The Wave Packet

The UMD Physics Newsletter

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Ralph Visiting at NSF

For the current academic year, and perhaps into the next, Elise Ralph has expanded her already substantial service work into being an Associate Program Director for Physical Oceanography at the National Science Foundation. This visiting position has given her the opportunity to make and maintain contact with many in her field and to promote the study of lakes as well as oceans. It has also provided a close, inside view of the grant proposal review process. While away this year, her position at UMD has been filled by temporary hires, Bill Wolz to teach Physics courses and Weiqi Lin for research and some teaching in limnology.

Habig Takes on Astronomy

Alec Habig has expanded his teaching portfolio to include the basic astronomy course that UMD offers as part of the campus's liberal education package. The department has not participated in the teaching of this course since Gordon Likely retired in 1991. Advances in computer technology and astronomical data sources in the intervening years have made possible some dramatic improvements in what can be delivered to the students in terms of both presentation and image content. Habig has also developed a new astrophysics course, to be offered for the first time next spring.

Friebe Award Fund Established

The department has been fortunate to receive a substantial gift from Alan Friebe to establish the Frank and Ruth Friebe Award Fund, in honor of his parents. Al graduated from UMD with a Physical Sciences teaching degree and has always taken an interest in physics, including a summer doing an honors research project in the department. He currently teaches computer networking skills in corporate settings. The Fund will help physics students to overcome financial barriers that might otherwise limit opportunities to study and to participate in research.

CSE Academy Inductions

Last September Howard Hanson was inducted into the Academy of the College of Science and Engineering, in recognition of his efforts in growing and promoting the Physics Department during his many years as a faculty member and Department Head. This year the department had the opportunity to make a second nomination, Dr. William Mularie (BA '61), of whom you may have read in last year's newsletter. He is retired from 3M and currently serving as CEO of the Telework Consortium in Herndon, Virginia. His induction will take place this September. Congratulations to both!

The department will be able to make nominations in future years as well. We would appreciate receiving nominations and information about the professional success of our alumni, which would help us identify potential nominees.

Howard Hanson (center) is inducted into the CSE Academy by Dean James Riehl (right). Tom Jordan (left) made the introduction.

Inside this issue

Honors and Awards

The **Outstanding Graduate Teaching Assistant** for 2001-2002 was **Maxwell Ankrah**. Maxwell is nearing completion of his MS with Professor Maps.

Andrew Clough received the **Outstanding Research Project Award** and **Erik Larson** the **Outstanding Academics Award** for 2001-2002. Andrew's project was an analysis of data from the Super Kamiokande neutrino detector, looking for astronomical sources of neutrinos, under the supervision of Professor Habig. He will complete his BS this spring and continue at UMD as a graduate student. Erik graduated from UMD with a BS in Physics last spring.

A sophomore physics major, **Sheridan Kelley,** was awarded the **Olson Scholarship** for 2002, to work with Habig on data analysis software for the MINOS project. **Branden Hakala** received the 2002 **Hanson Scholarship** and worked with Professor May on thermohaline intrusions in the Arctic Ocean; a description of the project can be found elsewhere in this issue. Branden plans to complete a double major in Physics and Mechanical Engineering next year.

Andrew Clough, winner of the Outstanding Research Project Award, being congratulated by Bo Casserberg (center) and Brian May.

Gift Funds

Gifts to the Physics Development Fund, the Donald Olson Memorial Scholarship Fund, the Howard Hanson Scholarship Fund, and the Friebe Award Fund may be sent to the Development Office, 315 Darland Administration Building, UMD, 10 University Drive, Duluth, MN 55812. The Development Fund is targeted at support of student research, through purchases of equipment and help with travel expenses, and of awards to undergraduates for superior performance. If you have questions or would like more information about making a gift of any type to the Physics Department, including estate planning, please contact us or the College's Development Officer, Tricia Bunten, at 218-726-6995 and tbunten@d.umn.edu.

Agnes and Howard Hanson with Hanson Scholar, Branden Hakala.

Alumni Visits

Several alumni have stopped by, including Dan Challstrom (BS '85), Qingyan Chen (MS '99), Michael Meyer (MS '96), and Ed Shaughnessy (MS '94). Mark Debe (BA '69) attended the second meeting of the External Advisory Board for the College, and will be joined on the Board by Steve Nicholas (BS '91, MS '93) this spring. Al Friebe has visited several times to finalize plans for the new award fund that he established. As usual, Maps and Hiller met up with Allen Anway (BA '63) at the judging for the Northeastern Minnesota Regional High School Science Fair and the Minnesota State Science Fair; this year we were joined by Steve Highland (BS '79), who has been teaching Physics at UW-Superior.

If you're ever in the area, please stop in. With some advance planning, we can arrange an opportunity for you to speak about your work or other topic of interest.

John Hiller and Erik Larson, winner of the Outstanding Academics Award.

Outstanding GTA, Maxwell Ankrah, with his supervisor, Jon Maps.

Howard and Agnes Hanson with Larry Thompson. Prof. Thompson will soon retire from the Chemistry Department but did teach Physics as well as Chemistry for a time while Howard was Department Head.

Catch Up with Past Grads

An update on Jim Gilbert (MS '93): He has had considerable success reinvigorating the Physics program at Rose State College in Oklahoma. To see a description of what he has accomplished, go to the March 13, 2003 issue of Campus E-clips at www.okhighered.org/newsletter.

James Baker-Jarvis, MS '80

I graduated from the University of Minnesota-Twin Cities in 1975 with a BS in Mathematics. Then with Karen, my future wife, I climbed mountains and bicycled all over North and South America for a few years. We had many "near-death" climbing experiences.

The main goal in my life has been to pursue my passions. One way to do this was to have two retirements, one when young and one when older. About this time I thought I better get going to obtain the degrees I need to pursue my passion for natural philosophy (physics). So we moved to Duluth, and I worked on my master's degree at UMD. I had a great time on my thesis research with Professor Jordan, on theories of wind-driven currents.

My wife and I then moved to Bellingham, Washington where she got a degree in carpentry in a Vo-Tech. In Bellingham we had a great time for a year, except that the unemployment rate was 25% and I had a hard time finding a good job. To support us, I mowed lawns and worked picking mushrooms at Mt. Baker Mushroom Farm. In the evenings there I continued with theoretical work and published a couple papers.

Next I applied to the University of Wyoming Physics Department, because we liked Wyoming, and obtained a Ph.D. in theoretical physics in 1984. After graduation I worked as an AWU postdoctoral fellow for one year on theoretical and experimental aspects of intense electromagnetic fields in lossy materials and dielectric measurements. Following that, I spent two years as Assistant Professor in the Physics Department at the University of Wyoming, working on electromagnetic heating processes, investigating information theory, and teaching classes. Then through 1988 I was Assistant Professor of Physics at North Dakota State University. There I taught courses in the areas of electronic properties of materials and performed research on an innovative approach to the solution of differential equations using a maximum-entropy technique.

In January 1989, I joined the National Institute of Standards and Technology (NIST) in Boulder, Colorado, where I have worked in the areas of microscopic relaxation, electronic materials, dielectric and magnetic spectroscopy, and nondestructive evaluation. I am currently Project Leader of the Electromagnetic Properties of Materials Project. I have two categories of research, one I do at NIST and the other in evenings and weekends. In the second category, just recently, I worked out and published a general theory of Maxwell's equations using a projection-operator, quantum-statistical-mechanical method. I am currently developing my approach to quantum mechanics.

I have been married to Karen for 25 years, and we have two children. We spend our time in the summers canoeing in northern Canada and teaching whitewater canoeing . We have competed in two whitewater slalom championships, one in Colorado and one in Duluth, and plan to go to Wausau, Wisconsin this summer for another one. I feel I have had a balanced and wonderful life, and I have very fond memories of UMD and the cross-country skiing around the city.

Peter Bennett, BA '74

I have fond memories of my time spent at UMD. My first awareness of the Physics Department was through my older brother, Charlie, who also majored in physics at UMD (BA '72). We were launching balloons from our rooftop at home in Grand Rapids, Minnesota on a typical -20 F December day, using plastic laundry bags filled with hot air from the chimney. I was struggling to calculate the lift, using my trusty slide rule and some formulas from the CRC handbook. I recall that this work filled a page, though now, I can't imagine how it could have been so complicated. At this point, Charlie said, "You have to meet Don Olson, at UMD." I'm not sure if anyone from the department contacted me, but I did attend UMD, of course.

This period was the heyday of the Olson flying field mills. Don was a pack rat. One tale has it that he had acquired several cases of army surplus rubber boots, all size 7. Some say they were all left foot. My first research experience was a summer job with Dr. Sydor. Our task was to acquire water samples from Lake Superior for comparison with ERTS satellite data. I was an avid boater, and was quickly promoted to captain of our vessel, the Oneota, even though I was younger than the other two students, Jim Rohlf (BA '73) and Kirby Stortz (BS '72, MS '78). I built some kind of sextant device for triangulating our position, which was rather challenging on choppy waters. I also built a cheap knock-off version of a water velocity logging meter, and calibrated it in Lester River. I managed to write a paper, and go alone to a conference in Tennessee. What a great undergraduate research experience!

I next moved south to UW-Madison to do graduate study in physics. One of the attractions of that campus was the magnificent Hoofers sailing fleet, anchored just beside the Memorial Union on Lake Mendota. I learned some time later that UW-Mad had an outstanding physics department. I arrived on campus for the first summer session (before the fall semester), proceeded to join the Hoofers, and then looked for a summer research appointment by knocking on doors. Fortunately, I didn't know that this was unheard of. Apparently my UMD experience was strong enough to convince one professor to take me on for the summer, to work on his liquid helium projects. Two years later, I changed to surface physics, and learned the fine art of ultrahigh vacuum and low energy electron diffraction from Barney Webb.

Following the PhD, I figured it was a

good time to see the world, and I took a postdoc appointment in Julich, Germany. Sixteen months later, I returned to the US for a more serious postdoc at Bell Labs, with Jack Rowe and Neville Smith. Come spring, it was time for boating again, and I moved from Murray Hill, New Jersey out to Brookhaven Lab on Long Island, where we commissioned the first beamline at the National Synchrotron Light Source (NSLS). My ulterior motivation was to sail on the Great South Bay, on my Hobie Cat and sailboard. Two years later, my friends (mostly sailing folk) thought I was crazy when I announced that I would become a professor at Arizona State University. "That's a desert! Do you know how far the nearest water is?" they implored. In fact, there is plenty of water here, and we have an extremely high per capita boat ownership, but the sailing is lousy, for lack of wind.

I came to ASU in 1983, intending to do surface studies with electron microscopes. This was the same year the STM was invented, but I was slow to catch on, and worked instead to design a UHV-STEM. During buildup of this instrument, I used reflection high energy electron diffraction (RHEED). A short while later, surface X-ray diffraction was "invented," by an old friend from Bell Labs, Ian Robinson. This technique is much better than RHEED, but it requires a synchrotron. I immediately switched to X-rays, partly because it provides a good excuse to periodically leave the desert and go back to Long Island for "a run" (at NSLS). I have done this faithfully for 12 summers now.

Back at ASU, our group works with a scanning tunneling microscope. We also have access to a Low Energy Electron Microscope (LEEM), which is the most effective form of electron microscopy for surface studies. My scientific program has focused on metal-silicon surface structures and reactions, using the several experimental techniques described above. Our group has joined the nano-bio revolution, and we are presently working on self-assembled silicide nanowires. Details can be found at http://phyastweb.la.asu.edu/homepages/bennettp.

Looking back, I certainly value my time in the UMD Physics Department. It is a reminder to me, as my own three children approach college age, that the local school can be quite effective, provided you find the right people there, as I was fortunate enough to have done at UMD. Lastly, let me invite any bright young Lake Wobegon-ers to consider doing graduate work at Arizona State University. We have no sailing club, but you certainly can thaw out down here, and also earn a nice graduate degree in physics, or materials science.

Joseph Wivoda, BS '90, MS '92

Upon graduating from UMD in 1992 with a B.S. and an M.S. in physics, with lots of work in computational physics, I went looking for work in the "Real World." That was a difficult period of time for new grads, and my first job offer was from Rainy River Community College in International Falls. I declined the offer, instead taking a job as a computer operator at the Minnesota Supercomputer Center. Rotating shifts gave me the opportunity to program an automated backup program for all of the Crays, and in three months I moved into the network and system administrator group. I found out that I wasn't the only person with a physics background: several of the programmers held M.S. degrees in physics! The fact that we all have strong problem solving skills makes us very valuable in computer science.

After working at MSC for a year, I worked as a consultant and regular employee for Medtronic. I did lots of programming and project management. It was a fun place to work, but I was just never comfortable in a large company. After two years there, I moved on to LDSi Consulting. LDSi is a small consulting company, and I had fun working in several areas. One day I would be helping a major law firm redesign their network and plan for growth; the next day I would be troubleshooting a Windows PC. There was plenty of variety and challenges. One day a client had a crisis, and they sent a bunch of consultants to fix it. Everything was a mess with nobody taking the lead. I began to tell people how we should fix it. The next day the owner of LDSi said I would make a good manager, something I said I would never be only a year before that. I agreed to the promotion and started managing a small group of people.

The small group quickly grew into a 22-person team of skilled network consultants, and we were the number-one revenue-producing area of the company. My title was changed to "Business Unit Manager" and I was accepted into St. Thomas' M.B.A. program. Life was good. Then Y2K came along. We started losing business as customers were spending less on I.T. I was laying people off every month, and my group was down to 11 people. I let a person go right before Christmas 2000, and my wife Angie, daughter Emilie, and I took a trip to Missouri to see her family. Driving through Iowa we decided that it would be great if we could get back to a small town existence.

I was pretty charged up when we got home, and I started looking for work. After a couple of weeks I found a job opening for an Information Systems Manager at Range Regional Health Services, the old Hibbing Hospital. It was the first place I sent my resume, the only place I interviewed, and the job I accepted! I am originally from Hibbing, and this was a great job opportunity. After some major projects and redesign of the department, I was promoted to Chief Information Officer last year.

The job is a huge challenge with never a dull moment. Health care is a frustrating and highly complex industry, perfect for a physics person! I don't solve Schrodinger's equation using computational methods (at least not MOST days), but the problem solving skills that I learned from UMD have never failed me. Plus, I also seem to be the guy everyone goes to when they want to know if a tank of water weighs the same or more with a fish floating in it. (I have had to answer to this question TWICE). I made a lot of friends at the Physics Department. I get together with a few of them every August for a camping trip in Hibbing. If you are interested in joining us, contact me. We have a good time, and the tradition is in its 12th year!

Student Research Projects

Branden Hakala, Hanson Scholar 2002

Thermohaline intrusions are a widespread feature in the Arctic Ocean. It is believed they may contribute to the lateral transport of heat, salt, and other tracers throughout the Arctic basin. Warm salty water entering through the Fram strait mixes with cold fresh water underneath the polar ice cap. As a by-product of this mixing, a convection phenomenon occurs in the form of salt fingering and diffusive convection. Salt fingering is defined as the energy released from an unstable salinity gradient where warm salty water overlies relatively cold fresh water. Diffusive convection, on the other hand, is energy released from an unstable temperature gradient and occurs when cold fresh water overlies relatively warm salty water. As the Atlantic current migrates around the mid-ocean basin, it mixes both vertically and laterally. The mixing gives rise to temperature and salinity fluctuations in the water column, and it is the lateral mixing of the Arctic and Atlantic waters that creates the thermohaline intrusions.

By using a database of conductivity, temperature, and depth (CTD) measurements gathered during an expedition in the Arctic Ocean in 1981, a profile-by-profile analysis of thermohaline intrusions was performed to investigate the properties of the intrusions. First, the intrusions' properties were determined by locating extrema in spice (a measure of how warm and salty the water is), temperature, salinity, and density after applying smoothing to the data. From the extrema locations, intrusion properties such as intrusion thickness (the distance between the midpoints of maxima and minima extrema), temperature perturbations (high frequency fluctuations), and salinity perturbations were calculated. Second, interface properties (regions between the extrema) were derived using the extrema data sets. All products of intrusion and interface calculations were tabulated and stored in files. Graphical representations were then created to allow visual investigations. The overall goal of this project was to create a database of thermohaline intrusion properties throughout the Arctic basin. This goal was not fully accomplished, but the first important steps were taken in the development of algorithms for determining intrusion properties. Further investigation of intrusion properties in other data sets is planned future work.

Dominic Sarsah, MS '02

My time at the UMD Physics Department was quite challenging and exciting. During my time there, I worked under the guidance of Professor Sydor, who was then working on the problem of light scattering from micron-sized particles. I continued working with him on this project by looking at the treatment of reflectance from micron-sized particles suspended in water. Remote sensing reflectance is a measure of how much of the downwelling light that is incident onto the water surface is eventually returned through the surface. The total reflectance is defined as the ratio of the upwelling irradiance to the downwelling irradiance just below the water surface. Reflectance from 0.5-50 micron particles suspended in water has many applications, such as in the scattering of light in large-volume Cerenkov radiation detectors used in neutrino experiments. Importantly for my project, it forms the basis for optical remote sensing of large lakes and oceans.

The customary approach to this subject follows the radiative transfer equation, which has no closed-form solution, and treats the reflectance from ocean water as an apparent quantity whose physical properties are vague. The most quoted solution for reflectance from ocean water is based on the Monte Carlo calculation presented by Gordon, Baker, and Jacobs and by Morel and Prieur, who give the total reflectance R(0-) defined as, E_{u-}/E_{d-}, the ratio of the upwelling irradiance E_{u-} just below the water surface to the downwelling irradiance E_{d-} just below the water surface according to:

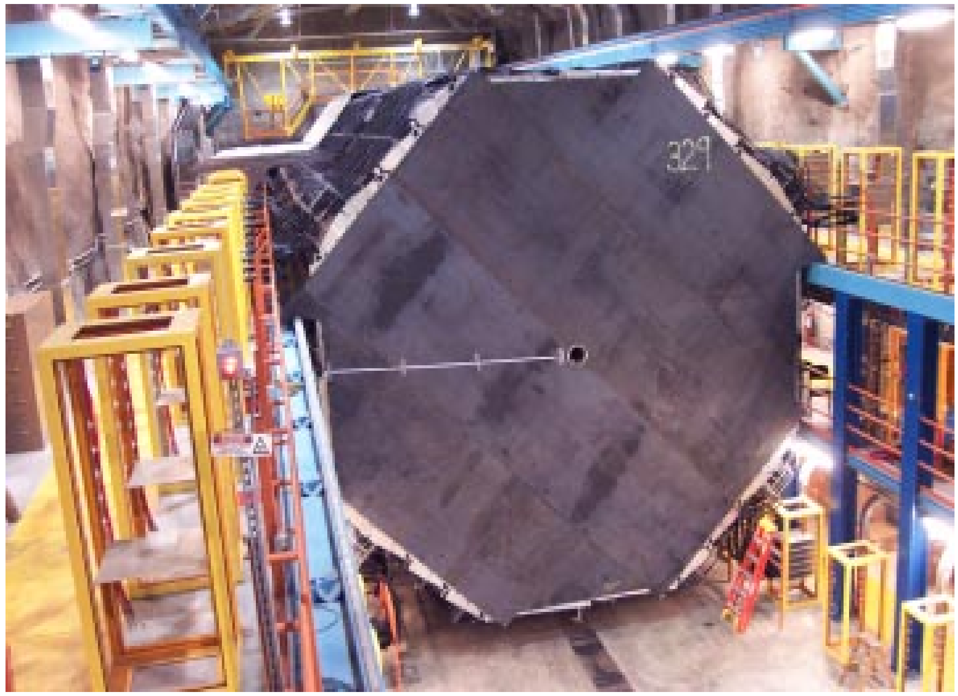
$$R(0-) = Cb_b/(a + b_b). \qquad (1)$$

It is said that Eq. (1) holds for any wavelength. Variable a is the total volume absorption coefficient, and b_b is the volume back-scattering coefficient. C is often presumed constant with a nominal value of ~0.33. Actually, the magnitude of C varies as much as 20%, depending on the distribution of the incident light field, hence the "apparent" property. The main problem with Eq. (1) is the fact that the physical dependence of C on scattering is obscured, thus its variability is unclear.

Fortunately, Professor Sydor, Bill Wolz (BS '95, MS '01), and Amanda Thralow (BS '97, MS '01) had worked on the case of a single back-scattering of a photon incident on the water surface, based on numerical modeling. I made a slight modification in their single scattering situation, and based on that premise I developed a reasonable formulation for the multiple-scattering case.

I took the statistical approach to describing processes that give rise to R(0-) from coastal waters. I then examined the dependence of R(0-) on observational geometry, accounted for multiple scattering, and examined the effects of the angular distribution of illumination sources. I also showed that the statistical approach allows for the separation of the dependence of R(0-) on observational geometry from its dependence on the volume scattering function. Such separation is tacitly implied in Eq. (1) when we treat C as a constant of geometry. However, C in Eq. (1) is not a function of geometry alone, not even in the case of single scattering, because the definition of b_b is restricted to a single scattering of a plane wave incident on a flat-water surface at the normal. On the other hand, R(0-) is the reflectance of a broadly distributed illumination that involves both multiple and single scattering outside the interval. Our approach lead to a simple physical expression for R(0-), an expression given in terms of the average geometric path factor C' and the dimensionless angle-independent ratio b/a where b is the total volume scattering coefficient. b/a is often referred to as the "source function" in radiative transfer theory.

I tested my results by comparing calculated and measured in-situ reflectance R_{rsw}, measured looking down at nadir. R_{rsw} is defined as L_{u-}/E_{d-}, the ratio of the upwelling radiance(L_{u-}) just below the water surface to the downwelling irradiance E_{d-} just below the water surface. Testing in terms of R_{rsw} was also valid for the remote sensing reflectance R_{sr}, defined as L_w/E_d, the ratio of the water-leaving radiance L_w and the irradiance E_d just above the water surface. One usually measures R_{rs}. In general, $R_{rs} = (tt'/n^2)R_{rsw}$, where tt' is the transmittance coefficient for the air-water and water-air interfaces, respectively, and n is the relative index of refraction for the air-water interface. The factor $1/n^2$ accounts for the spread in the solid angle of L_w as it emerges from water. Unlike R_{rsw}, accurate measurement of R_{rs} was quite difficult because one cannot distinguish the radiance emerging from water from the unwanted "specular" reflectance by the water surface when the water surface is not perfectly flat. Thus, testing the results using R_{rsw} rather than R_{rs} was quite appropriate. Just before leaving the Physics Department, I also looked at the dependence of back-scattering measurements on the scattering angle and drew a decisive conclusion to clarify that ordinary turbidity measurements were as accurate as in-situ measurements of reflectance. In my study, I primarily used data collected during the HYCODE and LES15, 2000 and 2001 experiment conducted by Rutgers University and sponsored by the Office of Naval Research under the HYCODE Project.



The MINOS far detector nearing completion. Slabs of steel alternate with scintillator in a sideways stack aligned with the neutrino beam to come from Fermilab, near Chicago. (photo by Jerry Meier, Sudan Underground Lab)

A MINOS Update

D. Jason Koskinen, MS '04

A normal morning consists of what? A bowl of a cereal, cup of coffee and the usual commute. For workers and physicists on the MINOS project there's breakfast and coffee for sure, but the usual commute is a 5' by 6' steel cage crammed full of 10-12 people ready to drop you half a mile below the surface of the earth at 7:30 am. Once down the shaft it's like stepping into every evil genius's dream hidden lair, complete with huge steel doors and a mindless henchman to bring you coffee (if you brought your own grad student that is). What lies beyond the steel doors is not a foolhardy plan for world domination (at least not yet) nor a maze with a roving Minotaur hidden within, but the far detector of the Main Injector Neutrino Oscillation Search, MINOS. The far detector is the final linchpin in the MINOS project, and there are many reasons for it to be submerged 2,574 feet below the earth.

The main precept of MINOS is to see if neutrinos oscillate from one type to another, specifically, muon to tau neutrinos. If they oscillate, then neutrinos have mass, and if neutrinos have mass, then the standard model needs to be tweaked and a whole slew of new theories pop up and others get squashed. To test this idea, you will have to involve hundreds of people from dozens of universities and several national labs to build and design all the equipment, and then, using the resulting template, you can take some data, unless you can find the design at your local Home Depot.

Take 120 GeV protons from the Fermilab Main Injector near Chicago and slam them into a row of 47 carbon fins to produce secondary pions and kaons. Using a magnetic horn, focus the positively charged secondary particle beam down a 500-meter decay tunnel so that they point towards the MINOS far detector in Tower, Minnesota. The pions and kaons will decay into muons as well as muon neutrinos. The extra pions, kaons and muons will be absorbed by the earth, while the neutrino is so weakly interacting that it will travel the 735 km through the earth relatively unimpeded. At the end of the neutrino's journey, it will hopefully interact with steel and produce a secondary light pattern through a scintillator strip. The same scintillator setup is at the near detector site and, by comparing how many of a certain kind of neutrino we see at the beginning of the trip to how many we see at the end, we can surmise that the neutrino changes type while on its trip, which would signify that neutrinos have mass. The reason this is all falling into an article in the UMD physics newsletter is because Professor Alec Habig is one of the collaborators with the MINOS project, and he employs a large group of UMD students to help him with caring for the far detector. The MINOS contingent at UMD is in charge of the Data Control Systems, the DCS, which boils down to making sure that equipment designed to monitor the far detector does not go down in a blaze of glory. This is handled by connecting all the monitoring equipment in a rack into a Rack Protection System (RPS) box. The RPS box does the job of shutting down the power supplies to the monitoring equipment if sensors detect voltage, heat, smoke, or humidity beyond set limits.

To summarize, the UMD MINOS group works half a mile under the earth, playing with a little box that makes sure that a $140 million neutrino oscillation experiment doesn't burn to the, umm, ground that's under the ground.

Computers now used in Physics Elementary Labs

by Denise Osterholm

In the past year some significant changes have come about in the Physics instructional labs. As a direct result of the new "Tech Fees," we have been able to incorporate computers, graphing, and data logging into both the General Physics and Introduction to Physics labs. In the past year and a half, we have purchased enough computers to have them available to all lab sections, though the degree of usage varies with the various lab requirements. Using software by Vernier, students now have the ability to utilize computers for graphing and data acquisition, as opposed to doing it all by hand. Though graphing by hand is still required in earlier labs to ensure an adequate understanding, the computers greatly enhance the range of learning capabilities available to the students. The new tools free up time for more important things, such as development and analysis of systems. Students can now collect and log data directly into the computers using sensors. This alleviates the tedious task of measuring points along a system and then plotting them either by hand or entering them into a computer or calculator. This greatly enhances the time available to students to perform experiments and analysis, as opposed to spending the time for collecting data.

There are four labs on the second floor in Marshall W Alworth Hall: Introductory Physics I & II and General Physics I & II. Each houses six lab setups with computer work stations at each (with the exception of Introductory II which currently has only three computers). There are typically 24 lab sections a week, taking into account all the various levels, and typically three students or less per lab setup, or up to 18 per section. The computers in three of the rooms, Intro I and General I & II are on a wireless network, using Novell, with two rooms on one "access point" and General II on another. The wireless network provides a lot more flexibility than would a hard-wired system, so moving things, if needed, is quite straightforward. In each room there is one printer that is also on the network, so all students have access to printouts.

Students are currently using data acquisition in "Motion Along a Line," with air tracks and motion detectors; "Newton's Second Law," using air tracks, flags and photo detectors; "Hooke's Law," using motion detectors and force sensors; "Atwood's Machine;" "Collisions and Conservation of Energy;" "Rotational Dynamics;" and "Capacitance." The students also use the Vernier graphing software (Graphical Analysis) in a host of other experiments, to perform graphing analysis.

In the figure below, a setup for analyzing Atwood's machine, a small change in kinetic energy of a mass as it speeds up is related to the force accelerating the mass. Both motion detection and force sensing are used in the experiment. Students, using the tools at their disposal, determine the change in kinetic energy using the force along a displacement, and determine the work done by the force.

Motion sensors allow students to sense things getting closer or farther away, typically used with air tracks, analyzing acceleration of falling objects, or observing simple harmonic motion. Force sensors determine how much force is being applied to an object. Photo sensors, using infrared beams, can determine the time it takes something to pass through the beam or the time it takes to travel from one sensor to the next. We also have sensors for determining illumination, or light sensing, voltage sensors, magnetic field sensors, and current sensors, giving us a wide range of sensing capability. These new tools help everybody. We are very happy to be able to provide them.

Experimental setup for "Atwood's Machine," using Vernier Logger Pro Software and motion and force sensors.

The Water Column

by Brian May

It's been a busy year at UMD, and it's hard to believe another year has slipped by. With Elise Ralph on temporary leave to work as a program manager at the National Science Foundation, I've been the lone physical limnologist/oceanographer working down at the Large Lakes Observatory. Within the Physics Department, Mike Sydor continues his work on the absorption and reflectance of natural waters. John Sorensen has been working on tracking mercury contamination in places like the St. Louis estuary.

My research continues to focus on mixing processes, both in oceans and lakes. Following up on work begun during my PhD thesis, I published a study this year comparing the characteristics of interleaving layers in two different ocean frontal zones. Ocean interleaving layers (or intrusions) typically have vertical scales of 50-100 meters and horizontal scales of 1-100 km. They are an important mechanism for transporting heat, salt and other tracers across ocean fronts. In the study, interleaving layers at the edge of a warm, salty eddy in the North Atlantic were compared to layers observed in the Arctic Ocean. A key difference was discovered in the slope of the layers -- in the Arctic, the layers slope between horizontal and isopycnal (constant density) surfaces, whereas at the edge of the eddy they do not. This slope suggests an important driving mechanism for the Arctic interleaving (an instability that converts potential energy stored in the frontal-scale density field into kinetic energy for the interleaving motions) that is absent in the North Atlantic eddy.

Limnological projects continue to feature Lake Superior as the main target. The Triaxus towed vehicle discussed in last year's *Wave Packet* is still on order -- this is one of the risks of being on the cutting, or should I say bleeding(!), edge of technology. Nevertheless, a new microstructure profiler was received as part of the instrumentation package, with successful initial testing last fall. This instrument features micro-scale shear probes that allow direct measurement of turbulent velocity fluctuations (down to about 1 mm scale). Preliminary analysis of these and earlier profiles has revealed an enormously variable turbulent mixing field. Not too surprisingly, the most intense times of mixing are spring and fall, when the lake is weakly or completely unstratified. In comparison, summertime mixing is extremely weak, with the presence of significant thermal stratification.

During 2002, a number of physics students have been involved with these projects. Branden Hakala completed a study to map out interleaving characteristics in the Arctic Ocean. Subroutines were developed to automatically determine the depths of interleaving layers and to calculate key properties such as the layer thickness, buoyancy frequency (measure of a layer's stability) and density ratio (ratio of temperature and salinity changes within layers). Phil Barker completed a study of the spectral properties of internal waves in Lake Superior. His work relied on temperature mooring data he helped collect during our 2001 field season.

Publications in 2002

Limnology and Oceanography

C.S. Chen, J.R. Zhu, K.Y. Kang, H.D. Liu, E. Ralph, S.A. Green, and J.W. Budd, "Cross-frontal transport along the Keweenaw coast in Lake Superior: a Lagrangian model study," *Dynamics of Atmospheres and Oceans* **36**, 83 (2002).

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Physics faculty and staff at Tom Jordan's retirement dinner. Front row: Darrin Johnson, John Hiller, Howard Hanson, Alec Habig. Back row: Bo Casserberg, Lori Johnson, Jon Maps, Brian May, Tom Jordan, Elise Ralph, Denise Osterholm, John Sorensen. Absent: John Kroening, Mike Sydor, Bill Wolz.

At the CSE Academy induction, Prof. Hanson kept the crowd in stitches, as you might expect.

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John Sorensen, Research Fellow
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In Memory of ...

Alfred Bolger (BA '60), who passed away on April 4, 2000.

Spring 2003 UMD Physics Newsletter Response Form

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Do you wish to be added to the alumni web directory?_____

(The URL is http://www.d.umn.edu/physics/contact/alumni.htm.)

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My nominee for the CSE Academy is _____________________________because:

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Send your reply by one of the following means:

• mail to University of Minnesota Duluth, Department of Physics, 371 MWAH, 10 University Drive, Duluth, MN 55812.

• fax to 218-726-6942.

• e-mail to jhiller@d.umn.edu.

• web page form at the URL http://www.d.umn.edu/physics/response.html.

Thanks!! We'll enjoy hearing from you!

Lost Addresses

If anyone knows a current address for someone on the list below, please send it in or have the person get in touch. Thanks!

James C. Anderson, BA '50
Wai Ang Chan, BS '75
Charles W. Hill, BA '55
Lloyd L. Horton, BA '51
James D. Johnson, BA '54
Wallace E. Johnson, BA '50
Michael R. Jones, BA '69
Kambiz Khosroshahroudi, BS '85
Nagi Keung Lee, BA '71
Peter C. Lukens, BS '90
John A. Miller, BA '59
Mohd I. Mohdyusof, BS '86
Yaseen S. Murayed, BS '85
Charles C. Nelson, BA '58
Gerald D. Nelson, BA '60
Wesley J. O'Brien, BA '56
Timothy S. Olson, MS '87
Lawrence W. Pirila, BA '66
Anthony K. Quick, BS '92
Mylan Radulovich, BA '60
Frederick C. Stewart, Jr., BA '59
Haichuan Tan, MS '96
Charles A. Turcotte, BA '50
Dale O. Wick, BA '59
Stephen Wong, Jr., BA '50