PhysicsFocus

Bethel University Physics & Engineering Newsletter

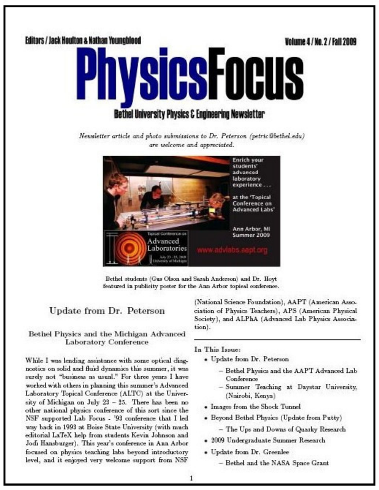
Summer 2010
Editors Jack Houlton & Lauren Otto

Volume 5, Issue 1

Inside this issue:

The Focus Gets a New Image

Since time immemorial (the past five years) Bethel University's PhysicsFocus has had the same drab appearance. Keeping with the dry nature of a physicist, it was typeset in LaTeX, always adorned with two columns of text and unruly images. In this great season of change, our very own colorblind professor, Dr. Peterson, remarked that the Focus needed more "color." He had looked upon the newsletters of other undergraduate university physics departments with a jealous eye. Being green (or is that red?) with envy, he set us about on a quest of improving the newsletter, raising the bar for all other university physics newsletters.


Editors / Jack Houlton & Nathan Youngblood

Volume 4 / No. 2 / Fall 2009

PhysicsFocus

Bethel University Physics & Engineering Newsletter

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

Bethel students (Gus Olson and Sarah Anderson) and Dr. Hoyt featured in publicity poster for the Ann Arbor topical conference.

Update from Dr. Peterson

Bethel Physics and the Michigan Advanced Laboratory Conference

While I was lending assistance with some optical diagnostics on solid and fluid dynamics this summer, it was surely not "business as usual." For three years I have worked with others in planning this summer's Advanced Laboratory Topical Conference (ALTC) at the University of Michigan on July 23 – 25. There has been no other national physics conference of this sort since the NSF supported Lab Focus - '93 conference that I led way back in 1993 at Boise State University (with much editorial LaTeX help from students Kevin Johnson and Jodi Hansburger). This year's conference in Ann Arbor focused on physics teaching labs beyond introductory level, and it enjoyed very welcome support from NSF (National Science Foundation), AAPT (American Association of Physics Teachers), APS (American Physical Society), and ALPhA (Advanced Lab Physics Association).

In This Issue:

- Update from Dr. Peterson
  - Bethel Physics and the AAPT Advanced Lab Conference
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Fall 2009 edition of the Focus

As you can see, we, the editors of the Focus, Jack and Lauren, have modernized the newsletter in many glorious ways. First of all, we are using Microsoft Publisher, a superior newsletter-writing program (especially if you want your pictures to be where you meant them to) than our previous LaTeX. Second, we have added a joke section, where only physics jokes are acceptable, and no chemistry or biology is allowed. And third, we have included a top-ten, must-know list for all incoming freshman physics and engineering majors that they are required to read upon penalty of death. This list has been passed down through the upperclassmen via divine revelation, and said freshmen are required to revel in its glory.

All in all, the new and improved version of the Focus is leaps and bounds above the preceding in many ways, and we are excited to unveil this new version of our department's newsletter to you in this issue. Enjoy!

Dr. Peterson's Retirement

This spring semester, many of us in the physics department began to realize that the professor that we enjoyed during the critical, formative time of general physics, our beloved Dr. Peterson, was retiring. All of this seemed so unreal, but began to sink in at the end of the semester as official announcements were made in chapel, on the announcements, Blink, and in commencement.

Dr. Peterson has played an essential and irreplaceable role in the development and reputation of our physics department. He will be deeply missed, but fortunately is not gone for good. His reflection and future plans follow.

Moving on… Sorta.

I will be formally retiring from my full-time faculty position this month and moving to a Program Director position in physics and astronomy at NSF-DUE (National Science Foundation – Division of Undergraduate Education in the Washington DC area) for the next two years. This will involve quite a bit of work with DUE's TUES (Transforming Undergraduate Education in Science) Type I, II, and III proposals in physics. I will also serve within several other leadership groups in DUE, for example receiving some funding from the NSDL "digital library" program (National STEM Education Distributed Learning).

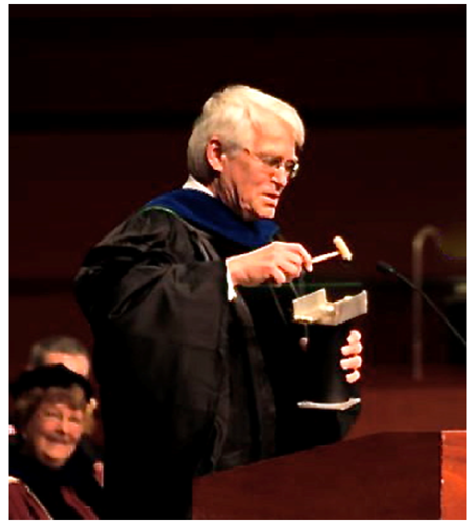
Story continued on page 2

> **"I see my future role in the department as more of cheering squad leader for crucially needed younger faculty members…" -Dr. Peterson**

In physics and astronomy education this program supports the Compadre program pathway (http://www.compadre.org/). The Compadre advanced lab Editor is currently imploring Bethel to get some of our state-of-the-art optics, AMO, and fluid diagnostic projects posted nationally.

To add to the confusion, this position is funded by a Bethel NSF grant to maintain a Senior Staff Physicist position at Bethel University. Such a "rotator" position anticipates my continued activity at Bethel and will support some travel back-and-forth between Arlington, VA and the Bethel campus. I will typically be around a few days each month and in fall-2010 will be working with Dr. Hoyt on the *LaserFest* outreach grant supporting our presentations in St. Paul high schools (see below). I also will be trying to push a few recent advanced lab projects (from Optics or Laser Physics classes) toward publication and national distribution.

So teaching physics for me will likely never be on quite the same scale again, and that may be real tough for me on a personal level. This began to sink in a bit as I was giving the commencement talk in May 2010. My theme in that address was simply an encouragement for graduates to humbly build on our "all too limited" strengths and our obvious weaknesses - and to not be ashamed to lean on our Lord who is walking with us.



Dr. Peterson demonstrating oscillations at Commencement

I see my future role in the department as more of cheering squad leader for crucially needed younger faculty members, and that is one major reason I find this NSF opportunity attractive. I am especially interested in applauding those physics/engineering areas that will bring our faculty and students together in team efforts across the walls of our labs and workstations, as this has really been a key to success in building up our department over several decades. Bethel's initiatives in physics/engineering have always been naturally close to Bethel math and computer science – yet we also need to increasingly seek out and champion work in conjunction with many of the sciences around us, including chemistry, biology, and psychology. Any isolated research at a small university is too often destined to rapidly peak and fade – but if we can stimulate and enable each other in our daily labors (in our own department, with other sciences, with industry/government help, and sharing with other colleges and universities) the sky is the limit. So we need to keep affirming and practically helping each other, while remembering there are few limits to our accomplishments if we are willing to give someone else the credit.

Department professors at a farewell party for Dr. Peterson

Internal Growth and Development—Student Research in Bethel Labs

While the summer of 2010 has been a busy summer of research for students abroad, the labs deep within the physics department have not remained idle either.

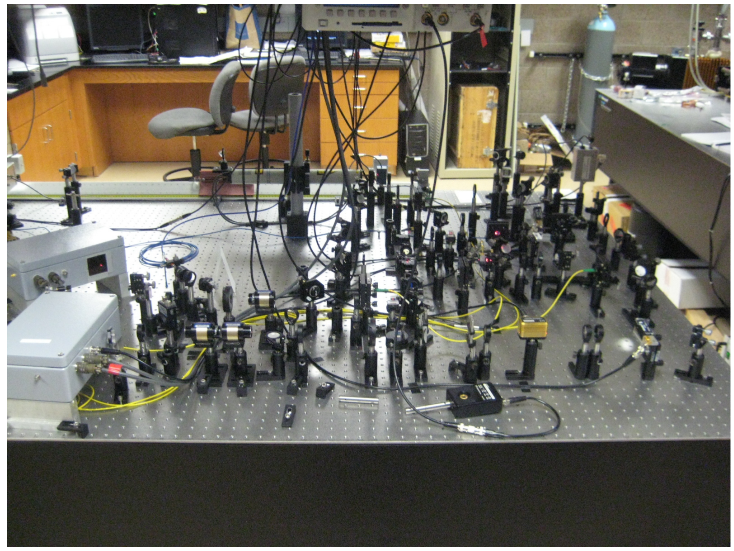
Dr. Stein and Dr. Hoyt both were busy leading projects in their own labs. Dr. Stein worked with Kent Underland, Brian Clark and Tim Stein in the Fluids Lab and Analysis Center. Dr. Hoyt progressed in the atomic, molecular and optical (AMO) lab with Dan Klemme, Brandon Peplinski, and Focus editors Jack Houlton and Lauren Otto. Also alumnus Peter Larson ('10) furthered his senior research with the help of Dr. Hoyt. Stories on pages 3, 4 and 5.

Forward Progress in the AMO Lab

An active research team made good progress this summer in the atomic, molecular and optical (AMO) physics lab. Work continued toward a lithium magneto-optical trap (MOT), which uses precisely tuned laser light and magnetic fields to cool and trap atoms at speeds as slow as a few centimeters per second. The team was diverse in age: Dan Klemme (second year), Lauren Otto (third year), fourth year students Jack Houlton, Brandon Peplinski, and Brandon Brunkow, and alumnus Peter Larson ('10).

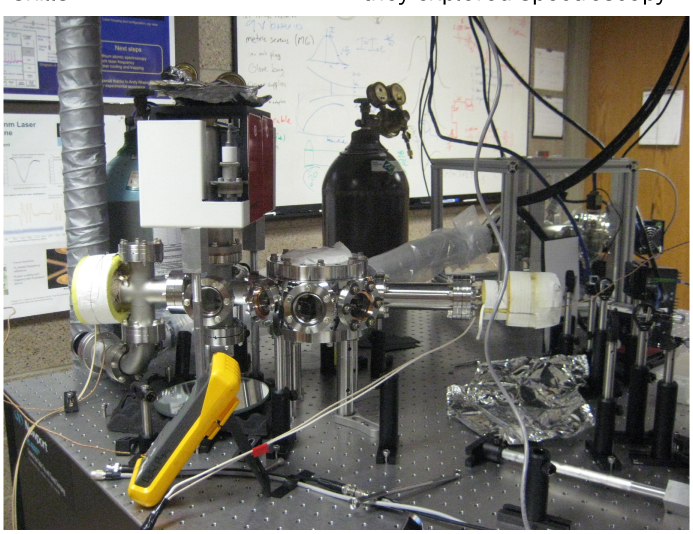
Dan persisted through several pesky electronics problems to produce a set of nice printed circuit board voltage controlled oscillator circuits. These circuits are critical to the operation of optical components elsewhere in the project. He also built some very useful power supplies. In the process he learned computer-aided design software, basic electronics (both theory and soldering!) and machining skills.

Lauren filled a blank end of the optics table with a wonderful forest of carefully aligned optical components. By the end of the summer she had designed and built a system to produce five different light frequencies for the MOT. It was a challenge that involved tweaking a stabilized laser diode, shifting frequencies with acousto-optic modulators, many hours of aligning lenses and mirrors, and coupling light into single-mode optical fiber. She also boosted the power of the master laser by almost a factor of 30 by injection locking another laser diode.



Five frequency optical setup constructed by Lauren Otto

Jack worked extensively with the vacuum chamber, vacuum pumping system, and optical window chamber seals; all of these are critical to the success of the MOT project. He learned the intricacies of ultra-high vacuum system components. He was joined mid-way through the summer by Brandon Peplinski, fresh from his term in Argentina. Together they explored spectroscopy of a lithium atomic beam, obtaining some nice results that will help stabilize the laser light for use in the lithium MOT.



The vacuum chamber and pumping systems worked on by Brandon Peplinski and Jack Houlton

Brandon Brunkow joined the team for a few weeks to help complete a different project. After he used a stabilized diode laser near 633 nm to obtain absorption spectra in an iodine vapor cell, he gingerly packed the laser (and a whole lot more) into boxes to be shipped to Portland, OR for a *LaserFest* demonstration (accounted by Dr. Peterson). He also highlighted the good performance of the lab's wavelength meter by making an engaging video to be used at the *LaserFest* demonstration.

Peter Larson continued his senior thesis work by measuring the emission linewidth of a helium neon laser. He used a clever feedback circuit to suppress thermal drifts in a beat frequency between two lasers.

"The team knew how to have fun, but they also worked hard putting critical pieces into place for the MOT."

-Dr. Hoyt

Story continued on page 4

Jack Houlton, Brandon Peplinski and Lauren Otto enjoying lunch on the wonderful Physics Patio, as seen by Dr. Peterson

His thesis last summer asked the fundamental – and theoretically complicated – question "What is laser linewidth?" and this summer he made a good measurement of it. More details can be found concerning Peter's project in the following article.

The AMO research team enjoyed each other this summer. They could often be found eating lunch together and worked their way through "The Lord of the Rings" (extended version!) trilogy on movie nights in campus housing. Someone's iPod was usually playing in the lab. The team knew how to have fun, but they also worked hard putting critical pieces into place for the MOT.

Peter Larson and Linewidth Measurement

This summer Peter worked on an extension of his senior research project from the previous school year. He took measurements of the linewidth of the beat note between two helium-neon lasers and mathematically determined the lasers' linewidths from the beat note linewidth.

Recently he worked on stabilizing this beat note in order to get a more precise measurement of its linewidth. By shining one laser through an acousto-optical modulator (AOM) and beating the first order beam against the other laser, the frequency of the beat note can be controlled by adjusting the signal being put into the AOM. The beat note signal is fed into a loop filter and then summed with a DC voltage and sent into the AOM's driver circuit, where fluctuations in the beat note frequency are used to control the frequency that the AOM shifts the beam. This circuit can be used as a negative feedback loop, so that when the beat note's frequency strays from a frequency selected by a stable signal generator, the difference between the two frequencies is fed back into the AOM, and the laser's frequency is adjusted to stabilize the fluctuations. Once the beat note is stabilized and locked to the signal generator's frequency, very precise measurements are taken and the linewidth of lasers is more accurately determined.

Reverse Entropy and other "Shocking" Summer Developments in the Fluids Laboratory

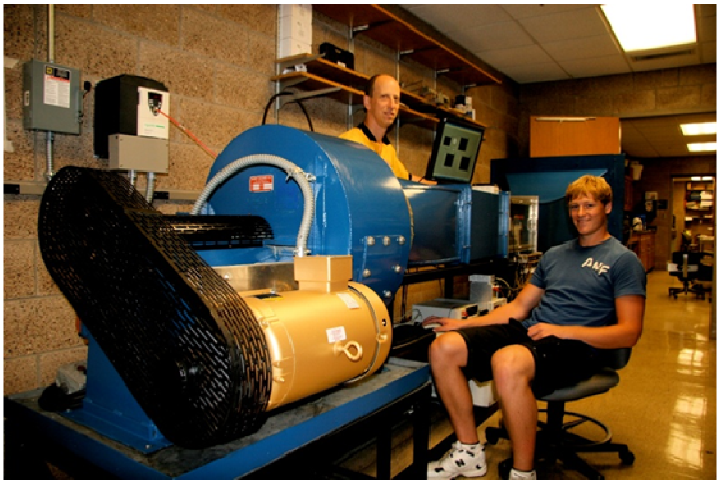
Before: a few pieces of the newly received wind tunnel

Summer endeavors in the Fluids Laboratory focused on two primary objectives, the refurbishment and instrumentation of a subsonic wind tunnel and high-speed video studies on shock waves and supersonic flows. Three of our current physics majors (Brian Clark, Kent Underland, and Tim Stein) led the way in addressing these objectives.

The Physics Department was fortunate to be given a subsonic wind tunnel by the University of Minnesota in December 2009. During the six months after the tunnel arrived at Bethel, it resided in a state of disorder, with pieces scattered at various locations in the physics hallways and under the Academic Center stairway. However, in recent months the tunnel has experienced reverse entropy, transforming from a state of disorder to a fully operational and refurbished wind tunnel that will have a valuable role in PHY420 Fluid Mechanics in the fall and in future student research projects.

The wind tunnel has been retrofitted with a new motor and equipped with a variable frequency drive (VFD) system which allows the wind speed to be finely adjusted to whatever speed is required for the experiment, making the wind tunnel better than it was originally designed to be. The Physics Department is extremely grateful for the work done by Greg Idrizow and Michael Lindsey of Facilities to make

Story continued on page 5



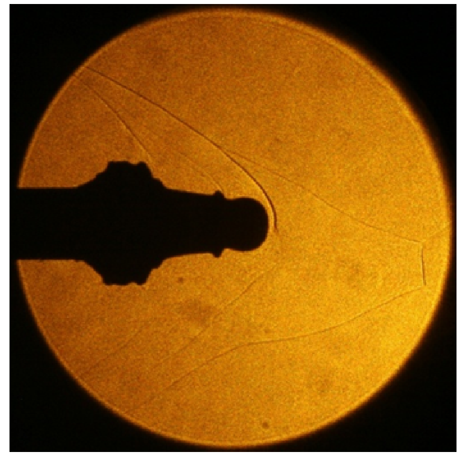
After: Dr. Stein and Kent Underland admiring the fully-assembled wind tunnel (painted in Royal blue), retrofitted with its new AC motor (BU gold) and VFD driver system (on wall)

this possible. Kent Underland has taken a lead role in the tunnel refurbishment. Initial steps have been taken to integrate the tunnel with LabVIEW for data acquisition and motor operation. LabVIEW is currently being used to interface with a pitot probe to indicate tunnel air speed and to measure the pressure distribution on an airfoil model. Also, steps have been taken to control the VFD with LabVIEW and to acquire and process signals from a six-component force/torque balance that will be used to support models. We anticipate that this summer work will pave the way for exciting student projects and research with this new tunnel.

In recent years, our pulsed dye laser has proved invaluable in the imaging of high-speed events, providing clear pictures about the behavior of shock waves and supersonic flows. Shadowgraph images using the pulsed laser (such as those below) provide convincing evidence that “a picture is worth 1,000 words.” Well, if a picture is worth 1,000 words, thousands of pictures per second certainly is “priceless!”

Shockwaves exiting the ping pong cannon in front of the ball

Brian Clark served as the principal investigator in summer high-speed video studies on shock waves and supersonic flow. The original plan for Brian’s summer work was to carefully study the dynamics of shock wave/soap bubble interactions and to painstakingly sequence the process using the pulsed laser. However, with the opportunity to “test drive” a NAC high-speed video camera, the focus of Brian’s work shifted to a more general study on high-speed video imaging and analysis on a variety of applications of interest to the department. Yes, a picture is worth 1,000 words, but we think that you will find several high-speed videos posted at http://www.bethel.edu/~kstein/HighSpeedVideo to be priceless.



Supersonic flow over a chess pawn in the Mach 3 Shock Tunnel

> **“Well, if a picture is worth 1,000 words, thousands of pictures per second certainly is “priceless!”**
>
> **-Dr. Stein**

A New Opportunity—*LaserFest*

During the month of July, the Bethel Physics Department was busy preparing for a new opportunity — presenting research and applications involving lasers at this summer’s *LaserFest*. Dr. Peterson and Dr. Hoyt traveled to Portland to represent Bethel. Dr. Peterson also gave us an account of this honor. Story on page 6.

"SPIE... presented Bethel with the only such grant in the north central region of the U.S."

-Dr. Peterson

LaserFest 2010—50 Years of Lasers

Bethel was delighted to be chosen as one of several global providers for laser science and engineering outreach during this LaserFest year of celebrating 50 years of lasers. *SPIE* (the global society for photonics and optics in science and engineering) presented Bethel with the only such grant in the north central region of the U.S. This work started in preparation for a *LaserFest* tutorial to be presented in conjunction with the AAPT summer meeting at Portland State University. We packed eight boxes with Bethel physics equipment about two weeks before the tutorial, and Dr. Hoyt and I presented the tutorial on July 17 at PSU. The next phase of the grant involves two demonstrated presentations at each of four St. Paul high schools (Central, Highland Park, Johnson, and Como) during the coming fall. Several students played critical roles in preparing for Portland, and additional experienced student laser workers are to help with the high school presentations.

Dr. Hoyt at the advanced lab workshop

Dr. Hoyt at the *LaserFest* tutorial

While in Portland we also participated in the presentation of a half-day advanced laboratory workshop including two laser/optics projects that have been playing an important role at Bethel – (Peterson) the stroboscopic holographic imaging of standing waves in gases, and (Hoyt) sub-picometer precision spectroscopy with BU constructed feedback stabilized lasers and wavemeter.

Bethel Physics Expands—Student Research Beyond Campus

The summer of 2010 has been a busy summer of research for many Bethel Physics students and alumni. So busy, in fact, that we can only include some of their stories in this issue of the Focus. These stories will include optics on large and small scales, supercomputing, plasma, Einstein, mountains and so much more within the stories of Nathan Youngblood, Sarah Kaiser, Adam Banfield, Michelle Lenz and Tim Gustafson. Stories on pages 7, 8 and 9.

Gravitational Waves, Surfing and Nathan Youngblood

Nathan Youngblood has been working with the Laser Interferometer Gravitational Wave Observatory (LIGO) research group at Caltech. LIGO's goal is to someday directly observe gravitational radiation by detecting motion in test masses. Gravitational radiation is generated by the motion of massive objects through the fabric of space-time. This causes ripples, or "gravitational waves" that stretch and squeeze space-time. Due to the nature of gravitational waves, a two arm Michelson interferometer with hanging mirrors should be able to detect a path difference when a gravitational wave is incident on the mirrors. Unfortunately, this strain in space-time is very small and even though LIGO can detect movements on the order of 10^{-19} meters, no gravitational waves have yet been detected.

Nathan has been working with his advisor on a data analysis pipeline that filters gravitational wave bursts from the noise in the detectors. These are gravitational waves that could result from astrological phenomena such as a core-collapse supernova and binary mergers (two massive bodies that spiral into one another). He has been doing a lot of coding MATLAB, UNIX, and PHP.

Nathan and his data analysis friends in the room where Einstein stayed while at Caltech.

In his free time, Nathan goes hiking, Frisbee golfing, and surfing with friends. Nathan says that, "California has been great and I have been learning lots of new things every day."

Quantum Optics with Sarah Kaiser

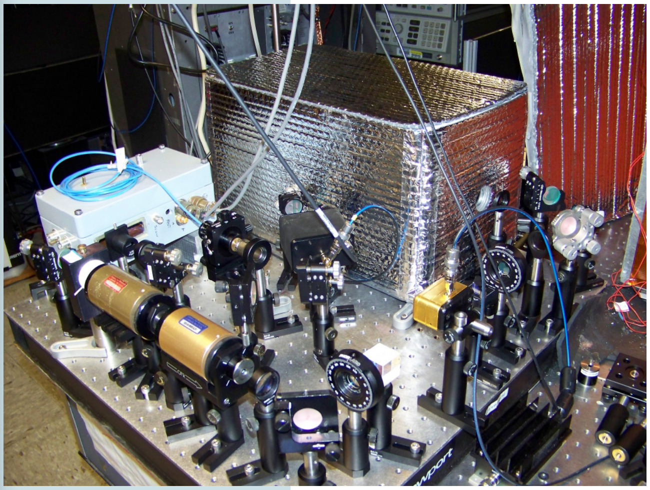
This summer Sarah Kaiser is doing research for the quantum information group at the National Institute of Standards and Technology in Boulder, Colorado as part of the Summer Undergraduate Research Fellowship (SURF) program. One of the major components in experimental quantum information is a final observation of the outcome with a measurement apparatus. In quantum optical systems this is usually some form of photodetector. When using these detectors with non-classical states of light it is important to understand fundamentally how the device is operates on the quantum state to produce a measurement. Quantum detector tomography provides a method of characterizing the measurement process on a quantum scale.

The general approach is to probe a measurement apparatus with known quantum states to reconstruct a positive operator valued measure (POVM) which uniquely characterizes the measurement operation. A maximum-likelihood (ML) algorithm is implemented to characterize superconducting transition-edge sensors (TES). These unique photodetectors can resolve incident photon numbers (up to 10 photons with ≥95% efficiency). POVMs for the TES have not been previously reconstructed and the ML method promises feasible results. The ML algorithm guarantees a physical reconstructed POVM where other methods fail.

Sarah Kaiser and Adam Banfield with other SURF students at the top of Twin Sisters Mountain near Rocky Mountain National Park

"This project has provided me with a very interesting view of how research happens outside of an educational institution. Government labs are very enormous entities, full of awesome science and bureaucracy."

Adam Banfield: Diode Lasers for Ytterbium Atomic Clocks



Adam's setup. The gray box at the left is the laser and the silver box at the back is the temperature controlled box. The optical cavity is in a vacuum chamber inside this box.

For the summer of 2010, Adam Banfield is in the Student Undergraduate Research Fellowship program at the National Institute of Standards and Technology (NIST), in Boulder Colorado. He is working with the Optical Frequency Measurements group in the Time and Frequency Division of NIST.

Adam's project is to lock a distributed feedback (DFB) diode laser to an optical cavity. The active region of a DFB diode laser is periodically structured. This internal periodic structure acts as a diffraction grating, providing wavelength selection and linewidth narrowing without the need of an external grating. The goal of locking the laser to an optical cavity is to further narrow its linewidth. The 759 nm laser is being considered as an alternative master laser for the optical lattice of the group's ytterbium optical atomic clock. So far he has constructed a temperature controlled box for the optical cavity, coupled light into the cavity, and observed a Pound-Drever-Hall error signal. In the remaining time of his project, he hopes to lock the laser to the cavity, measure its linewidth, and determine if it is suitable for the optical lattice.

Adam has been enjoying his time in Colorado, especially the time spent hiking and rock climbing in the mountains. He also enjoys working at NIST. "I have learned a lot about, and been able to participate in, cutting edge physics research. The staff and students I am working with here are always willing to answer my questions or help me with my project."

Michelle Lenz and Molecule Optimization

Michelle Lenz is working in the University of Minnesota's Chemistry department under Dr. Don Truhlar, one of the top computational chemists in the world. Her project involves testing methods for predicting reduction potentials for ruthenium catalysts in aqueous solution. Using various chemical software programs, she builds molecules involved in the redox reactions, optimizes their geometry, and calculates solvation and gas-phase energies to ultimately determine free energy changes. By comparing the theoretical numbers to experimental data, parameters such as quantum chemistry model, basis set, integration grid size, density fitting, and atomic solvation radii are adjusted to improve the accuracy. All jobs are run at the Minnesota Supercomputing Institute, where Michelle also attends weekly tutorials that demonstrate available software relevant to the chemical, physical, and biological sciences.

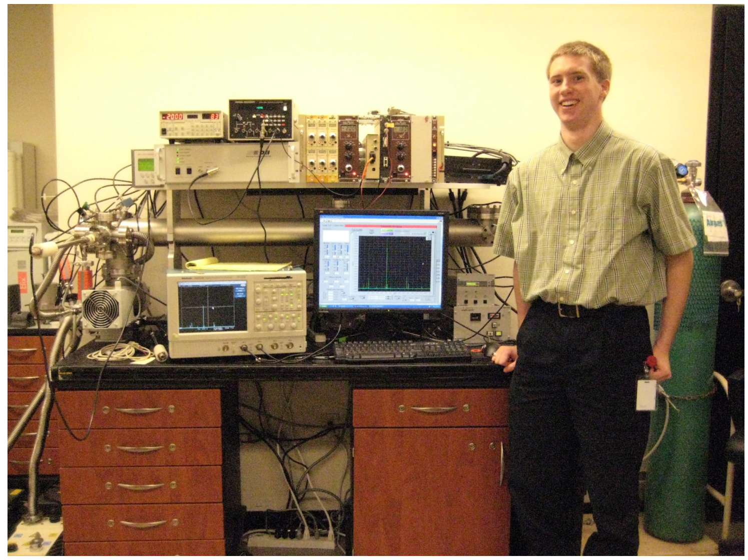
Tim Gustafson, Plasma and Mass Spectroscopy

Tim Gustafson has been busy as an intern at the Oklahoma State University in the University Multispectral Laboratories (UML) where he has been working under Dr. James Barnes IV, the son of our very own University President. He has been working with experimental mass spectrometry using a method called Glow Discharge – Time of Flight – Mass Spectrometry (GDToFMS). He uses a GD (a small plasma made by running a large amount of power through a gas like argon) to ionize a sample of natural copper for tuning. These excited argon atoms strike the copper atoms on a direct insertion probe and cause them to be blown off the surface (sputtered) and become ionized. Pulsing the GD power supply allows a higher instantaneous power through the GD without damaging equipment.

Story continued on page 9

By pulsing an accelerating voltage to apply the same potential energy to a group of ions, he can measure the time that it took the ions to travel through a 1.00 meter tube and then calculate the mass.

Tim has been studying the mass spectra at different times during the GD pulse because the ions vary in intensity throughout the duration of the pulse, due to the different mechanisms for ionization. The high energies present split everything down to their elemental components. For about 100-200 microseconds after the pulse is turned off, Penning ionization occurs. This allows molecules to remain intact and be observed directly. "Hopefully, we will be able to continue work with more complicated molecular samples once we complete the tuning process."



Tim standing by his work station at UML

Bethel Builds Luxurious Patio for our Beloved Department

Last fall, many of you may have noticed the construction occurring right outside the general physics lecture hall (AC246) where general physics lectures take place. Daily one could hear jackhammers, saws, diggers and other such noisemaking construction equipment right outside the physics department, between the AC, CC and BC. You could also hear Dr. Stein trying to project his voice over such distractions during general physics lectures at 9 AM every Monday, Wednesday and Friday. Unless lectures were moved to the Underground…

But alas the suffering pain of constant vibrations in the Fluids and Modern labs has finally come to an end, and we are all grateful for the glorious new patio we have been provided with for our own exclusive enjoyment! Completed just in time for the beautiful spring weather. All you have to do to find perpetual bliss is exit the lecture hall through the outside door!

That's right! The Physics Patio come fully furbished with three tables and 12 chairs (so heavy that the big bad wolf couldn't blow them away!), a luxurious railing that surrounds two of the patios four sides, beautiful tiling design, a complete wall of windows for maximum viewing of the Brushaber Commons, access to school ventilation systems, perfect sun between 10 AM and 2 PM (I think they are trying to tell us something…), and some famous art sculptures. What physics major could ever want for more! It is simply heaven.

So alumni, come on down to Bethel University, visit the undergraduates, and take part in the enjoyment of the wonderful patio built just for us! Courtesy of Jay Barnes III.

A view of the luxurious, spacious brand-spankin' new Physics Patio!

Bethel University Physics & Engineering Newsletter

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

BETHEL UNIVERSITY
College of Arts & Sciences

JOKES

A student recognizes Einstein in a train and asks, "Excuse me, professor, but does New York stop by this train?"

A not-so-bright physics student was taking an exam and was stumped by a particular question. The answer to the problem was 'log(1+x).' The student copied the answer from the good student next to him, but didn't want to make it obvious that he was cheating, so he changed the answer slightly, to 'timber(1+x).'

[http://cas.bethel.edu/dept/physics/]

The Top Ten List of Everything Incoming Freshman Should Know, Courtesy of Peter Larson

10. Learn to use Mathematica. It will always be easier to write a little bit of Mathematica code than to perform its functions manually.

9. Learn to use an oscilloscope. It's one of the most important tools you have besides your brain. Don't let your lab partner do everything on the scope.

8. Learn to write legibly for yourself and for whoever is grading your work. Some writing tips:

A. Cross your sevens and Zs.
B. Learn your Greek alphabet.
C. Be able to tell your capital, lower-case, Greek, and script characters apart.
D. Standardize your script characters so they always look the same.

7. Use a binder and college or narrow rule loose-leaf paper. They are great for organization and everything can be three-hole punched and kept in chronological order. Also, write dates in your notes for each day to find things easier later.

6. Keep your textbooks from your physics and math classes. They are great references for later because you won't remember everything.

5. Go to help sessions to get yourself focused and get the homework done. With a room full of people working on the same problems, you're likely to do better.

4. Get to know upperclassmen. They know everything you have learned and more and will likely be willing to look at a tough problem and point you in the right direction.

3. Don't save general physics homework for Thursday night. It might work the first week or two, but it won't work for long. You'll also learn the material better if you start sooner, rather than waiting until Thursday night.

2. Read the book. It helps to read the week's lessons before the lectures start and you begin the homework. Also, at least skim the book before tests.

1. Even if you have taken some physics before, don't trust the first week. General Physics gets much harder. Also, if you don't enjoy it, you probably won't next year either. There's no shame in switching, as long as it isn't to chemistry or biology.