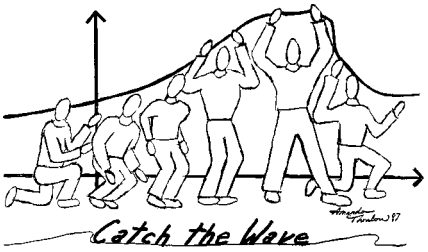

The Wave Packet

The UMD Physics Newsletter

Issue No. 5 ***Spring 2000*** ***http://www.d.umn.edu/physics/newslett/newslett.htm*** ***Editor: J.R. Hiller***

Brian May Arrives

Becomes Third LLO Faculty Member

The department of physics has gained another new faculty member. Brian May recently joined the department, arriving from Halifax, Nova Scotia. Though Brian was born in the United States (in Alaska), he grew up in Newfoundland, on the east coast of Canada. After high school, he attended a one-year program in outdoor education and language study in Norway. Then, he went to Queen's University in Kingston, Ontario, where he completed a B.Sc. in physics. He moved to Dalhousie University in Halifax, Nova Scotia to do graduate work in physical oceanography and successfully defended his Ph.D. thesis in 1999. Following in the footsteps of Elise Ralph and Meng Zhou, Brian holds a joint appointment at the Department of Physics and the Large Lakes Observatory.

Brian's research program focuses on the dynamics of mixing processes in lakes and oceans. His Ph.D. thesis work involved observation and theoretical modelling of intrusions at fronts in the ocean. Of particular interest were a series of intrusions (4 warm and salty layers, each roughly 50 meters thick) found to extend laterally into the interior of the Arctic Ocean. Using their distinct temperature and salinity properties, Brian tracked the layers over a distance of roughly 200 km. He compared the observed properties (primarily the slopes of intrusions) with those predicted by theoretical models of the intrusion process, in order to investigate possible formation mechanisms. The intrusions are thought to contribute significantly to the overall heat budget of the Arctic Ocean and are a topic of ongoing research.

While in graduate school, Brian had the opportunity to participate in a number of research cruises. He first got his feet wet on the Scotian Shelf, close to home. However, with a developing interest in Arctic oceanography, he ventured further afield on cruises through the Canadian Arctic Archipelago and the Beaufort Sea. These cruises gave him hands-on experience in using a variety of ocean instruments, including conductivity-temperature-depth profilers (which give information on the temperature and salinity structure of the ocean) and acoustic doppler current profilers (which give information on the currents in the water column). Memorable experiences include lowering CTD instruments from an ice flow in the middle of the Arctic Ocean, with inquisitive seals looking on!

At UMD, Brian continues to pursue a mix of theoretical and observational research in physical limnology and oceanography. He has ongoing interests in the dynamics of thermohaline intrusions and other mixing processes in the Arctic Ocean. He is also expanding his observational interests to lakes, such as Lake Superior. He is developing a program to measure small-scale turbulent mixing, using "micro-structure" instruments. These instruments measure temperature and velocity fluctuations in the water column at millimeter scales, thus giving valuable information on the smallest-scales of mixing activity. He anticipates using these instruments to study a variety of processes including wind-driven mixing in the upper water column, boundary mixing in the lower water column and mixing by breaking internal waves in the lake interior.

Since moving to Duluth, Brian has felt right at home. He is an avid cross-country skier and has been enjoying the abundance of ski trails nearby. In the summer months, he competes in a sport called orienteering, which involves running and navigating by map and compass. He enjoys a wide variety of outdoor activities including running, hiking, cycling, canoeing and kayaking. He is joined in Duluth by his wife Abbi and daughter Rachel.

Honors and Awards

The **Outstanding Graduate Teaching Assistant** for 1998-99 was **Andrew Wuchter**. He joined the graduate program after completing a BS in Physics at Luther College in Iowa. His MS is nearly complete, under the supervision of Professor Maps.

Shawn Putnam was awarded an **Olson Memorial Scholarship**, to carry out a research project with Professor Zhou during the summer of 1999. A description of the project is given in this issue of the newsletter, in the section on student research. Shawn is now a Junior physics major.

Inside this issue

Semesters become us

This year is UMD's first on the semester system. The academic year still starts just after Labor Day. (Don't want to miss the State Fair!) We finish the Fall semester just before Christmas, and start Spring in mid January. We're done by the middle of May.

The conversion process was long and at times difficult, but the hard work paid off in a smooth transition. The curricula for the majors were completely rewritten, with added emphasis on experimental work. The newest course, "Experimental Methods," has not been offered yet and is not fully developed. We are counting on our current search for an experimentalist to bring in someone with time to finish the job. The other ongoing consequence of semesters is a large fluctuation in enrollments for introductory level courses. This will ring through the system for a year or two.

Catch Up with Past Grads

Allen Anway, BA '63

I came from Cloquet, MN to study at UMD from 1959 to 1963, with majors in physics and math. From there I went to the University of Chicago (1963-1968) for MS and PhD degrees in physics. My physics professors at UMD were Dr. Hanson for the 1st and 4th years, Dr. Gergen for the 2nd and 3rd, and Professor Olson for laboratories. It was in my freshman year I first saw a teacher, Dr. Hanson, applauded by 125 students for a striking physics demonstration. After Dr. Gergen's electronics lecture, his notes so precise they could be transferred verbatim to the notebook, it was a race from the 4th floor to the 1st floor of the old Science building (now Chemistry) to get the 'good' Tektronix oscilloscope before anyone else could and start the lengthy lab. Mr. Olson suddenly moved his senior laboratories into the sophomore courses, giving us students a stunning display of what advanced physics was about. At that time I did not realize or appreciate what a good education I was getting.

One thing I did appreciate was that around my junior year at UMD I met Dorothy Comstock, originally a physics major, but switched to math. We married in July 1964 and have 3 daughters. Dorothy has taught math at most institutions of higher learning in the Twin Ports. Now she is working on her PhD. Yet another connection with UMD is that after I graduated, my mother got her education degree from UMD and worked as a teacher in the Cloquet School System until retirement.

Having seen the Chicago area and the Duluth area, I thought the Duluth area was the better, so I sought employment here. I ended up in 1969 at UW-Superior across the bay as assistant professor of physics, showing up for 5 separate periods of employment. Mingled in with such employment was industrial work both as employee and consultant. Finally when UW-S ended my employment the 5th time, I decided that I would go out on my own as a self-employed consultant and not look back.

Besides working at consulting, I was fortunate to get a superb partner for manufacturing, Don Dettmann, also a UMD graduate. (His father was a UMD professor of accounting.) We have markedly different talents, sales and physics, but similar values. Our partnership A2D2 Electronics has lasted more than 12 years, as we manufacture bin level sensors for industry. My basement houses our manufacturing equipment, but more and more we are farming this out to subcontractors. UMD physics, especially Don Olson, taught me some of my machining skills.

My eldest daughter, Carol, started at a small liberal arts college in Minnesota. Soon she switched her major to physics, not consulting me, but much to my delight. In her senior year she did badly on the physics GRE. Upon questioning her, I found her woefully unprepared in modern physics. Then I realized how well I had been prepared by UMD at my corresponding time, and was now enraged at her ill preparation. Then her advisors recommended that she select low-level graduate schools. Getting her to set her sights higher was tough, but I didn't want her to sell herself short. Finally she got in at UCLA and received her PhD in physics partly as one of the discoverers of the top quark. My family's physics legacy now spans three generations, starting with my father, H Wilbur Anway, a BS graduate of the University of Minnesota.

As I was trying to help Carol, a dean at the University of Chicago told me that the physics committee sought students from state schools and not from liberal arts schools, even though he encouraged them to consider liberal arts students. The committee felt that the state schools best prepared their students for physics.

Dorothy and I continue to work at our respective jobs without much thought of retirement. We enjoy the scenery in the area with a lot of walking in the woods. Miller-Dwan Hospital is permanently displaying 26 20x24 prints of my 5x7 Ektachromes of the local scenery.

Darrin Johnson, MS '90

After graduate school at UMD in the spring of 1991 I began teaching at a private high school here in Duluth called The Marshall School. With my only teaching experience coming as being a teaching assistant here at UMD, I found the going quite challenging.

I taught at Marshall for 7 years, teaching physics, physical science, and even some chemistry. Someone told me that teaching gets easier after your first year, but I found it just gets harder because you find there is more and more stuff out there you should be doing in your classroom. Eventually I built a physics program which included projects such as catapults and electric cars, a physics club, an annual science night where students did demonstrations and displayed their projects, a demonstration club made of seniors who did demonstrations for the grade school, and a few other things. I also became adequate at building things such as a bed of nails and a Jacob's ladder.

Eventually in 1995 I started to teach some introductory math courses in the evening at Lake Superior Community College. I can honestly say teaching math is nowhere near the fun of teaching physics. Regardless, in 1996 I married a math teacher (my wife Annette).

In 1997 I started teaching part time at UMD while still teaching at Marshall. I was very busy, and the year flew by.

Last year I taught here at UMD and at Lake Superior College. And this year I am happy to say I am working only here at UMD. I have been teaching the algebra-based sequence and the non-math based course "Ideas in Physics" along with some calculus based classes. I am very much enjoying my time at UMD because I feel I'm giving something back to the university for my education.

On a personal note my wife and I have bought a house which overlooks Lake Superior and are planning on starting a family. I spent last year doing a lot of running (over 2000 miles) and finished Grandma's marathon in my best time ever (2:52) and even accomplished finishing a 50 mile race in 95 to 100 degree heat.

A Sampling of Student Research Projects

Ajaya Ghimire , MS '00

The computation of the spectrum and physical properties of bound states in quantum field theories (QFT) has led particle physicists to try many computational techniques. To solve problems in QFT, while maintaining Lorentz invariance and other symmetries, is still considered to be a very challenging task and hence defies many of these techniques. Light-cone quantization (LCQ) is an alternate approach to the formulation of quantum field theories with a view to solve relativistic QFT problems more efficiently and elegantly. LCQ simplifies such problems to a greater extent for computational purposes. Therefore LCQ has been emerging as a promising method for solving relativistic bound-state problems in recent years.

My theoretical work on light-cone quantization is to solve the eigenvalue problem for a field-theoretic model constructed by S.J. Brodsky, J.R. Hiller, and G. McCartor [Phys. Rev. D **60**, 054506 (1999)]. This model has been extensively studied using a combination of discrete light-cone quantization (DLCQ) and Pauli-Villars regularization, and computation has been done using the Lanczos algorithm. The model has a fermion acting as a source and sink for bosons and is regulated by the addition of a Pauli-Villars boson field. The field-theoretic eigenvalue problem can be reduced to a coupled set of integral equations for wave functions that describe contributions from states with a fixed number of particles.

My project is to solve these coupled integral equations using a function expansion approach based on the finite element method. The wave functions depend on the number of physical and Pauli-Villars bosons and are functions of light-cone momenta. The wave functions are first expanded in eigenstates of the z component of angular momentum. This simplifies the equations because angular momentum is conserved. The coefficients in the expansion are functions of longitudinal and transverse momentum components, and these are expanded in a set of finite-element basis functions chosen to simplify as much as possible the integrals in the coupled equations. A study of the behavior of wave functions in the coupled integral equations suggests that a factor incorporating boundary conditions can be inserted in the basis function expansion.

The coupled equations are arranged in the form of matrix with a known eigenvalue (to be taken as -1/g, where g is the bare coupling). In my work, the total number of bosons (physical and Pauli-Villars) is limited to a maximum of 2. The range of transverse momentum squared is limited by imposing a cutoff value, to have a finite matrix. Even the range of individual angular momenta is also restricted to be finite. The result is a complex symmetric matrix computable on the PCs of the department's computational lab. The work is still in progress.

The results will be compared with those previously obtained and will be expected to be convergent with them. I aim at computing the Fock-sector wave functions describing the lowest-mass eigenstate of the light-cone Hamiltonian of the proposed model in (3+1) dimensions. Physical quantities such as the fermion form factor slope, structure functions for fermions, physical bosons, and Pauli-Villars bosons, the distribution amplitude for the physical boson, average momentum, average multiplicities are all interesting to compute for comparison.

Shawn Putnam, BS '01

Last summer I was awarded the Donald Olson Memorial Scholarship by the Physics Department to conduct a research project under the supervision of Dr. Meng Zhou titled: "The Spatial Variability of Temperature, Phytoplankton and Zooplankton Distribution in Lake Superior." The objectives were to design and construct a towed vehicle which will carry instruments measuring physical and biological variables simultaneously at resolutions of 1 m in the vertical and 1 km in the horizontal, and second to explore the relationship between the spatial variability of temperature, phytoplankton, and zooplankton distributions in Lake Superior.

During this time I learned that the feeding behavior of zooplankton is of great interest; however, due to the complexity of the physical and biological processes influencing such behavior and difficulties in observation, a common behavioral theory doesn't exist. For instance, within southeastern Lake Superior, integrated phytoplankton samples showed the concentration of phytoplankton to be at a minimum, while the abundance of zooplankton was relatively high. Given that zooplankton feed upon phytoplankton, the fact that both phytoplankton and zooplankton populations were not at maximums within the same region of Lake Superior leads to an interesting question: What kinds of physical and biological processes support such high zooplankton populations in southeastern Lake Superior? The traditional method for studying the physical and biological processes in Lake Superior is by net tows and CTD casts at stations. These stations are sometimes 10s of kilometers apart from one to another, which limits the resolution of measurements between them. This resolution between stations cannot resolve the spatial variability of temperature, phytoplankton, and zooplankton distributions. Therefore, measurements at higher resolutions are needed. Most importantly, the physical and biological information must be measured simultaneously for a better understanding of Lake Superior's environment.

The towed vehicle I constructed is designed to be a simple vehicle providing the mounting space and protection for mounted instruments during towing through the water. The towed vehicle, currently named Waterhog, can handle towing speeds between 0-6 knots, and has maintained a stable flight path between the surface and 200 meters during our tests. A hydraulic winch equipped with a steel-shielded conduction cable and a slip ring provides depth control via pay-in and -out. The conduction cable provides simultaneous communication between the instruments mounted on the Waterhog and the data-acquisition computers located in the dry lab on the R/V Blue Heron. The instruments mounted on the Waterhog consist of an OPC (Optical Plankton Counter), CTD, and fluorometer. The OPC provides real-time measurements of the number and size of plankton, which pass through a tunnel of fixed cross sectional area. The CTD measures temperature, conductivity, and depth. The fluorometer measures the concentration of fluorescence in the water column, which is proportional to the biomass of phytoplankton. CTD and fluorometer measurements are sent to the OPC through two jump cables. The OPC integrates data from all three instruments into one data string, and sends this information to a data acquisition computer in the dry lab at real-time through the conduction

cable. In our cruise, all three instruments, plus GPS information were integrated together via the OPC Software which records and displays the information twice every second in real time.

The Waterhog's versatility and efficiency are its strongest qualities. With the assistance of computer programs developed by Professor Zhou and Y. Zhu in the last few years, someone with little programming experience can use graphics software to analyze measurements within a few hours during the cruise. The Waterhog also has the capability of mounting additional instruments such as a tilt sensor, flow meter, transmissometer and other wanted equipment. The Waterhog's capability to operate continuously allows us to study spatial variability and distribution of physical and biological variables.

After construction and testing of the Waterhog, a cruise was conducted in the southeastern Lake Superior east of Marquette from July 15 to 20, 1999. The towed vehicle was deployed twice, making transects heading near shore which covered 70 km in the horizontal and 0-100 m in the vertical. The cruise's results suggested that an up tilting of the thermocline assists the transport of nutrient-rich deep water to the surface, which leads to high productivity of phytoplankton beneath the thermocline (between 30 and 40 m). The warm surface water and high phytoplankton concentrations below the thermocline provided favorable physical and biological conditions for zooplankton. The abundance of zooplankton reached 10^4 individuals / m^3 in the warm surface water, and $3x10^3$ individuals / m^3 between 20 and 40 m.

Xiaoyun Fei, MS '00

Currently I am working on a project, revising the 'PR' program which had been developed in the early 90's for work with photoreflectance. I am revising it in order to study the scattering of light from particles suspended in water. The program collects data from a lock-in amplifier which can make accurate measurements of small signals, even when the signals are obscured by noise which may be a thousand times larger. The program also drives a monochromator in either forward or backward directions. At run time, a real-time graph could be displayed on-screen. Raw data could be smoothed before being saved into a floppy disk for further analysis.

Many problems still remain unsolved. Whenever the power source goes out, we might easily lose a whole day's work since any information stored in RAM is not able to survive a power failure. Also we have to use another computer for doing further data analysis because the IBM-PC is a bit out-dated, with no hard drive. At the beginning of this semester, I attempted to run PR on a newer computer (an Intel 486); it seems that the old version does not work or work properly under the new circumstances. The signal transmission between the lock-in amplifier and the computer system is over a RS232 cable. Sometimes, I suppose, the computer runs so fast that its serial port needs more information than the lock-in can provide. The solution is to slow down the computer reading speed to match up with the lock-in sampling rate. By using a time function call, I set the data collecting interval to be near the 3 ms at which the lock-in operates. I still have difficulties handling those serial port signals. Maybe the function I used doesn't fit the old RS232 standard.

Besides data collecting, I have to rewrite the data analysis portion. I have kept the original user interface but am trying to enhance the capablity for error control. There is something wrong with the display format which I am trying to fix. Overall this project is a good practice for computer-aided scientific research. Although I have difficulties, I am still expecting it to be done this summer.

Alumni Visits

Several alumni have stopped by, including Kirby Stortz (MS '78), Don McLish (BS '68), Danny Dale (BS '93), and Brian Kohn (BS '68). Dr. Dale gave a seminar on "The Bulk Motion of the Local Universe." Several of us again met up with Allen Anway (BA '63) at the judging for the Northeastern MN Regional H.S. Science Fair.

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

Gift Funds

Gifts to the Physics Development Fund and the Donald Olson Memorial Scholarship Fund may be sent to the Development Office, 315 Darland Administration Building, UMD, 10 University Drive, Duluth, MN 55812. The University is currently engaged in its "Campaign Minnesota" to improve the financial base from which it serves the state. If you have questions or would like further information regarding a gift of any type to the Physics Department, including estate planning, please call our Development Officer, Steve Johnston at 218-726-6995.

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In Memory of...

Paul Town (BS '49), who passed away April 28, 1999 and Mathematics Professor Duane Anderson, March 8, 2000.

Spring 2000 UMD Physics Newsletter Response Form

Name:_____

Address:_____

Phone:_____

E-mail:_____

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Title:_____

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

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

Are you willing to serve as a career information resource for physics students?_____

(The current list is at http://www.d.umn.edu/physics/career/alum-res.htm.)

Would you like to be featured in the next newsletter?_____

Tell us about yourself:_____

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Send your reply by one of the following means:

- mail to Department of Physics, 371 MWAH, 10 University Drive, University of Minnesota Duluth, 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
Larry R. Frank, BS '77
Gary M. Grann, BA '63
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
Mary Kiiskinen, BS '68
Nagi Keung Lee, BA '71
John A. Miller, BA '59
Mohd I. Mohdyusof, BS '86
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Yaseen S. Murayed, BS '85
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