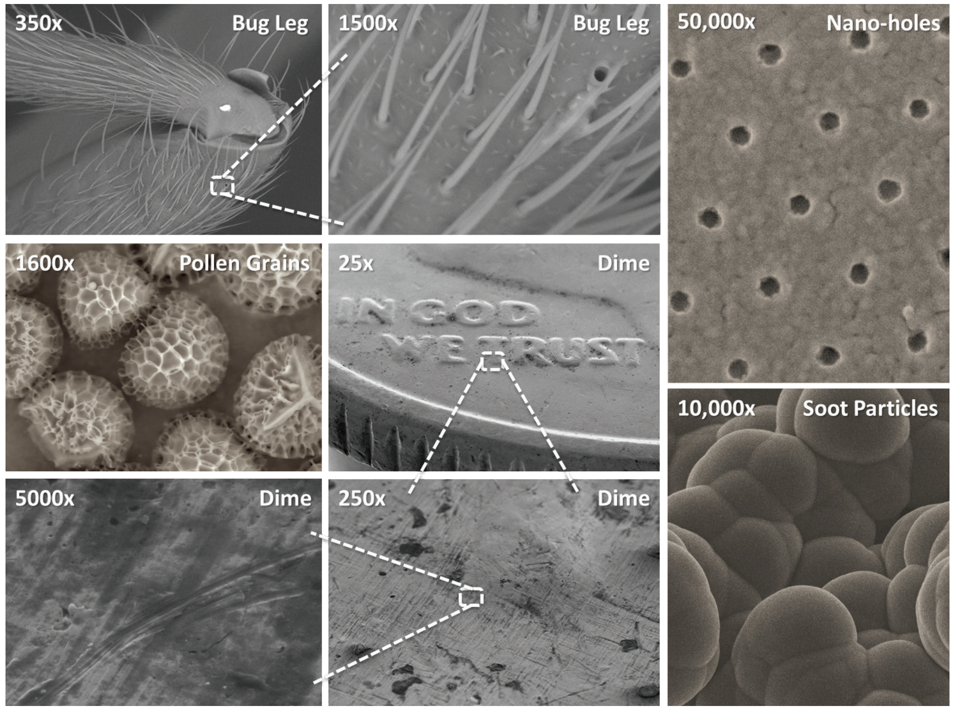

Figure 6. Various SEM images. Notice the wide range of magnifications and samples.

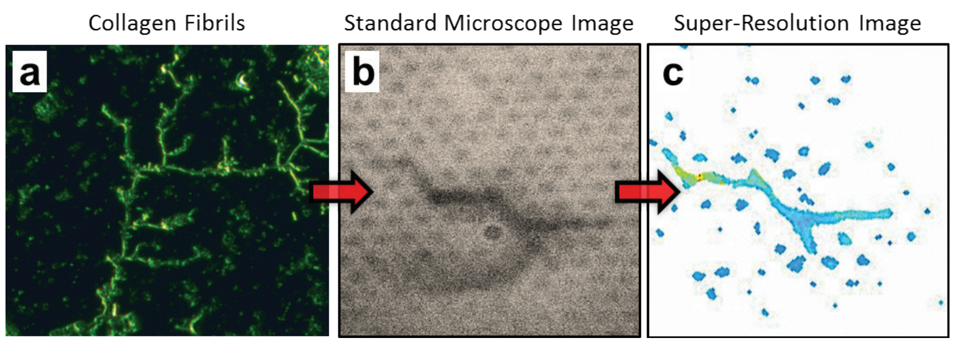

Figure 7. Super-resolution optical microscope. (a) Image of some "rattail" collagen fibrils. (b) Standard microscope image of a single fibril, showing only a faint blurry line. (c) Super-resolution optical image of the same fibril.

Alumna Uses Physics to Bring Hope to AIDS Victims

Rachel Wilson for The Clarion

This article originally appeared in the April 10, 2014 issue of The Clarion.

For many Americans, the AIDS epidemic in Africa is a shocking reality—a true testament to the evil in our world. Even so, the epidemic is often removed reality—a distant idea with little impact in the daily lives of most Westerners. However, for Bethel alumna Amy Herman-Roloff ('00), the AIDS/HIV epidemic is part of her daily reality.

Herman-Roloff graduated from Bethel in 2000 with a double major in physics and English literature and writing, and now lives with her husband and two daughters in Harare, Zimbabwe, where she works as the chief science officer at the Center for Disease Control and Prevention.

For the last eight years, Herman-Roloff has tended daily to the burdens of the deprived, desti-

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tute, and disadvantaged in Africa.

"As Christians, we have the opportunity to alleviate a piece of the burden of HIV by walking with people and not judging them, by showing our love for them as a child of God in real and practical ways," she said. "We are given God-inspired words of encouragement, acceptance and love to share with hurting people."

Having received a master's in epidemiology from the University of Minnesota and a doctorate in epidemiology from the University of Illinois at Chicago, Herman-Roloff specializes in HIV prevention research. Since studying abroad at Daystar University during her time at Bethel, Herman-Roloff's heart has been in Africa.

"I was hooked and knew that God was calling me to spend a significant portion of my life here," she said. "In many ways, it's home."

Alumna Amy Herman-Roloff ('00) lives in Zimbabwe, where she works as the chief science officer at the Center for Disease Control and Prevention. | Photo for *The Clarion* courtesy of Amy Herman-Roloff

Herman-Roloff focuses on prevention of mother to child transmission and male circumcision as it pertains to HIV prevention. As "operational research," Herman-Roloff explores how programs are being executed and how the CDC can advance HIV prevention programs.

Her research is seeing significant social impact.

"Male circumcision for HIV prevention is one of the newest and most effective prevention strategies for HIV prevention among heterosexual men," she said.

In 2006 and 2007, randomized trials were held to evaluate the strategy. Results showed that the operation reduced heterosexual males' probability of acquiring HIV by at least 60 percent.

The challenge of living and researching in a developing country is figuring out how to implement such prevention strategies with such insufficient resources.

Herman-Roloff's work in Kenya explored the effectiveness of various circumcision delivery methods and which level of health-care workers should be allowed to

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Scholar-Athlete Award Caps Mehlhorn's Distinguished Career

Tyler Schmidt for The Clarion

This article originally appeared in the April 24, 2014 issue of The Clarion.

There is no denying that senior J.D. Mehlhorn has had almost unparalleled success on the football field in his four years in a Bethel uniform, but it's his accomplishments off the field that have distinguished him as a stellar and well-rounded athlete, student and humanitarian. Most recently, Mehlhorn received the Bob Stein Scholar-Athlete Award.

One of the most prestigious honors given to a collegiate football player in the state of Minnesota, the Bob Stein Award is presented by the Minnesota chapter of the National Football Foundation. The award recognizes one student-athlete each year who has made an exceptional impact on the field, in the classroom and in the community.

Similar to his acceptance of his other honors, Mehlhorn received the news with the utmost humility.

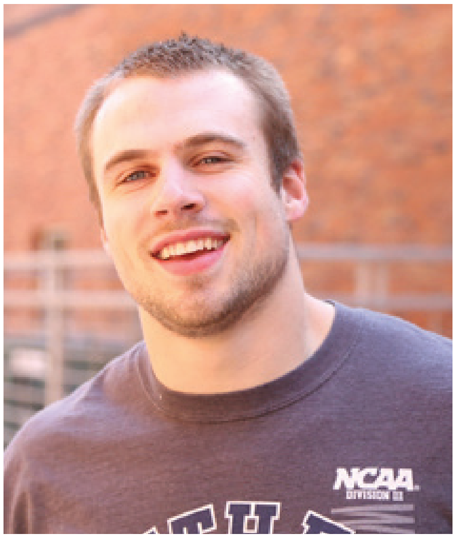
"Hearing about some of the previous recipients and what they've done and are continuing to do definitely made receiving this award feel pretty special," Mehlhorn said.

As an athlete, he was named to the All-MIAC first and second teams, received D3Football.com All-Region Honors and was named to the 2013 preseason All-American Team in his four-year career. His individual efforts have helped Bethel achieve a 41-8 record over the last four years and hold a spot in the Division III Top 25 poll every month since October 2010.

Perhaps most notably, Mehlhorn was selected as one of 22 national finalists for the All-State AFCA Good Works Team. As a recipient of college football's top community service award, Mehlhorn was flown to the Sugar Bowl in Louisiana and honored at halftime.

As a student and as a citizen off the field, Mehlhorn has committed himself to a life of excellence and high achievement. A biokinetics [and physics] major, the Lakeville, Minnesota native has maintained a 3.96 GPA and has

Mehlhorn continued on p. 8



Mehlhorn, who was All-MIAC first and second team while at Bethel, will attend Appalachian State University in North Carolina, where he will assume a graduate assistant position with a strength and conditioning concentration for his master's work. | Photo for *The Clarion* by Drea Chalmers

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made the dean's list every semester since his freshman year. This excellence in the classroom has helped Mehlhorn earn a $7,500 postgraduate scholarship that he will use to continue his education.

Upon graduating this spring, Mehlhorn will attend graduate school at Appalachian State University in North Carolina, where he will work in the exercise science department and assume a position as a graduate assistant with a strength and conditioning concentration for his master's work. Mehlhorn said this avenue is one that will help him pursue his ambition to work with athletes as a strength and conditioning coach.

When it comes to his passions and aspirations for life after graduation, Mehlhorn praises the work and character of the coaches he has had over the years.

"I've had so many coaches over the years influence me in such a positive way," Mehlhorn said. "I want to take so much of the good stuff that they've given me and pour it back into the lives of other kids and athletes."

Mehlhorn's time at Bethel is nearing an end, and there is some degree of uncertainty regarding his future. However, if his track record is any indication, Mehlhorn is on his way to do great things.

bethel.edu/news/clarion/articles/2014/April/scholar-athlete

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perform the operation. She also researched the cultural tolerability of the operation.

Amid a scarcity of healthcare professionals, Herman-Roloff's findings proved monumental.

"The findings from my work allowed nurses to be able to provide the service legally in Kenya," she said. "And Kenya has almost reached its target of circumcising 860,000 men in the past five years... since now both nurses and doctors can provide the service."

Herman-Roloff also dedicates her time and expertise to female sex workers and other "key populations" in the HIV epidemic. Abused, discriminated and marginalized, it's nearly impossible for these women to access health services.

Herman-Roloff studies to whom, how and why these young women submit to sex as a means to make a living.

"There are a surprisingly high number of 12 to 14-year-olds," she said, explaining that her work goes on to develop prevention programs and the availability of health services to female sex workers.

For Herman-Roloff, her work hits close to home. She and her husband's two daughters, Keza and Shela, were both adopted after being born in Africa and abandoned soon thereafter. Even more devastatingly, one of her daughters was born in a field.

"This lack of access to health services for my child's birth mother motivates me to continue to learn how we can provide quality health services that are accessible to the poor and marginalized," Herman-Roloff said.

Science has opened up a world of opportunities for Herman-Roloff.

"Science has allowed me to not only explore intellectually and professionally... but also to explore a beautiful part of the world that I now consider home."

bethel.edu/news/clarion/articles/2014/April/alumna-aids

Summer Student Researchers

The Physics & Engineering department's strong focus on teaching through research brought more than a dozen Bethel students into Bethel's labs this summer to participate in NSF grant-related research. Students spend most of the summer working in the labs alongside professors to learn how to do research and to apply the concepts and problem-solving skills that they have learned in classes to real-world problems. We asked students to describe their summer projects and to tell us about some of their favorite parts of working in the

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lab. Here is what they had to say.

BENJAMIN COPAN ('15)

I took high speed videos of the shockwaves inside a ping-pong cannon (PPC) and the shockwaves just outside the PPC using a technique known as shadowgraphing.

A PPC uses atmospheric pressure to fire a ping-pong ball. The ball is placed at one end of a plastic tube (~1-3 meters long), which is subsequently sealed with tape evacuated to a very low pressure. Finally, the tape at the ball end is punctured; the pressure difference between the inside of the tube (for my work, 5 – 40 Torr) and the atmosphere (~760 Torr) pushes the ball, which accelerates and is fired from the tube at about 300 meters per second. To visualize airflow, we aligned a strong laser through a pinhole, which acts as a diverging lens and results in spatially coherent light. The beam is aimed across the path of the PPC at a screen. Differences in pressure bend the light, resulting in an interference pattern which is filmed with a high speed camera at 20,000 to 50,000 frames per second. The coolest part of my research was watching the tape get blown off the cannon in slow motion.

SHANE DIRKS ('15), SETH ERICKSON ('17), & ANNA SLATTERY ('17)

This summer we worked with Dr. Hoyt in the Atomic, Molecular and Optical physics lab. Our project involved the Magneto-Optical Trap, an apparatus that utilizes lasers at four different frequencies in conjunction with a strong magnetic field to cool and trap Li-7 atoms in a vacuum chamber. We then perturbed the dense cloud of cold (~500 microK) atoms using a resonant beam and filmed the resulting motion at 10,000 frames per second using a high speed camera. The resulting videos allow us to view the kinetic interaction of light with matter in real time and analyze the motion of the atom cloud to better understand the dynamics of the trap. We were also able to turn these videos into interactive educational programs, and it was inspiring to know that our videos could aid our fellow physics students. It has been a growing experience for all of us, both in the practical laboratory skills and in what it means to be only one part in a much longer, open-ended lab.

TAYT EIDEN ('15)

I worked on creating a vignette tool to show students about one of the properties of metals. Metals on a very small scale can have their electrons forced into oscillations creating a wave. This wave can be used for various sensing purposes. I really enjoyed the people and the conversations I have had. I enjoy the lab setting and it is fun to occasionally take a break from my project and go help other people with theirs.

CHRIS ERTSGAARD ('15)

This summer I worked under Dr. Lindquist in the NanoLab with four other students. Our goal was to demonstrate dynamic control of plasmons (ripples of the electron gas density along a metal surface) using a computer generated hologram. The hologram was a 2D image formed by the interference pattern of reflected laser light off a spatial light modulator (SLM). Holograms possess both amplitude and phase information. By manipulating both independently, one can determine the position of a plasmon on a metallic surface. I specifically worked on designing the program that generated these holograms and was successful in directing the position of a plasmon. After we confirmed plasmon control, we used the program for super-resolution chemical imaging of a collagen strand. My favorite part of this summer was painting microscopic shapes with laser light, observing the blinking of molecules stimulated by the plasmons, and working with my wonderful co-workers.

PETER HEPPNER ('15)

This summer I worked to create an interactive video which allows students to take data from high speed videos of a PPC. The majority of the summer involved building and taking high speed video of a clear cannon so that the students would be able to see the ball traveling down the length of the tube when the cannon was fired. The cannon is a plastic tube (or two tubes connected in the middle) which get sealed with packing tape and pumped down to near-vacuum pressures with a ping-pong ball inside. When the tape on the end where the ball is resting is cut, the air rushing into the tube causes the ball to accelerate and shoot out the other end, reaching a maximum speed of about 250 meters per second. After taking high speed video of the cannon being fired at numerous initial pressures and with a five and ten foot tube lengths, I used the Interactive Video Vignette Tool, which was developed at the Rochester Institute of Technology to create an interactive video. My favorite part of working in the lab this summer was seeing an interesting project through from start to finish.

RACHEL McKOSKEY ('15)

This summer I had the chance to work in Dr. Lindquist's nanotechnology research lab mainly as a programmer. Throughout the summer I have been designing programs such as a super-resolution imaging program to model Surface Enhanced Raman Spectroscopy (SERS) activity and collagen as well as a spectrum monitoring system that reveals any shifts in a spectrum due to a change in the surrounding gases.

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My favorite part of working in the lab is not only the experiences that we are able to get but also the atmosphere we work in. Most of the time is spent with other students working on similar or related projects, which helps to motivate you as well as give you a comfortable working environment. Lastly, you can choose your own hours so if you prefer to work later one day and leave earlier another, you can.

ALISSA MONTZKA ('16)

This summer, I worked with the Atomic Force Microscope (AFM). To make probes for the AFM, I glued a piece of either 100μm or 15μm tungsten wire to the end of a tiny tuning fork. Then, I electrochemically etched the wire down to a very fine point (approx. 100 nm). These homemade tips, as well as a few commercial ones, were used to take topographical images of nano-structures.

I also used COMSOL to model the tuning fork probe with and without a tungsten wire attached and simulate the vibrational frequencies. I then used Excel and Matlab to analyze that data and come up with the quality factor of the tuning fork using a Fourier transformation. The purpose of this study is to see how much the size of the tungsten tip affects the Q value of the tuning fork. Typically, the highest Q values give the best scans. My favorite part of working in the lab was getting to know some other students and professors. I also loved being one of the first people to use the SEM and see it in action.

NATE PARKS ('15)

I worked on some early stages of development towards a high precision, low cost frequency comb. Another name for a frequency comb is an optical ruler, because an optical ruler, much like your ordinary ruler, is useful for measuring. The difference between an optical ruler and an ordinary ruler is that an ordinary ruler measures free space, or lengths, while an optical ruler measures spectral space, or frequencies. An optical ruler is somewhat of a staple in Advanced Optical Physics labs today, so this project is an effort to develop one, in order to demonstrate to other undergraduate universities that using some tricks and leveraging costs, it can be done for much cheaper than previously believed. My favorite part is creating custom circuit boards and power supplies. It's fun to see something you have built come together and work just like you planned. With all the planning, drilling, screwing, and soldering, it's almost like a big kids Lego project.

Society of Physics Students (SPS) Events

SPS BANQUET

The department held its annual SPS banquet on April 29, 2014, which included a scrumptious dinner and dessert followed by the presentation of scholarships and new Sigma Pi Sigma members. The main event of the evening was a presentation from Carl Schmuland on "Saving Science," using history, philosophy, and personal experience to think through Christianity in a world of secularized science.

The banquet in the Eastlund Room, which was very well-attended by current students and department guests.

New Sigma Pi Sigma inductees, with SPS officer and Tom Greenlee.

Carl Schmuland giving his talk on "Saving Science."

SPS ICE CREAM SOCIAL

Many students came and much ice cream was consumed. See the photos for more details!

Beecken's opinion of ice cream was shared by many.

Spring 2014 Graduates

(L-R) Front row: Deborah Haarsma (Commencement Speaker), Alyssa Hamre, Ayriel Ash, Dan Mohr, Pengxue Her, Nathan Gessner, Jared Schultz, Tom Greenlee; *Back row:* Chad Hoyt, Keith Stein, Josh Clarke, Jay Brooks, Tristan Boyd, Mark Turner, Cullen Norman, Nathan Lindquist, Ben Heppner, Jared Wall; *Not Pictured:* J.D. Mehlhorn, Micah Larson, Robert Hoglund, Alex Wiedmann