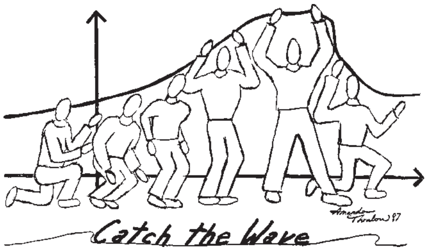


The Wave Packet

The UMD Physics Newsletter

Issue No. 9 *Spring 2004* ***http://www.d.umn.edu/physics/newslett/newslett.htm*** *Editor: J.R. Hiller*

Habig Awarded McKnight Professorship

Several years of hard work on neutrino astrophysics have gained Alec Habig the award of a McKnight Land-Grant Professorship. This is a systemwide award developed by the University of Minnesota to recognize promising tenure-track faculty. It provides two years of funding, including one year of paid leave for research. Of the four UMD awardees since the program's inception in 1987, two are in the College of Science and Engineering and they (Habig and Elise Ralph) are both in the Physics Department. In practical terms, the award represents increased opportunities for travel and student participation in research.

Most of Habig's work is focused on two collaborations, one that uses the Super Kamiokande neutrino detector in Japan and one that will study neutrinos in a beam sent from Fermilab (near Chicago) to a just-completed detector in the Tower-Soudan iron mine. In the latter collaboration, known as MINOS, Habig was recently promoted to Operations Manager for the new Soudan detector. In this new position, he is responsible for evaluation of the new detector and for making certain that the detector is ready when the beam is turned on in 2005.

Promotion and Tenure for Ralph

Congratulations go to Elise Ralph for award of tenure with promotion to Associate Professor. She joined the department in January 1997 as a joint hire with the Large Lakes Observatory and has done extensive work on temperature and circulation patterns in Lake Superior. Most recently she was on leave at NSF as an associate program director for physical oceanography. With her return this January, the position was realigned to be entirely within the Physics Department. At that time Ralph also took over from Bo Casserberg as Director of Graduate Studies.

Thralow Lends a Helping Hand

One of our recent graduates, Amanda Thralow (BS '97, MS '01), has returned briefly as an instructor in the calculus-based sequence, on loan from the Mathematics & Statistics Department. Habig's promotion to Operations Manager for the MINOS detector created a gap in our teaching staff that had to be filled on short notice, and the Math/Stat Department was kind enough to help us out. Thralow has been a full-time mathematics instructor at UMD since she completed her graduate degrees in Physics and Applied Mathematics.

Inside this issue

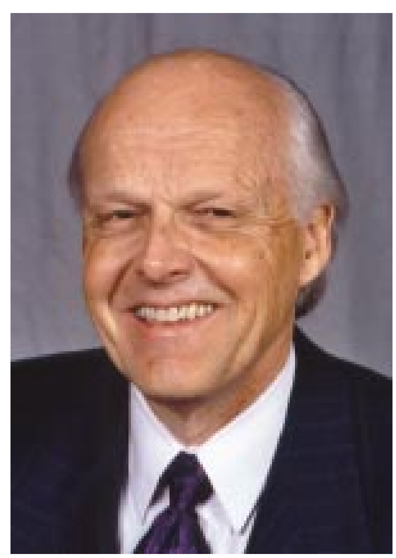
Slaunwhite Visits as Supercomputing Intern

During this past summer, Jason Slaunwhite, an undergraduate Physics and Computer Science major at Union College in Schenectady, New York, worked at UMD, supported by the Minnesota Supercomputing Institute's internship program. The work was supervised by Professor Hiller. Slaunwhite explored the usefulness of a particular technique for the numerical solution of integral eigenvalue problems that arise in quantum field theories. He has continued the project as a senior thesis in Physics and Computer Science at Union College, where he will complete his degree this spring.

2nd CSE Academy Induction

In September, Dr. William Mularie (BA '61) became our second inductee to the Academy of the College of Science and Engineering. He is retired from 3M and currently serving as CEO of the Telework Consortium in Herndon, Virginia. He joined our first inductee, Professor Howard Hanson, and a number of distinguished graduates from other CSE programs.

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.



Dr. William Mularie, CSE Academy Inductee.

Honors and Awards

The **Outstanding Graduate Teaching Assistant** for 2002-2003 was **Yuhu Yan**. Yuhu is working toward a Ph.D. in Water Resource Sciences under the supervision of Professor Sydor.

Branden Hakala received the **Outstanding Research Project Award** and **Andrew Clough,** the **Outstanding Academics Award** for 2002-2003. Branden worked with Professor May on thermohaline intrusions in the Arctic Ocean; the project is described in the previous issue of the *Wave Packet.* He will complete his BS this spring. Andrew finished his BS at UMD last spring and has remained, in the MS program, in order to continue working with Professor Habig and the Super-K collaboration.

A sophomore physics major, **Andrew Bianconi,** was awarded the **Olson Scholarship** for 2003, to work with Habig on the SNEWS project, which is to use the neutrino detectors of the world to provide astronomers early warning of a supernova, from which neutrinos are emitted several hours before visible light. **Daniel Gastler** received the 2003 **Hanson Scholarship** and worked with Professor Habig on upgrades to a Monte Carlo program used for analysis of the Super-Kamiokande neutrino detector. Dan plans to complete his degree this spring and enter the Physics PhD program at Boston University in the fall. The first award from the Friebe Fund was made to a first-year graduate student, **Jason Koskinen**, to help fund a summer at CERN, the European high energy physics center, where he worked on the calibration detector for the MINOS project. Descriptions of all three projects can be found elsewhere in this issue.

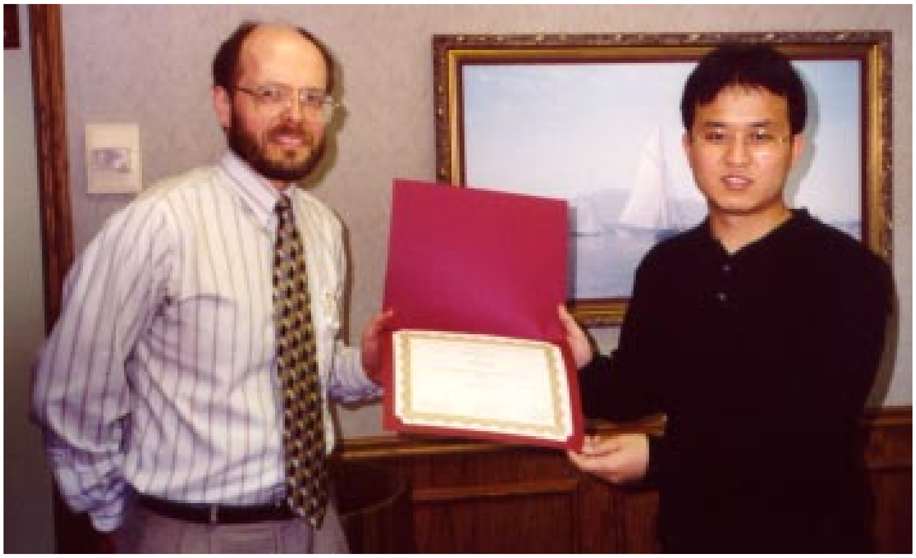
Professor Howard Hanson and Hanson Scholar Daniel Gastler.

Professor Hiller and Andrew Clough, winner of the Outstanding Academics Award.

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, or go online at www.d.umn.edu/development/waystogive.html.

Professor May and Branden Hakala, winner of the Outstanding Research Project Award.



Professor Hiller and Outstanding GTA Yuhu Yan.

Alumni Visits

Several alumni have stopped by, including Ron Boe (BS '94), Neal Jahren (BA '88, MS '90), Don McLish (BS '68), and Shawn Putnam (BS '01). Mark Debe (BA '69) and Steve Nicholas (BS '91, MS '93) attended the third meeting of the External Advisory Board for the College last spring. Maps and Hiller joined Allen Anway (BA '63) and Steve Highland (BS '79) as judges for the Northeastern Minnesota Regional High School Science Fair.

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.

Hermantown Lumber Donates Blocks

The Hermantown Lumber Company, of 3707 Lavaque Road in Hermantown, donated a dozen one-foot 4x4 cedar blocks, used for mounts to support Helmholtz coils that students use to determine Earth's magnetic field. This experiment uses Hall-effect magnetic sensors and Vernier Lab Pro data acquisition software. Many thanks to Hermantown Lumber for this gift.

Graduating seniors for 2003, Patricia Quigley, Konrad Johnson, and Andrew Clough.

Planetary Science Lecture Series

During the fall semester, the department and the Physics Club sponsored the Planetary Science Lecture Series. Graduate student John A. Peterson organized the ten-part series with talks ranging from Mercury to Neptune. Most aspects of planetary sciences were discussed at a level appropriate for all college students. Professor Vicki Hansen, McKnight Presidential Professor of Earth and Planetary Sciences, presented a talk on Venus; the other talks were presented by Mr. Peterson. Each week an exciting area of planetary sciences was discussed in the main physics lecture hall. Several talks included demonstrations; others included three-dimensional images. The series was attended by an average of about ten people per week. Cookies and milk were provided, and those who attended seemed to enjoy themselves.

Tricia Bunten, the CSE Development Director, with Lois Olson and Olson Scholar, Andrew Bianconi.

Innovation Night

In March, the local PBS station, Channel 8, and the Duluth Children's Museum hosted Innovation Night at the Depot, an opportunity for children of all ages, but particularly middle-school students, to see what is happening in the Northland by way of technology and innovation. The Physics Department represented UMD, with posters and displays about the MINOS neutrino detector and the R/V Blue Heron, and gave attendees an opportunity to appreciate angular momentum conservation. The latter was a big hit with the crowd; volunteers rode on a spinning platform, with weights to augment their moment of inertia or with a spinning bicycle wheel as a gyroscope. Some riders returned more than once, making angular momentum more popular than the donut machine next door. Habig, Hiller, Johnson and Ralph ran the show.

Catch Up with Past Grads

Peggy Davis Chun, BS & BA '69

I embarked on a career path in physics and engineering because of complete curiosity and sheer stubbornness. My high school physics teacher presented the subject very poorly. I was convinced there was something more to discover and set off to find it.

From Day 1 at UMD in 1965, I was a committed (all meanings intended) Physics Major. At the end of my Freshman year, I was recruited by Professor Don Olson as student labor for his research work and assisted in: crunching reams of electric field strip chart data on an old Friden calculator, making antennae (the worst job you could have), modifying radiosonde packages to fly on balloons for three-dimensional data collection during auroral activities, etc. Those were good, old days. Not only did I have the experience of working on research, but I also learned the value of being part of a team. I feel very privileged to have worked for Don Olson and to remember his contagious enthusiasm, dedication and values. He imparted this to all of us who worked for him.

One plug: The Donald E. Olson Memorial Fund is so important to continuing Don's special spirit for those who come after us.

I graduated in 1969 after being pushed to the academic limits by Professors Michael Sydor, John Gergen, Bo Casserberg, and my advisor, Howard Hanson, and to research boundaries by Don Olson. UMD provided me with a great academic foundation as well as preparing me for the research environment.

Unfortunately, when I graduated, the aerospace industry was in a tail spin. My desire to work for NASA was a farfetched dream. Fortunately, I graduated with both a BA and a BS (teaching) degree in physics from UMD. I found a job teaching junior high math for the Los Angeles City Schools. It got me by, taught me much, and helped me to eliminate a career path. I fulfilled my one-year teaching contract, survived a six-week teachers' strike, packed my car and moved to Boulder, Colorado. With my sights still on a position with NASA, I began graduate studies at the University of Colorado (CU) in Astro-Geophysics. I had the privilege of working under two esteemed atmospheric researchers, contemporaries of Don Olson's: Dr. Heinz Kasemir and Dr. Lothar Ruhnke at the National Oceanic and Atmospheric Administration (NOAA) in Boulder. Now I was chasing thunderstorms instead of auroras.

After one year of graduate school, I again tested the waters to see what my chances were of obtaining a position at NASA. I went from underqualified to overqualified! Frustrated, but stubborn, I found a summer job working at the Naval Weapons Center, China Lake, CA. I never went back to finish that graduate degree at CU, but I did eventually receive my Master's in Systems Engineering during my 29 years as a civilian employee for the Navy at China Lake.

I also met my husband Jay at China Lake. We were married in 1978. He continues to put up with me and, unwaveringly, supports my endeavors, no matter how obtuse they may be. Jay is a mechanical engineer and (University of Nevada) program manager at China Lake. Besides work we dabble with astronomy, old cars, alternative energy concepts for residences, an apple orchard in New Mexico (very true observation that NM is not known for apples) and traveling adventures. Our family consists of a convicted chicken-killing dog (reformed) and 4 cats.

My tenure with the Navy enabled me to change career paths a number of times, starting out in atmospheric physics research, changing to alternative energy research (solar, wind, geothermal) and finally to air breathing and solid propulsion systems research. My job fun meter was so very high that I almost forgot about NASA. I had many amazing career options at China Lake with opportunities to work on programs that went from conceptual ideas into development research and transitioned into production. Don Olson even came out to China Lake to set up several electric field mills to support Navy activities. Of course, Don's goal was to have a worldwide network of field mills to study global atmospheric electric effects no matter what the Navy wanted with the data.

In 2000, after 29 years at China Lake, I was offered my career opportunity of a lifetime at NASA. I was selected to be a senior systems engineer supporting all of the aerospace research projects at the NASA Dryden Flight Research Center, located at Edwards Air Force Base in the Mojave Desert of California. I have a deep appreciation and fascination with aircraft, especially the SR-71 which was still operational by NASA when I came to Dryden. The things that NASA does to aircraft are remarkable in pushing the aviation envelopes. It's been wonderful to be a part of the recent history, from solar-powered high-altitude endurance aircraft to the hypersonic (up to Mach 10) vehicle, X-43A, which is expected to attempt another flight later in 2004.

In February, 2004, I was selected to be a senior systems engineer for the newly formed NASA Engineering and Safety Center (NESC). NESC was initiated as a result of the Space Shuttle Columbia accident. As of this writing, I am embarking on this new job for NESC, looking forward to meeting the challenges in the development of a new organization and to contributing to the safe return to flight of the shuttle and support of the International Space Station.

My career fun meter is as high as it's ever been! Curiosity, stubbornness, a mentor with high standards and a good academic foundation have gotten me to this point. What a wild ride it has been! It is good to follow dreams, no matter how circuitous the route.

Craig Jensen, BA '73

UMD and its Physics Department have contributed much to my education and to my life. I came to UMD in the fall of 1969 as a basketball player with an interest in engineering and a love of the outdoors. Physics was as close to engineering as one could come, so the Physics Department became my academic home. The staff probably has no recollection of me as a student in the department since I spent a good portion of my time in the gym, or traveling to road games. I remember one particularly troubling event late one quarter in Modern Physics Lab when Mr. Olson approached me and asked who I was since he did not remember ever seeing me before!

As graduation approached in 1973, I watched a fellow senior, George Clock (BS '73), who was clearly at the top of our class, struggle to find a job in physics in the midst of an economic downturn. I believed that if George was having a hard time finding a job, then my chances were remote, and I headed to graduate school. I had already been accepted into several graduate programs in physics when I received a call from the Metallurgy Department at Iowa State University. They were willing to provide me with an assistantship in their department, which I accepted.

I chose to study the electromigration of hydrogen isotopes in niobium, vanadium and tantalum. This topic was of "practical" interest, as these metals were thought to be candidates for fusion reactor materials where large electric currents could concentrate hydrogen to levels where embrittlement might occur. Also, electromigration was a significant cause of integrated circuit failure. From a theoretical standpoint, we hoped that study of isotope effects could provide information on the effects of mass and charge on the phenomenon of electromigration. I did continue with my physics education by taking three quarters of solid-state physics and an equal amount of quantum mechanics courses.

With a PhD in metallurgy in 1977, I accepted a position in the Department of Chemical Engineering and Materials Science at the University of Minnesota in Minneapolis. I continued my research on hydrogen transport in metals. I developed a fondness for teaching and a dislike for the effort required to secure research funding. I also learned more chemical engineering than I had anticipated.

In 1981, I accepted a position at the Alcoa Technical Center near Pittsburgh, Pennsylvania. Initially, I was involved in the use of electron-beam and x-ray techniques for characterization of the microstructure of aluminum alloys. My physics background helped me to understand and utilize diffraction techniques in these endeavors. Later, Alcoa became involved in producing products with thin film coatings, such as rigid memory disks, enhanced reflectors and radar-absorbing coatings. My dim recollection of electromagnetic field theory and optics helped a great deal. (My knowledge of E&M in 1973 was already dim, as Professor Jordan can testify; at least I saved the textbooks.) In the late '90s, I became more involved in failure analysis activities for Alcoa. While many of these investigations were fairly mundane, we were occasionally asked to provide help to the FBI when aluminum ended up in the middle of a crime.

In 1999, my wife accepted an excellent job opportunity in the Chicago area. As a side benefit, we are now closer to the Boundary Waters Canoe Area, which I visited while at UMD and which we enjoy greatly. I found employment with Packer Engineering, which does forensic engineering and consulting work for legal and insurance clients. Many of the investigations in which I become involved are much broader than metallurgy. Physics provides a good background to understand phenomena ranging from electrical incidents to vehicle dynamics.

I have many fond memories from four years at UMD. My time at UMD and in the Physics Department was a great investment. I have been able to pursue a wide variety of interesting vocations with my physics background. I would like to thank the University and the Physics Department for making this all possible.

Steve Wanzong, MS '92

I moved to Madison, Wisconsin immediately after graduation in July 1992. Family generosity helped me through until I found employment at the University of Wisconsin-Madison, Space Science and Engineering Center in October of 1992. SSEC has many programs (see http://www.ssec.wisc.edu), but is famous for weather satellite research. The founder of SSEC, Vern Suomi, was recognized as the "father of weather satellite systems."

Initially I worked on the GOESPathfinder project in the NOAA/NASA Pathfinder Program. I tested custom software that would process data streams from the VISSR/VAS sensors onboard the GOES-7 satellite. (GOES =Geostationary Operational Environmental Satellite; VISSR = Visible and Infrared Spin Scan Radiometer; VAS = VISSR Atmospheric Sounder). At the time GOES-7 was the main weather satellite covering the United States.

In May of 1993 I was introduced to a scientist within the Cooperative Institute for Meteorological Satellite Studies. He hired me on the spot to help with intercalibration of geostationary satellites with polar-orbiting instruments. The intercalibration is necessary to achieve consistency of the data sets involving several sensors. For a brief description of the project, please see http://cimss.ssec.wisc.edu/goes/intercal/overview.html. CIMSS is housed within SSEC and is made up of NOAA, NASA and UW-Madison workers. The only reason I was able to be hired into this position was because of my MS in Physics and specifically the Computational Physics program.

In the same time frame, I was also part of the Tropical Cyclone group. This is a research group under the umbrella of CIMSS and SSEC. I helped develop many of the products that can be seen on the following web page: http://cimss.ssec.wisc.edu/tropic. My main task was building custom software to calculate atmospheric motion from weather satellites. We tracked clouds and water vapor motion and assigned them heights in the atmosphere. These data have been used in numerical weather models to improve intensity and track forecasts of tropical cyclones.

In 1998 I accepted a network and unix systems administration job within SSEC. I am responsible for approximately 300 "unix" computers in the building. We have a hugely diverse computing base (IBM AIX, SGI IRIX, Sun Solaris, HPUX, RedHat Linux, MAC OS X). I now provide support for the groups in which I used to work. In some ways this is a much more stressful occupation. Dealing with a constant stream of people in front of you or on the phone is as challenging as the systems work. There are many days when I wonder why I moved into this profession. I haven't ruled out a return to the sciences.

Student Research Projects

Kiran Billa, MS '04

My stay at the UMD Physics department helped me to strengthen my research skills. I worked under the supervision of Professor Jonathan Maps on the characterization of quartz tuning forks to be used in atomic force microscopy. In fact, after studying the behavior of tuning forks, one can use the tuning fork as a sensing element in any scanning method.

The tuning forks I studied were fabricated from quartz crystals, which have piezoelectric properties. The tuning forks are used in watches and commercially available in a closed can. The dimensions of one arm are 3.6 x 0.6 x 0.25 mm^3. The resonant frequency is 32768 Hz. The piezoelectric behavior of the tuning fork can be modeled as an LCR circuit, which I spent time on understanding because the mechanical motion of the tuning forks can be measured electrically by using such a model.

When we drive the tuning fork with an oscillating external drive voltage, the charge developed on the opposite faces of the tuning fork causes the arms to bend. The charge is proportional to the displacement of the arms of the tuning fork. I used an op-amp-based current-to-voltage converter to measure the current through the tuning fork. So basically I measured a current proportional to the displacement (actually velocity) developed in the tuning fork. Controlling the experiment and collecting the data was done using a computer via LabVIEW. The tuning fork's motion was measured as a function of frequency. I also drove the tuning fork with different drive voltage amplitudes and as expected the resonant frequency and quality factor were independent of drive voltage.

First I studied the behavior of the tuning fork when it was in its closed can (in vacuum). The resonant frequency and quality factor were found to be 32764 Hz and 90000 by fitting the frequency response of the tuning fork to the LCR model. Next I punctured a small hole in the can and re-measured the response. I found that the resonant frequency dropped to 32756 Hz and the quality factor dropped to 10000. The reason for this change in part was that when the tuning fork is vibrating in air, it drags some air molecules along, adding mass, and this results in a lowering of the resonant frequency. The reason for the change in the quality factor is that the damping is higher. Finally I removed the tuning fork from the can and attached a small tungsten wire to one of its arms, to simulate a tip used as a probe in a force microscope. The resonant frequency dropped to 30060 Hz and the quality factor to 3000. The reasons for the drops in the resonant frequency and the quality factor are the increased damping, the broken symmetry of the arms, and the increase in mass.

Maxwell Ankrah, MS '04

My stay at UMD was exciting and challenging. I saw snow for the first time when I came over from Ghana in 2001. Back home we have only two seasons: wet and dry. Teaching labs and taking classes in the same semester was also new to me, since most students in Ghana go to school full time without working. My academic advisor was Professor Jon Maps. I would say I was privileged to work with one of the best advisors here at UMD. He was available when needed not only to me but to other students as well.

In my research I studied the measurement of frequency shifts near a surface. We used the basic principle of atomic force microscopy, which measures the force between atoms on a nanometer scale. In the experiment the cantilever was a quartz tuning fork with a sharp probe attached. When the probe is moved over the sample, interatomic potentials cause the cantilever to deflect in response to the contours of the surface and change the resonant frequency of the tuning fork. Either this deflection or the frequency shift can be used to map the surface topography of the material.

My project focused on moving the probe closer to the sample and measuring the associated frequency shift, so scanning was not part of this project. As the tip was brought close to the surface, I expected the frequency to drop due to long-range attraction and then rise rapidly due to short-range repulsion.

The sample was mounted on a piezoelectric actuator, and a LabVIEW program was written to advance the sample toward the probe and record the frequency shift and the sample position. According to other researchers, observable frequency shifts occur typically within 10 nm of a sample surface. I observed positive frequency shifts over wider ranges with significant hysteresis. A series of sample surfaces of glass and graphite eventually showed the negative frequency shifts due to long-range attraction followed by positive shifts from short-range repulsion, respectively. The hysteresis was due in part to the piezoelectric positioner. However, I was unable to identify the cause of the frequency shifts occurring over the wider ranges.

Sheila Amenumey, MS '04

This is my third year at UMD. It is hard to believe all the knowledge I have acquired within these few years. Though challenging, I am currently finishing my MS program in Physics and starting another program in Water Resources Science to which I was admitted in the fall of 2003. I would like to take this opportunity to express my gratitude to Professor Sydor, my advisor, for allowing me to work with him. He has been working on the problem of scattering and absorption from micron-sized particles as it pertains to the reflectance of light from particles in Great Lakes and oceans.

My project is concerned with devising measurement of forward scattering of light from micron-sized particles at ~ 1^o angle. The measurements are important in determining the properties of diffuse reflectance observed in remote sensing of biological productivity in marine environments. There is a general paucity of data on the angular distribution of scattering by micron-sized particles, and none exists for the scattering at angles smaller than one degree. Yet, an appreciable fraction of scattering by micron-sized particles occurs at angles smaller than one degree. Scattering of light is a phenomenon in which the direction of photons is changed when they encounter discontinuities in the medium, or interact with particles at the atomic or molecular level. It is responsible for the reflectance that provides a means for satellite monitoring of organic and inorganic content of ocean water. For marine environments, scattering comes from particles such as viruses, colloids, bacteria and phytoplankton. The scattering from such particles occurs in a highly forward direction and is difficult to measure because collimated beams have a natural width, and detectors have a physical size that extends beyond the spread in the scattered beam. In essence it is difficult to distinguish between scattering at very small angles and the directly transmitted ray. Yet, 90 percent of the scattering by marine particles is confined to a few degrees of the incident angle. In general, marine waters contain viruses and particles, which are smaller than 10 nm. Thus their presence cannot be detected on a large scale by means other than the scattering of light. Recently, it has been recognized that bacteria can contribute significantly to the scattering of light from oceans, especially at blue wavelengths and in clear ocean waters, where phytoplankton is very scarce. Thus the notion that phytoplankton is the dominant source of scattered light may be incorrect. Phytoplanktons are microscopic plants that are incredibly diverse in species, size, shape, and concentration. Their chlorophyll and related pigments strongly absorb light. These particles are generally much larger than the wavelength of visible light and are efficient scatterers; thus they strongly influence the total scattering of light. Their concentration is a general indicator of biological productivity, important in assessing fisheries, pollutant concentration and the general quality of water.

To monitor particles on a wide scale, we employ satellite measurements of the reflected light. The reflectance can be related to the optical properties of ocean waters, such as its volume scattering coefficient and its absorption by chlorophyll. However, reflectance from ocean water comes from multiple scattering that depends on the total scattering coefficient, which is in the highly forward direction. Thus true understanding of the reflectance from ocean water demands that we measure the scattering at very small angles. The object of my work is to measure the forward scattering at very small angles using coherence and polarization. Some researchers have reported measurements of scattering at small angles from suspended polystyrene spheres, but their work has not been published. Others have attempted to measure forward scattering but have only estimated the forward scattering at angles less than 3^o. Besides its application in the understanding of remote sensing reflectance (Rrs) spectra from ocean waters, measurement of scattering near 0^o is important in problems of underwater imaging, theoretical interest in connection with multiple scattering theory, and measurements of particle size distributions.

To distinguish between scattered and directly transmitted light, we employ measurement of beam coherence after it passes through a water column. Light that is scattered loses its coherence because the photons undergo a random shift in phase during the scattering process. Thus by observing the interference for a beam transmitted by water containing suspended micron-sized particles, we can use measurement of fringe visibility to separate the light that is scattered at small angles from the directly transmitted beam and determine the volume scattering function at small angles.

Scattering can change not only the phase of the photon but also its polarization. In this experiment we check whether the separated light has the same polarization as the incident light. Partially polarized light can be viewed as a mixture of unpolarized and polarized light, similar to the visibility criterion.

This work applies to Rrs, the reflectance of light from the sun and the sky by marine particles in the direction of the observer. Rrs is defined as the ratio of the radiance reflected by particles in marine water to plane "downwelling" irradiance just above the water surface due to sun and sky. For multiple scattering Rrs is related to the optical properties of water, parameterized by the total volume scattering coefficient b and the total absorption coefficient a. Since over 30% of the contribution to b comes from forward scattering within 3^o, we decided that measurement of scattering at angles less than 3^o had practical merit in application to remote sensing of marine waters.

Mie Theory predicts that the volume scattering function should flatten out at small angles. This behavior was observed for scattering angles less than 1^o in the laboratory, with micron-sized polystyrene spheres suspended in particle-free water. Comparison of plots of the volume scattering function for four particle sizes showed that the function has a slightly different shape for each particle size. Our results were comparable to Petzold's work to some extent, because he interpolated the volume scattering function to less than 0.1^o; however, we actually measured it.

Further work is currently being done by considering the measurement of particle size in water by means of the forward scattering lobe. The angular distribution of scattered light in the main lobe of the Fraunhofer diffraction pattern of a particle changes rapidly with size, but is largely independent of its refractive index. The particle sizes used include 2, 4.5, 8 and 10-micron spheres. It is hoped that the results of the project will result in the development of an instrument for the measurement of forward scattering which has a great importance in marine remote sensing, underwater imaging, and theoretical interest in connection with multiple scattering theory.

Daniel Gastler, Hanson Scholar, BS '04

During the past summer I continued my work with Professor Habig on the Super-Kamiokande neutrino detector. This summer's work focused on completing the upgrades I began earlier to the NUANCE Monte Carlo program used at Super-K. This Monte Carlo program gives us the expected number of muons that are created from neutrino interactions that will pass through our detector. It goes through all the processes involved, from taking the incoming neutrino flux to finding the energy and trajectory of the muons that enter the detector. The primary goal in my work was to integrate a newer model for the propagation of muons in a medium, called MUM (MUons+Medium), into the Monte Carlo code. MUM is used to simulate the energy loss of muons as they go through the rock surrounding Super-K. It is first used to get an upper limit on the water-equivalent distance values considered for each energy. This means that MUM gives an average distance that a muon with a specified energy can travel. MUM is later used to propagate each muon considered from its initial location to the detector. Adding this gives NUANCE a choice between the current simulator and MUM, which makes a more accurate description of muons propagating though rock. Now that this work is complete, the revisions I made can be added to the official copy of NUANCE, which will allow the MUM code to be used by other scientists.

This summer I also had the opportunity to work with the Condor parallel computing system located at the Super-K detector. The system allowed me to utilize 200 Sun Ultra-SPARC III processors at the same time. I wrote several scripts that instructed the system on how to generate and store the results of passing the NUANCE muons through a model Super-K detector. The computer system then generated the equivalent of a hundred years of data in the span of a few days.

Scott Haynes, MS '04

In the summer of 2002, temperature measurements were made from a mooring in the western end of Lake Superior. As part of my thesis work, I am analyzing the data recovered from the mooring to investigate the time-dependence of internal waves in the lake. The spectrum of internal wave displacements is used to characterize the frequency and amplitude of internal waves. I am interested in how the spectrum varies over time, specifically in relation to wind events and changes in stratification. By looking at the dispersion relation between stability and internal wave frequency, I hope to see if wind direction correlates with the slope of internal wave propagation, possibly indicating lee waves. Using ELCOM, the Estuary and Lake Computer Model developed by the Center for Water Research at the University of Western Australia, I plan to model internal lake oscillations during sustained wind events, hopefully observing basin scale internal waves and energy decay rates similar to those seen in the mooring data.

Andrew Bianconi, Olson Scholar 2003

The project on which I worked over the summer was part of the SuperNova Early Warning System, SNEWS for short. The SNEWS collaboration hopes to provide early notice to astronomers of a supernova event, based on the detection of neutrinos emitted before the visible light..

My work was geared more toward automating the communication of a supernova event. Several detectors are in place over the world, each of them connected to an overseer program. Improving the efficiency of the program code was part of my duty to aid in the project.

The code portion that was improved was the data checking by the main overseer program. If a set of data turns out to be something interesting but then doesn't seem to fit all the characteristics of a definite supernova, a message will be sent to staff, asking them to look at the data. If all the checks come out flawless, all participants in SNEWS will be alerted.

Jason Koskinen, Friebe travel award recipient, MS '04

I don't think someone has asked me to write about what I did over my summer vacation since I was in my second year of school. Now that I am in my second year of graduate school I probably can't write "I rode my bike and got ice cream from the ice cream truck, and I went swimming." I can actually still write that I went swimming, but my locale for swimming was either Lake Geneva in Switzerland or at the tip of the Adriatic Sea near the Italian/Slovenian border. I'd have to say that last summer was probably better than the one I wrote about in second grade.

Swimming in Lake Geneva was weekend leisure after working at CERN, a European particle physics laboratory just outside Geneva, Switzerland, on the Calibration Detector (CalDet) for MINOS (Main Injector Neutrino Oscillation Search). MINOS is the search for neutrino oscillations in which a beam of muon neutrinos are fired from Fermilab in Batavia, Illinois, through the earth to the Soudan underground mine to see if on their path they change to tau or electron neutrinos. The Near Detector, stationed just past the beginning of the neutrino beam, will sample the neutrinos before oscillation, and the Far Detector will sample them after the theorized oscillation. MINOS collaborators will then compare how many neutrinos were detected compared to how many should have been detected if no neutrino oscillations happen. The purpose of CalDet is to see the different responses of the Far and Near Detectors' electronics when they were detecting the same particle. CalDet was rigged with one half Near Detector electronics and one half Far Detector electronics, and then put into a muon beam at CERN. My time there was spent working on CalDet which constituted connecting, as well as disconnecting, hundreds of cables and coding software to find light leaks and cross-talk errors.

Italy was time for work, study and fun. I spent three weeks in Trieste, Italy, at the tip of the Adriatic sea attending the Particle Physics summer school at the Abdus Salaam International Center for Theoretical Physics (ICTP). An event that leaves one speechless both saying it and attending it as well. The ICTP summer school was coordinated and directed by world-renowned theorist Dr. Alexi Smirnov and had presentations running from the very theory-based "Quantum Chromodynamic Dynamic Phase Transitions" to the much more digestible "Future Accelerators." Being one of two Americans (the other I never even saw at the summer school) presented me with the opportunity to socialize with young physicists from Peru, Ecuador, Spain, Uruguay, Australia, Bangladesh, Serbia and Ukraine, in and out of the summer school. Free days were spent either traveling to Venice or walking around Trieste and going out to eat at fantastic little Italian restaurants and pizzerias.

All told it ended up being a fantastic experience in which I was afforded the opportunity to study and work on physics in some of the most beautiful places in the world. Oh, and it was also nice being able to ride my bike from provincial France to work at CERN, and then after work go downtown for some ice cream and swim in Lake Geneva. I guess all in all I did end up riding my bike, getting ice cream and going swimming, just like I did in second grade.

John Peterson, MS student

I am currently working on an MS degree in physics, advised by Professor Brian May. My research involves the study of large lakes on present day Earth, specifically Lake Superior, and ancient Mars, specifically the Gusev paleolake. It is a combination of the strength of the UMD limnology program with my longtime passion, Mars. The title of my thesis is "Circulation of Large Lakes on Present-Day Earth and Ancient Mars."

My background is in computational methods, and the bulk of my thesis will be based on computer simulations. I am using the program MITgcm, a global circulation model developed by the Massachusetts Institute of Technology; reanalyzing data from the National Oceanic and Atmospheric Administration; and using some in-situ measurements to test the code and determine if it can resolve the actual circulation and temperature structure of Lake Superior. I will compare the computational results with data collected by Earth-orbiting satellites and moorings placed by Professors May and Ralph.

I spent the summer of 2003 as a Graduate Research Assistant at the Large Lakes Observatory. During that time, I selected and installed the computational program MITgcm and have become knowledgeable in its use. I twice traveled on the R/V Blue Heron during the sea acceptance tests for the new Triaxus towed undulating vehicle. While I had hoped the new instrument would provide a good supply of data for my thesis, the inevitable trials and tribulations in an instrument implementation prohibited me from using it heavily. Some useful temperature measurements have been obtained, nevertheless.

My primary interest is in Martian bodies of water. Once I have determined that the circulation model is sufficiently accurate to recreate Earth conditions, I will make slight modifications to the code to allow it to simulate the surface of Mars. I will use data from the Mars Orbiting Laser Altimeter aboard the Mars Global Surveyor and data from the Mars Exploration Rover Spirit to computationally model a lake environment which may have existed back when the Red Planet was warmer and wetter. While the atmosphere of Mars cannot currently support the presence of water in liquid form, scientists have long speculated that in the past it well could have. With the Viking missions of the 1970's and the recent Mars Exploration Program missions, the hunt for water has led scientists to strongly believe that water once existed in liquid form, modifying the Martian landscape. Recently, the Opportunity Rover discovered evidence of a very high level of salts in the Meridiani Planum. The Gusev Crater, which is to the north of the Ma'adim Valles has long been proposed as an ancient lake bed. With Spirit on the ground, it is an opportune time to computationally model the circulation of the proposed lake in the hope that evidence can be found in support of its existence. Such analysis is more important now than it has been in the past due to the new direction of NASA to engage in a strong program of Mars discovery.

Publications in 2003

Classical Physics

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Limnology

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The Water Column

by Elise Ralph

During the past year, our presence in the water column has continued to expand with new areas of research and several graduate students. Currently, three faculty members, Mike Sydor, Brian May and I are conducting research within the water columns of lakes and oceans.

In February, Sydor attended the 2004 meeting of The Oceanography Society and the American Society of Limnology and Oceanography where he presented his recent work on determining unique signatures of the inherent optical properties of water with remote sensing. He has also been working with colleagues involved with LEO-15, an ocean-observing site off the coast of New Jersey. Sydor currently has two students working with him as part of the graduate program in Water Resources. Yuhu Yan is finishing his PhD thesis proposal. His thesis will use neural networks to explore the signal from SeaWifs data, with an application of determining water quality. Sheila Amenumey is finishing her MS from the department and is now also enrolled in the Water Resources PhD program; her work is described elsewhere in this issue.

Brian May is continuing his work on readying the Triaxus system for users of the R/V Blue Heron. The Triaxus is a platform equipped with a variety of sensors including an optical plankton counter, as well as instruments that measure conductivity, temperature, pressure, turbidity and fluorescence. The Triaxus will provide users with an excellent platform to create unique three-dimensional data of the water column and this should continue to foster interdisciplinary work on the lake. Two MS students are working with May. John Peterson has been working on the software that will collate the different data streams that come from the Triaxus system. In addition, he is interested in using a general circulation model, developed at MIT, to model the circulation of Lake Superior as well as lakes that may have existed on Mars. Peterson is looking for opportunities in other graduate programs where he can continue to develop his interest in Mars. Scott Haynes is also working with May on Lake Superior. His MS thesis will characterize internal waves of Lake Superior using data collected during the summer of 2002 and a numerical model for lakes and estuaries, developed by the University of Western Australia. He is interested in alternative energy sources and is considering how the spatial distribution of internal waves in Lake Superior may be used in a practical way.

In January, I returned from my stint at the National Science Foundation, under the IPA program. While there, I was a program director in the physical oceanography program, which funds all aspects of the physics of the ocean, from nonlinear wave-breaking to the ocean's role in the earth's climate. It was an excellent chance for me to participate in a variety of programs and to become reacquainted with current activities in physical oceanography. I'm pleased to be back home in the department and am working on developing some new numerical techniques for water circulation, as well as thinking about a proposal for another field project.

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Spring 2004 UMD Physics Newsletter Response Form

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- 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
Robert A. Hayes, BA '58
Judith A. Holmbeck, BA '68
Lloyd L. Horton, BA '51
James D. Johnson, BA '54
Michael R. Jones, BA '69
Kambiz Khosroshahroudi, BS '85
Nagi Keung Lee, BA '71
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