School of Mathematics, University of Minnesota

Newsletter Volume 12 Spring 2006

From the Department Head

My third year in this job is coming to a close, with two more to go! Like most academic types who find themselves in administrative positions, I have mixed feelings. The best part is that I get a "front-row seat" where I can watch all that is happening in a first-class mathematics department. This newsletter will give you some idea of what I am talking about.

Lawrence Gray

During the Fall Semester, we underwent an External Review. We have these every ten years or so, and they give us a chance to get some feedback from a review team made up of top mathematicians who visit our department for a few days. The team consisted of Mary Ellen Bock (Purdue), John Guckenheimer (Cornell), Jalal Shatah (Courant), and Gang Tian (MIT). They thoroughly looked into every aspect of our department, and interviewed dozens of people, including University administrators, lots of faculty from math and other departments, and many of our graduate and undergraduate students. They were also provided with a 2-volume self-study, prepared by the department for the review.

In the report of the review team, written at the end of the visit, the department was found to be strong and healthy (as expected). The re-

The Math Newsletter is published annually for the members, alumni and friends of the School of Mathematics.

port contained a number of suggestions, including a recommendation for changes in our PhD requirements (a proposal is currently under consideration) and comments related to hiring and outreach. These suggestions were the focus of our faculty retreat following the review. You can see some evidence of a stronger emphasis on outreach in this newsletter, and I also hope to form an "Executive Advisory Committee", consisting of representatives from outside our department (both academic and industrial), who will help us to strengthen our outreach efforts. In regards to hiring, we will be going through a substantial investigation of our hiring strategies over the next few months, with the object of creating a new hiring plan, to replace the previous one that has expired. I am grateful to the review team for their excellent work.

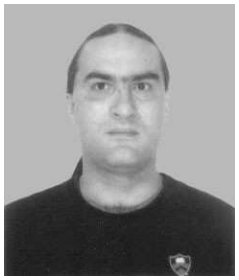
My own activities have included heavy involvement with the Minnesota Department of Education, in connection with standards and expectations for mathematics courses in the public high schools. In February, I was part of a team that represented Minnesota at the "American Diploma Project Alignment Institute". The object was to share resources with other states as we try to clearly articulate the expectations that should be attached to the high school diploma, particularly in math and English, in order to prepare students who graduate from high school for postsecondary education and for the workplace. I also continue to work on various panels whose task is to select items for the state public school math exams, and to determine "gradelines" for those exams.

These activities have constituted most of my own personal contribution to departmental outreach, although some of you may have seen me in one other small outreach effort when I appeared briefly on the 6:30 news, talking about a pseudo-mathematical formula that had been created by a psychology professor in Wales to determine which day of the year is the most depressing. Needless to say, I did not find much validity in the formula. Unfortunately, for the 10:00 o'clock version of the news, the story had become somewhat altered, and the presentation made it appear that I was the professor from Wales!

Lawrence Gray

Welcome to Incoming Faculty and New Postdoctoral Appointees

As we traditionally do each year in these pages, we extend our welcome to those faculty members and postdocs who joined the School in September 2005: Assistant Professors Adrian Diaconu and Marta Lewicka, as well as Dunham Jackson Assistant Professors Calin Chindris, Luan Thach Hoang, Scott Wilson and Alexander Yong. We are delighted to have these talented mathematicians join our faculty. We also welcome the new staff members Carla Claussen and Debra Ronningen.



Adrian Diaconu

Adrian Diaconu's research interests are Number Theory and Automorphic Forms. Before joining our department, he served as Ritt Assistant Professor at Columbia University (2000-2004), as well as an Assistant Professor at Lehman College (CUNY), and a Visiting Professor at Columbia, the following academic year (2004-2005). After earning his M.Sc. and Ph.D. degrees from Brown University in 1998 and 1999, he spend a year as a member of the Institute for Advanced Study in Princeton. He did his undergraduate work at the University of Bucharest, completing his B.A. degree in 1994. His awards include an NSF Grant and the Joukowsky Foundation Outstanding Dissertation Award.

Marta Lewicka

Marta Lewicka's research interests include Nonlinear Partial Differential Equations, Systems of Conservation Laws, Traveling Fronts in Reaction-Diffusion Equations and Topological Methods in Nonlinear Analysis. She comes to us from the University of Chicago where she served for three years (2002-2005) as L.E. Dickson Instructor in the Department of Mathematics, and a Research Associate in the Department of Astrophysics. She earned her Ph.D. in 2000 from Scuola Internazionale Superiore di Studi Avanzati (SISSA) in Trieste and spent the following two years as a Post-doctoral Fellow at Max Planck Institute for Mathematics in the Sciences, Leipzig, and an EU Post-doctoral Fellow again at SISSA. Her B.Sc. and M.Sc. degrees are from the Czestochowa Polytechnic (1996) and Gdansk University (1998). Her awards include an NSF Grant and a Special Teaching Award from the Department of Biology, University of Chicago, for designing and supervising an experimental course sequence on Mathematical Biology.

Calin Chindris' research interests are Representation Theory of Algebras, Quivers, Invariant Theory, Algebraic Geometry and Combinatorics. He earned his Ph.D. in 2005 from the University of Michigan, Ann Arbor. His B.A. (1998) and M.A. (1999) degrees are from Babes-Bolyai University, Cluj Napoca (Romania). Calin's many awards and fellowships include the 2005 Sumner Myers Award for best Ph.D. thesis, and the 2005 Wirt and Mary Cornwell Prize in Mathematics, both at the University of Michigan, Ann Arbor.

Luan Thach Hoang's research interests are Partial Differential Equations, Dynamical Systems and Fluid Mechanics. His Ph.D. (2005) is from Texas A&M University, and his M.A. (2000) from Arizona State University, Tempe. He also did graduate work at Indiana University (2000-2002). His B.A. degree (1997) is from the National University, Ho Chi Minh City where he also began his graduate study. Luan's many awards and fellowships include the Departmental Graduate Fellowship (2002-2005) and the 2002 AUF Fellowship, both at Texas A&M University, as well as the 2001 Eberhard E. Hopf Fellowship and 2001 James P. Williams Memorial Award at Indiana University.

Scott Wilson's research interests are Algebraic Topology, Discrete Geometry and Mathematical Physics. His Ph.D. (2005) is from Stony Brook University. Scott's awards include VIGRE Graduate Fellowship (2000-2003), and 2004 Nathans/Simons Fellowship Award for Outstanding Research.

Alexander Yong's research interests include Algebra, Algebraic Geometry, Combinatorics and Computational Mathematics. He earned his Ph.D. in 2003 from the University of Michigan at Ann Arbor. During 2003-2005 he served as a Visiting Assistant Professor at the University of California, Berkeley, and also spent part of this period at the Department of Statistics and the Fields Institute, University of Toronto. His Bachelor's (1998) and Master's (1999) degrees are from the University of Waterloo. Alexander's many honors and awards include NSERC Postdoctoral fellowship (held at the Dept. of Statistics, and the Fields Institute, U. of Toronto) (2005); Rackham Dissertation Fellowship (2002); NSERC Scholarship for graduate studies (1998-1999); and K.D. Fryer Gold Medal, University of Waterloo (1998).

Promotions

Professor Jiaping Wang was promoted to the rank of Full Professor effective September 2005. Jiaping's research area is differential geometry.

Awards and Recognitions

Dennis Hejhal Awarded the Garding Prize

Professor Dennis Hejhal was awarded the Eva and Lars Garding Prize of the Royal Physiographic Society. The award ceremony took place in Lund, Sweden, Dec. 2, 2005. The prize is accompanied by a monetary award of 150,000 SEK (about 19,000 dollars). Hejhal was awarded the prize in recognition of his paper, "On a result of Selberg concerning zeros of linear combinations of

L-functions", published in the year 2000, and for his numerical work on the eigenfunctions of the Laplacian, seeking to better understand the connections with the Riemann Hypothesis. Garding, who attended the presentation, is a very prominent Swedish mathematician now in his eighties. Dennis says that he thanked Garding for this honor "paa svenska". We congratulate Dennis on this great honor.

Dennis Hejhal (far left) receives the Garding Prize

The 2006 Andre-Aisenstadt Prize Awarded to Tai-Peng Tsai

Tsai, who received his Ph.D. in mathematics here in 1998, was awarded the prize for his work in nonlinear partial differential equations, especially the Navier-Stokes equations. Tsai's thesis advisor was Professor Vladimir Sverak. Tai-Peng Tsai's current position is at the University of British Columbia. The url for the Andre-Aisenstadt Prize web site is: `http://www.crm.umontreal.ca/prix/prix_Aisenstadt_fr.shtml`

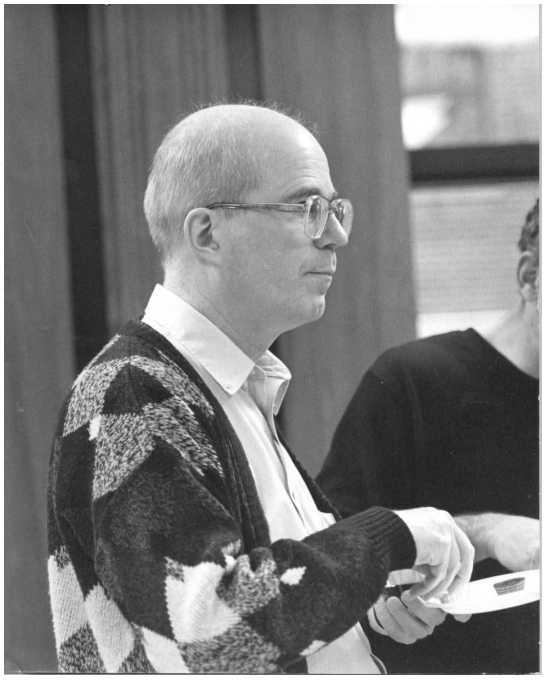
Featured Colleagues

Andrew Odlyzko

In 2001, Andrew Odlyzko, a renowned mathematician and computer scientist, became the Director of the Digital Technology Center, Assistant Vice President for Research at the University of Minnesota, ADC Telecommunications Chair Professor and Professor of Mathematics. Andrew's research areas include number theory, combinatorics, probability theory, coding theory and cryptography, as well as data storage, data mining, internet commerce, and much more. An unusually articulate and friendly person, Andrew met for two hours with members of the newsletter committee to help us prepare this article.

Andrew was born in Poland and emigrated with his family to the United States as a boy. He did his undergraduate studies at the California Institute of Technology (Caltech). At first, his interests were divided among biochemistry, physics and mathematics. It is noteworthy that Andrew's first publication was actually in biochemistry. In time, however, he became more attracted to mathematics, finding pure thought more inspiring than working in the lab.

One of the great benefits available to the best students at Caltech was the possibility of summer work at the Jet Propulsion Laboratory. The math group there was assembled from very talented people, some of whom did not function well in a traditional academic setting, but who often were brilliant at addressing specific problems. Included in the group was Eugene Rodemich, who was briefly at the University of Minnesota in the early 1960s.



Andrew Odlyzko

The students in the math group at the Jet Propulsion Lab were able to get first hand experience in techniques on the edge of mathematics and computer science, such as linear programming. In Andrew's case, this work later proved useful in his Ph.D. thesis work in number theory, and his work at the Jet Propulsion Lab influenced his choices in graduate school and beyond.

After finishing at Caltech, Andrew decided to do his graduate study at MIT. He was originally attracted to combinatorics and the group assembled there by the late Professor Gian-Carlo Rota. In a thoroughly charming incident, Rota offered the students a bounty of one dollar for each mistake they found in a manuscript that he was finishing rapidly to meet a deadline. In a few days Andrew reported to Rota that he had found sixty mistakes. Rota paid him (a tidy sum for those days) and, more important, invited Andrew to join him as co-author of the paper.

In time, after studies that included a class from Professor William Messing of the University of Minnesota (who was then teaching at MIT), Andrew became more attracted to number theory and did a thesis on bounds for discriminants of number fields under the direction of Professor Harold Stark. As mentioned earlier, Andrew was able to adapt some of the techniques of linear programming to achieve his results. He went on to become one of the world's leading researchers in number theory. In 1986 he was an invited speaker at the International Congress of Mathematicians at Berkeley, one of his many major honors.

For more than two decades, Andrew has been the foremost expert on numerical calculation of the zeros of the Riemann zeta function. The celebrated Riemann Hypothesis, which asserts that all the so-called nontrivial zeros of the zeta function are found on the straight line consisting of complex numbers with real part one-half, is a fundamental issue in number theory. Most experts agree that this hypothesis will eventually be proven, but the problem has been extremely challenging. In 1897, F. Mertens formulated a conjecture that, if correct, would have implied the Riemann hypothesis. However, in a remarkable achievement, Andrew and his collaborator H.J.J. te Riele proved (1983) that the Mertens conjecture is false. This work required both theoretical analysis and computational investigations. In other computational work Andrew has provided some of the most penetrating experimental evidence to date that the Riemann hypothesis itself is true. This research is continuing.

Andrew did much of his research while at the Bell Laboratories in Murray Hill, New Jersey. Bell Labs was set up in the 1920s to do research that could benefit the communications industry. It was owned, in a complex relationship, by AT&T and Western Electric. When Andrew went to Bell Labs in 1975, it had a mathematical sciences research center with 70-80 Ph.D.s. Andrew joined the department in this center led by the famous mathematician Ron Graham. While Andrew expected to stay there for two or three years, the appointment worked so well that he remained for twenty-six! He eventually became head of a department. Under the pressure of emerging technology and government policy, Bell Labs went through a series of breakups that led, to our great good fortune, to having Andrew here at Minnesota.

We have already mentioned the wide range of areas of mathematics to which Andrew has made important contributions. When we asked him about applications of his work that would be useful to the telecommunications industry, Andrew cited his work on cryptography. In addition there is, for example, his well-known work on random polynomials, which has application to filter design. Andrew resisted the committee's efforts to coax him to make predictions on the future of the Riemann hypothesis.

Not content with working on mathematics, Andrew has also pursued a continuing interest in economics. A current project is his study (and prospective book) analyzing the great British railway mania of the mid-nineteenth century and comparing it with the recent internet bubble of the late 1990s. In constant dollars the British railway mania involved much larger investments than the internet bubble. And, although it produced few bankruptcies, the losses were enormous.

Given the nature of the printed and handwritten material about the railway mania, this project has led Andrew to do extensive library research around the world. Since his source materials are neither digitized nor easy to scan, Andrew has taken to making digital photographs of documents - when permitted by the appropriate authorities - and he will have to sort through these tens of thousands of digital photos to search for

key material.

As the Director of the DTC (Digital Technology Center) at the University of Minnesota, Andrew coordinates wide-ranging interdisciplinary research, encompassing such areas as bioinformatics and computational biology, graphics and visualization, information storage, networking, cryptography and data mining. In addition to his own research projects, especially those on the zeros of the zeta function, he mentors postdocs and currently supervises a doctoral student (working on the complexity of calculations related to the Riemann zeta function). He has three patents, serves on the editorial boards of over 20 technical journals, and is an organizer and principal speaker at conferences worldwide. His work is widely cited in the popular press and electronic media. He is an enormously inspiring example of a scientist who bridges the often wide gaps between pure and applied research, academia, industry and commerce. We are very fortunate indeed to have Andrew on our faculty.

(The newsletter committee thanks Andrew Odlyzko for making this article possible.)

Ofer Zeitouni

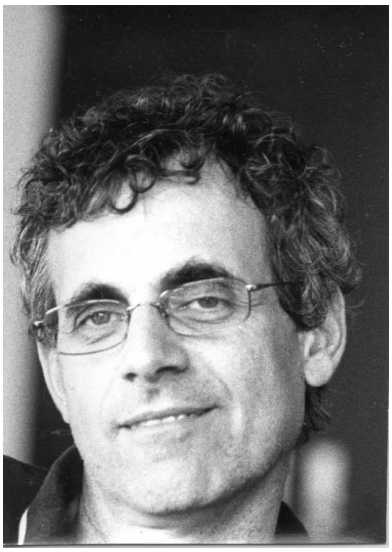
Professor Ofer Zeitouni is a world leader in probability theory and its applications. He has made important contributions to the theory of large deviations, random walks, random matrices, and filtering and statistical detection. He joined the School of Mathematics in 2002. Members of the newsletter committee were fortunate enough to have a very enjoyable conversation with Ofer, which covered many topics while discussing his life and his mathematical work.

Ofer was born in Israel, but his father studied civil engineering in France, and the family lived there until 1968. They returned to Israel in May of that year, having had an opportunity to witness the civil unrest in France during that Spring. Ofer describes himself, in his youth, as a "tinkerer", who gradually moved deeper into mathematics.

Ofer received all his university training in Electrical Engineering, at the Technion in Haifa, Israel. The education system in Israel had been modeled on a German format, and we were interested to learn that in the early twentieth century students went on strike in order to force teaching in Hebrew and not in German as the professors wanted.

The Master's degree in Israel is much more oriented towards research than it is here. While Ofer performed his five years of military service, working as an engineer, he was able at the same time to complete a Master's degree and some research papers.

Ofer's doctorate in Electrical Engineering was under the direction of Professor Moshe Zakai. Like Ofer, Zakai had moved from engineering toward pure mathematics, and he was working at that time in the Malliavan calculus, stochastic differential equations and filtering theory. Ofer refers to Zakai as "an extremely inspiring person".



Ofer Zeitouni

Another inspiration was Amir Dembo, who was a friend of Ofer from high school. Their paths "intersected" many times. They both came to America at the same time and they continued to work together. Coming to the U.S.A., Ofer spent a year at Brown and then went to MIT. He was fortunate to meet Dan Stroock, who was working on a book on the theory of large deviations, an area in which Ofer has a considerable reputation. Stroock had spent a year in Minnesota, where he worked with Gene Fabes and Nestor Rivière, and was later the featured speaker at the Rivière symposium (now the Rivière-Fabes symposium).

After his time at MIT, Ofer returned to Israel to accept a position in Electrical Engineering. Realizing that there was actually no good place, for someone with his background, to learn about large deviations, he decided to write a book, with Amir

Dembo, on this subject. This text is very well known, although Ofer merely describes it as "useful". As a faculty member in Electrical Engineering, his interests also expanded to mathematical biology and statistical mechanics.

A sabbatical at Berkeley brought him to the field of random matrices and related problems in filtering. Ofer is particularly good at describing how these problems affect our everyday lives, for example in identification of signals from different cell phones which simultaneously access the same base station. Ofer states clearly that he often looks at practical sources for interesting problems. But he does not categorize himself as an applied mathematician since he does not typically follow a problem "all the way" to its final point of application. (We asked him if he had ever received a patent; his answer was that he had never applied.) Ofer's wide-ranging work in probability and related areas provides a good illustration of the symbiosis between applied and pure problems in mathematics.

One of Ofer's recent papers was reviewed in Nature by Ian Stewart under the title "Where do drunkards hang out?". The paper in question (with Dembo, Peres and Rosen) proved a conjecture of Erdős and Taylor that had been open since 1960. The problem was to establish a difficult limit law for the behavior of random walk and its continuous analog, Brownian motion. One tool in the proof was a profound analysis of the fractal geometry of Brownian motion.

Among other honors, Ofer received the Bergmann Memorial Research Award in 1991, and shared the 2003 prize from the Henri Poincare Institute for one of his papers. He was an invited speaker at the International Congress of Mathematicians in Beijing, 2002.

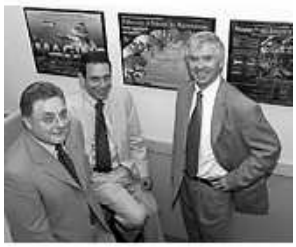
Our interview ended with a moment chatting about the state of mathematics in Israel. While there is some hostility towards higher education at the moment and a disturbing trend towards emigration by scholars, Ofer stresses that there is a great pool of talent and he expresses the hope that these current tendencies may prove to be temporary.

(The newsletter committee thanks Ofer Zeitouni for making this article possible.)

IMA Related News

The National Science Foundation has renewed the IMA funding for another five-year period, 2005-2010. The $19.5 million renewal grant is the largest single research investment in mathematics ever made by the NSF and is a major vote of confidence in the direction that the IMA has been pursuing under the leadership of its director Professor Doug Arnold. The NSF's math director William Rundell made the announcement during a ceremony at the IMA on July 20, 2005.

The IMA's innovative interdisciplinary programs bring together mathematicians, scientists and engineers to collaborate on important scientific and technological problems. In his speech Dr. Rundell indicated that he considers these programs an essential component of the NSF portfolio. The reader can gauge the breadth and impact of these programs by visiting the IMA web pages (`http://www.ima.umn.edu/`) and following the links there, including ones to articles in the popular press and other presentations in the media.



The IMA renewal: Doug Arnold with Dean Crouch and Director William Rundell

An equally important part of the IMA's mission, effected through the IMA's postdoctoral program, is strengthening the talent base of mathematical researchers who are able to engage in interdisciplinary collaborations. In an interview with the UMNnews Professor Arnold said: "If you look at the alumni of the postdoc program, you find many, many leaders in all sorts of areas of mathematics who carry with them an emphasis on interdisciplinary work. They're at excellent universities throughout the country, great colleges, successful companies... it's a very, very impressive list. I think when the NSF looked at that list, it said, 'Wow, this place is a great investment'."

The IMA was founded in 1981, with IT Distinguished Professor Hans Weinberger as the IMA's first director, who established the "Thematic Year" annual program pattern as an amazingly successful way for cooperation between mathematicians and scientists. This pattern has certainly stood the test of time - how many scientific enterprises can boast a 25-year period of unqualified success?

The current Annual Program is the **IMA Thematic Year on Imaging** (September 2005 - June 2006). The three following projected future "Thematic Years" are to be on "Applications of Algebraic Geometry" (September 2006 - June 2007), on "Molecular and Cellular Biology" (September 2007 - June 2008), and on "Mathematics and Chemistry" (September 2008 - June 2009).

Imaging (September 2005 - June 2006)

As usual several faculty members of the School of Mathematics participate intensively in this program. They include, in addition to the IMA's director Doug Arnold, also professors Don Aronson, Peter Olver, Fadil Santosa, Arnd Scheel, Vladimir Sverak, and Ofer Zeitouni. These faculty also participate in mentoring the postdocs. Don Aronson (Professor Emeritus) serves as the Director of the IMA's Postdoctoral Program.

From the IMA web site `http://www.ima.umn.edu/2005-2006/`
"Imaging science is highly interdisciplinary, naturally connecting mathematical sciences with a variety of application areas. Mathematical areas that have contributed to this field include harmonic analysis, partial differential equations, integral geometry, calculus of variations, probability theory, statistics, and learning theory. Historically, interchange of ideas among researchers coming from different applications has been impeded by barriers of jargon and culture. By bringing together a range of researchers and emphasizing the underlying mathematical structures and algorithms in the highly interdisciplinary atmosphere of the IMA, this program is a great opportunity to significantly contribute to advances in imaging science." "For example, the analysis of 'shape' has driven research in differential geometry, stochastic diffusions and nonlinear partial differential equations."

The "New Directions" **Short Course on Quantum Computation**, August 15-26, 2005, was also a noteworthy event. The principal speakers were Alexei Kitaev (Caltech) and Peter W. Shor (MIT), both of them world leaders in the area of quantum computing and quantum information theory.

This subject, of considerable mathematical beauty and physical interest, is currently at the stage of basic research, but it might lead to a phenomenal advance in computing. The likelihood of such progress is hard to assess, but before we dismiss such ideas out of hand, we might consider how unlikely the concept of nuclear power would seem in the days before FDR funded the Manhattan project.

The great physicist Richard Feynman was an early proponent of quantum computing, and John von Neumann, one of the fathers of modern computing, is also one of the founders of quantum information theory. The notion of quantum entropy, as well as the fundamental results about it, are due to him.

It is only rather recently that scientists began to realize that such arcane phenomena as the Einstein-Podolsky-Rosen "paradox" (not a paradox any more) might really have practical applications (in quantum cryptography already). Quantum computers offer the possibility of performing enormous numbers of calculations simultaneously on the same machine, far exceeding the capabilities of conventional computers. Those of us privileged to attend these lectures were able to sample the extremely ingenious algorithms which may someday make quantum computers a reality.

More information about the Quantum Computing Course can be found at the IMA web site `http://www.ima.umn.edu/2004-2005/ND8.15-26.05/talk-materials/`

Looking ahead to the upcoming summer program, the Summer 2006 New Directions Short Course (June 19-30, 2006) will present **Biophysical Fluid Dynamics**. This course is described on the IMA web site at `http://www.ima.umn.edu/2005-2006/ND6.19-30.06/`
It will be "an intensive short course designed to efficiently provide researchers in the mathematical sciences and related disciplines the basic knowledge prerequisite to undertake research in fluid dynamics relevant to the biological realm. The course will be taught by Michael J. Shelley, Professor of Mathematics at the Courant Institute,

NYU, and Raymond E. Goldstein, Professor of Physics and Applied Mathematics, at the University of Arizona."

IMA Public Lectures

(`http://www.ima.umn.edu/public-lecture/`)
We received reports about two very interesting talks that were given in Spring 2005, too late for coverage in the previous newsletter. We present them here.

On February 9, 2005, Dr. David Baraff of Pixar Animation Studios gave an exciting lecture entitled "Math Behind the Curtains: Dynamic Simulation at Pixar Animation Studios". He illustrated recent advances in digital film-making by discussing the uses of the mathematical technique called dynamic simulation in producing the film "The Incredibles".

We recall that in May 1998, the department sponsored a lecture by Pixar's Dr. Tony DeRose entitled "How Geometry is Changing Hollywood". This was at the time when Pixar's "Toy Story" and "Geri's Game" were still making the headlines and "A Bug's Life" was under production. It is gratifying to see that mathematics is continuing to play a central role in the development of this technology.

On March 30, 2005, Thomas C. Hales of Pittsburgh University gave a talk entitled "On Computers and the Future of Mathematical Proof". Professor Hales is a renowned researcher who proved the "Kepler Conjecture" (dating back to 1611) about the tightest arrangement for packing spheres. His solution is long and highly nontrivial, and although mathematicians accept this proof it has never been completely checked. With that background, Professor Hales gave a bracing account of his own experiences checking mathematical proofs in many areas, and the gaps he discovered. Although this may sound like a depressing exercise in humility, mathematicians do seem to be able to make their way to the truth, despite missteps on the road!

In the latter part of his talk, Professor Hales then discussed the currently active field of computerized proof-checking, which combines programming with formal logic, and which should extend the capabilities of all mathematicians in time. Professor Hales has started the "Flyspeck Project" (`http://www.math.pitt.edu/~thales/flyspeck/index.html`), with the particular goal of producing a formal proof of the Kepler Conjecture.

The 2005 - 2006 IMA Public Lectures included:

"Does Math Matter to Brain Matter?" (December 8, 2005), by Philip Holmes (Princeton University);

"Artful Mathematics" (February 8, 2006), by Daniel Rockmore (Dartmouth College);

"Gravity's Cosmic Shadows: A Mathematical Unveiling" (March 22, 2006), by Arlie O. Petters (Duke University); and

"Mathematics and Magic Tricks" (April 19, 2006), by Persi Diaconis (Stanford University)

Abstracts of these lectures can be found at the IMA web site `http://www.ima.umn.edu/public-lecture/`

$2.3 Million DOE Project Funded for Quasicontinuum Multiscale Methods

Professor Mitchell Luskin is the project principal investigator of a $2.3 million DOE project to develop a multiscale method based on hydrid ab initio and quasicontinuum methods. The University of Minnesota is the lead organization, and the University of California, San Diego, and the Pacific Northwest National Laboratory are collaborating organizations. Other University of Minnesota participants are Richard James and Ellad Tadmor of the Department of Aerospace Engineering and Mechanics.

The project goal is to develop hydrid ab initio and quasicontinuum methods on a rigorous mathematical, physical, and chemical foundation. Rather than being based on classical interatomic potentials, this method will utilize quantum mechanics-based potentials capable of realistically describing the complex chemical bonding required to meet the design needs of advanced materials. Longer time scales will be achieved by a new accelerated ab initio molecular dynamics algorithm.

A mathematical analysis of the quasicontinuum method rigorously validating the method and ensuring its accuracy is being developed. This will provide error indicators to be used with modern adaptive mesh techniques and state-of-the-art multilevel solution methods to yield the most efficient and reliable numerical solutions. New parallelization techniques and software tools capable of working with adaptive grids and multiphysics computational methods are being developed for advanced computer platforms to simulate realistic materials.

Curriculum development and graduate student training in multiscale mathematics at the University of Minnesota is being expanded. A yearly workshop is being planned for project participants as well as representative researchers from the multiscale mathematics community to exchange ideas and discuss methods in multiscale mathematical research.

Retirements and Resignations

Steve Agard

Stephen Agard earned his Ph.D. from the University of Michigan in 1965. The pioneering work in his thesis, under the direction of the distinguished complex analyst Fred Gehring, showed that quasiconformal mappings could be defined using only preservation of angular measure up to a uniformly bounded factor.

Steve joined the faculty of the School of Mathematics in 1967 after spending two years at Stanford University as an Instructor. At the University of Minnesota, Steve has produced his most famous work, a penetrating study that extended Mostow's rigidity theorem to a larger class of groups, while he continued to make important contributions in the area of quasiconformal mappings.

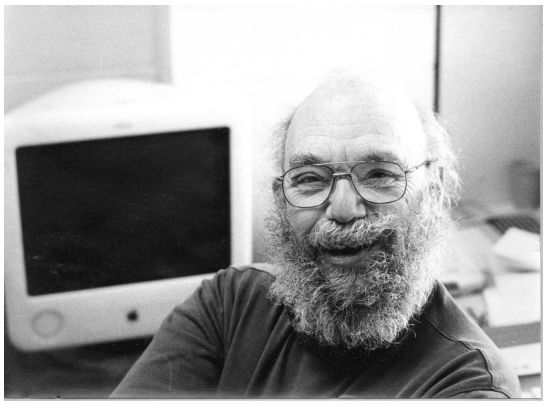
Steve has made many major contributions to the functioning of the department, serving as Director of Undergraduate Studies from 1991 to 1995 and coordinating the actuarial science program for 19 years, since 1987. Roughly 400 students in the actuarial program have graduated since Steve took over.

Since the undergraduate senior projects were instituted several years ago Steve has been in great demand by the students as project mentor and he has responded enthusiastically, guiding about 5 students each academic year.

A personal note of interest: In the 1950s, Steve and colleague Wayne Richter were on the same intercollegiate baseball team at Swarthmore College, Steve's undergraduate institution.

We wish Steve the best in his retirement, which we suspect will be very active.

Hillel Gershenson



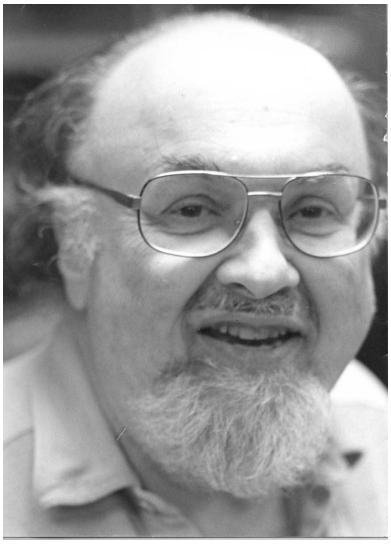
Hillel Gershenson joined the faculty of the School of Mathematics at the University of Minnesota in 1967, coming from Cornell University. He wrote his thesis in algebraic topology at the University of Chicago under the late Eldon Dyer.

Before going to Cornell, he was an instructor at Princeton University. His contributions include an analysis of the relationship between different methods for computing homotopy groups and a

beautiful generalization of the Toda bracket, a secondary operation in homotopy groups.

Hillel has served the School in many ways. He has been the Director of Graduate Studies as well as the Director of Undergraduate Studies. In a broader university framework, Hillel served two terms on the important Senate Judiciary Committee. A wise, patient colleague, he will be missed.

Jay Goldman



Jay Goldman joined the faculty of the School of Mathematics in 1970. He had been a student of the distinguished probabilist William Feller at Princeton, and spent 5 years on the faculty of Harvard University.

During his years in Cambridge, Mass., Jay became very active in combinatorics. This was the period when the late Gian-Carlo Rota ran an inspiring seminar at MIT, a seminar which is credited with the emergence of algebraic combinatorics as an exciting new field in mathematics. This led to a fruitful collaboration between Jay and Rota. A noteworthy example is the widely read and appreciated "On the foundations of combinatorial theory IV", which appeared in Studies in Applied Mathematics, 1970.

Jay is a mathematician of broad interests, including knot theory, the theory of numbers, and the history of mathematics. He has served as the adviser for two doctoral students, and also inspired our colleague Jim Joichi (now retired) to change his research interests to combinatorics.

When Jay came to Minnesota, there was no other person on the faculty in combinatorics. Jay played an active role in getting Dennis White here. This beginning led to an impressive group, including Dennis Stanton, Paul Edelman, Vic Reiner, and Ezra Miller. Jay also played a role in the start of our famous program UMTYMP, which now forms part of a broader outreach program ITCEP, under the leadership of Harvey Keynes.

Jay is an avid reader, an active photographer, a lively trader in photographic equipment, and a devoted bibliophile. We wish him the best of luck in retirement.

Conan Leung

Conan Leung, distinguished differential geometer and Professor of Mathematics at the University of Minnesota, resigned in May 2005, in order to take a position at the Chinese University of Hong Kong and the Institute of Mathematical Sciences there. Conan received his Ph.D. in 1993 from MIT, where his thesis was directed jointly by I. Singer and S.-T. Yau. He joined our department in 1994. Conan was very active in bringing distinguished differential geometers, geometric analysts and mathematical physicists to Minnesota. He has played an important role in the Yamabe Symposium, which occurs every second year (the next one being on symplectic geometry in Sept. 2006), as well as in the building up of the present group here. He was a very accessible and interactive colleague. He will be greatly missed.

A Tribute from the DUGS

Above there are official summaries of the contributions made to the department by three retiring faculty members, Jay Goldman, Hillel Gershenson, and Steve Agard.

Here I would like to make some personal comments about how these people have helped me run the undergraduate program. Indeed, without the assistance of these three individuals, my job would have been immeasurably more difficult and our undergraduate program would have been measurably weaker.

Jay Goldman has been for many years the advisor to our honors undergraduates. In that capacity he has successfully guided many talented students through their undergraduate years. Jay

seems to have a knack (perhaps "gift" is the better word) for finding exactly the right courses for each of these students to take. Jay has also coordinated our scholarship activities. At our committee meetings to award scholarships, Jay seems to know every honors student personally, including knowing which ones have special circumstances that might merit special consideration.

Hillel Gershenson has worked with me both as an undergraduate advisor and as Assistant Director of Undergraduate Studies. His attitude can best be described by the following story. When I asked him this winter, during the heavy advising period leading up to the beginning of registration, if he had too many students to handle, he said "It doesn't matter. I enjoy doing it." When I arrived in Minnesota 31 years ago with a 24-foot U-Haul truck full of stuff, Hillel was one of the people who helped me unload my belongings. And through all the years he always has laughed at my jokes.

Steve Agard has been the advisor for our actuarial students, has coordinated the actuarial program, and has taught our actuarial science courses. During his tenure in this position, the actuarial program has become one of the most vibrant parts of our undergraduate major, attracting to mathematics many students who might not have thought of math as a possible major, and providing excellent employment prospects for these students. Steve's specialized knowledge in this area will be hard to replace.

To these valued friends and colleagues, I say "Ave et Vale", or as Mr. Spock would say, "Live long and prosper."
David Frank
Director of Undergraduate Studies

Remembering a Minnesota graduate

Professor Janet Andersen, a 1992 graduate of our Ph.D. program, died in an automobile accident on November 24, 2005. She is survived by her husband of 29 years and their three children.

In her thesis, Janet used computers to produce a counterexample in commutative algebra. She exhibited strong mathematical insight, and considerable ingenuity in using the available computer resources. Her advisor was Prof. Joel Roberts.

After earning her doctorate, Janet joined the Mathematics Department of Hope College in Holland, MI, where she held the rank of Professor at the time of her death. She served as department chair from 2000 to 2004.

Professor Andersen was very active in projects to improve the quality of undergraduate mathematics education, participating in many workshops and conferences. She received National Science Foundation grants for undergraduate curriculum development, and was co-author of three textbooks. Most recently, she had been developing a sophomore level mathematical biology course.

She also has chaired the Mathematical Association of America committee on the teaching of undergraduate mathematics, and served as director of the Pew Midstates Science and Mathematics Consortium, a collaboration of 11 liberal arts colleges and two research universities.

Professor Andersen was a valued member of the mathematics community who was dedicated to excellence in undergraduate mathematics education. Her passing is a great loss to all of us, her colleagues, students, and family.

A "Mathematics Department Scholarship Fund in memory of Janet Andersen" has been established at Hope College.

Academic Visitors

Distinguished Ordway Visitors (2005-2006)

The Distinguished Ordway Visitors Program brings outstanding mathematicians to Minneapolis for prolonged periods, significantly enhancing the creative environment of the School. The visitors typically give several lectures, including a colloquium lecture and several seminars, and the exchanges of ideas with our faculty and students often result in research collaborations.

This year's Ordway visitors were the following.

Henri Berestycki, Centre d'Analyse et Mathematiques Sociales, EHESS, Paris (partial differential equations, calculus of variations, mathematical modeling), March 26 - April 7, 2006;

Bennett Chow, UC at San Diego (differential geometry), Sept. 4-30, 2005;

Craig Huneke, University of Kansas, Lawrence (commutative algebra, algebraic geometry), March 27 - April 7, 2006;

Stefan Hildebrandt, University of Bonn (partial differential equations, calculus of variations), March 27 - April 23, 2006;

Francois Loeser, Ecole Normale Superieure, Paris (algebraic geometry), Feb. 15 - March 15, 2006;

David Vogan, MIT (representation theory), Oct. 2-8, 2005.

David Vogan's visit

To give a more detailed description of what one of our distinguished Ordway visitors does, Professor Paul Garrett has kindly given us the following note about Professor Vogan's visit.

Prof. David Vogan's one-week Ordway visit afforded interested faculty the opportunity to talk to Prof. Vogan about his current thinking on representation theory, its applications, and its underpinnings. His expository lectures encouraged students and non-specialists to look seriously at several standard, but daunting, technical ideas, by using these ideas to describe some aspects of Langlands' celebrated program[1].

One popular entry to Langlands' conjectures is Legendre-Gauss Quadratic Reciprocity, leading to Artin and Takagi's classfield theory. Rather than describe either of these in detail, one might note that there was a significant shift in viewpoint over the 120 years from Gauss' work to Artin and Takagi. Indeed, Legendre's viewpoint on Quadratic Reciprocity (though he did not manage to prove the result) proved surprisingly compatible with classfield theory, in which reciprocity laws per se are construed as corollaries of structural results.

Similarly, Langlands' conjectures are not overt reciprocity laws, but structural claims which would have (complicated) concrete reciprocity-like assertions as corollaries. A little more specifically, one might say that Langlands' conjectures were (in part) a synthesis of the Artin-Takagi classfield theory and Harish-Chandra's (and Gelfand's) representation theory of reductive Lie groups, itself a descendant of the representation theory of Wigner and Bargmann in the context of quantum mechanics.

In Langlands' early work classifying representations of reductive real Lie groups, a basic notion was that of parametrization of representations by more elementary (but non-trivial) objects that can be seen as distant descendants of the highest weights in the classical theory. With 40 years' hindsight it is easy to see that this parametrization also has much in common with the Artin-Tate reformulation of classfield theory. Further, the nascent spectral theory of automorphic forms, developed in part by Langlands at the same time, stimulated by earlier ideas of Selberg and Gelfand, spun out Euler products containing data related to both classfield theory and the parametrization of representations. Langlands' accomplishment was to manage a view sufficiently broad so as to make (conjectural) sense of these coincidences.

To give substance and precision (and proof) to Langlands' program is of course a different matter than its conception, despite the profound insights and technical virtuosity necessary to formulate the conjectures even in primitive forms.

One essential aspect of the development of the program has been the choice of descriptive apparatus (parametrization) for the various players involved, for example, algebraic groups. The notion of root datum, emphasized by Prof. Vogan in his lectures, is a beautifully refined version of the root system notion used already by Lie, Killing, and E. Cartan before 1900. This notion is essential to any coherent formulation of Langlands' conjectures, but in its most formal incarnation may appear to the novice not seriously related to the main program. Prof. Vogan took some care to show the genesis of this idea, and its role in various conjectures.

Kirillov's (heuristic) orbit method, another (conjectural) parametrization idea for classes of representations, has provided ideas that have helped to polish some technical details in the Langlands program. Prof. Vogan himself has been a fundamental contributor to the representation theory of reductive real Lie groups, also collaborating with Speh, Knapp, and Zuckerman to clarify the inter-relationships of various constructions of irreducibles. Charmingly, since the (conjecturally) parametrizing spaces in the Kir-

[1] a family of inspiring conjectures proposed by the famous mathematician Robert Langlands in 1967

illov viewpoint are orbifolds rather than something smoother, one must study the geometry of singular spaces. Further, rather than desingularizing (by some device) to define away the problem, it seems that the precise nature of the singularities contains the information we want, so we must study singular spaces directly. Again, the inevitability of this issue was highlighted in Prof. Vogan's lectures.

Much of even this fragment of Langlands' program is still conjectural, but has stimulated much fruitful reflection on subtle interconnections of seemingly disparate parts of mathematics. Prof. Vogan offered useful fresh perspectives on some important features of the program.

2005-06 Continuing Postdocs and Visiting Faculty

Assistant Professors:

Wenming Hong (Ph.D. Beijing Normal University, measure-valued branching processes, large deviations)

Huiqiang Jiang (Ph.D. Courant Institute, partial differential equations)

Simon Morgan (Ph.D. Rice University, geometric measure theory, harmonic maps)

Jonathan Rogness (Ph.D. University of Minnesota, topology; joint visitor with ITCEP)

Chian-Jen Wang, Dunham Jackson Assistant Professor (Ph.D. Ohio State, automorphic forms and representation theory)

Doug Wright, Dunham Jackson Assistant Professor (Ph.D. Boston University, partial differential equations)

Associate Professors:

Victor Padron (Universidad de Los Andes, Merida, Venezuela; differential equations and applications)

Postdoctoral Associates and Postdoctoral Fellows

(This includes IMA Postdoctoral Associates who participate in the teaching activities.)

Yassine Boubendir (Universite Paris 13, acoustics and electromagnetics, applied mathematics, numerical methods)

Mihail Cocos (University of British Columbia, differential geometry, geometric analysis)

Brian DiDonna (Ph.D. University of Chicago, condensed matter physics)

Johnny Guzman (Ph.D. Cornell University, numerical analysis of partial differential equations)

Matthias Kurzke (Ph.D. Max Planck Institute for Math in the Sciences, calculus of variations, nonlinear partial differential equations, materials science)

Anastasios Matzavinos (Ph.D. University of Dundee, applied mathematics, mathematical biology)

Christian Poetzsche (University of Augsburg, Germany; qualitative theory of dynamical systems, evolutionary equations and inertial manifolds)

Magdalena Stolarska (Ph.D. Northwestern University, applied mathematics, mathematical biology)

Joo Sookyung (Ph.D. Purdue University, nonlinear partial differential equations, liquid crystals, superconductivity)

Emanuel Yomba (Ph.D. University Yaouande I, Cameroon; nonlinear partial differential equations)

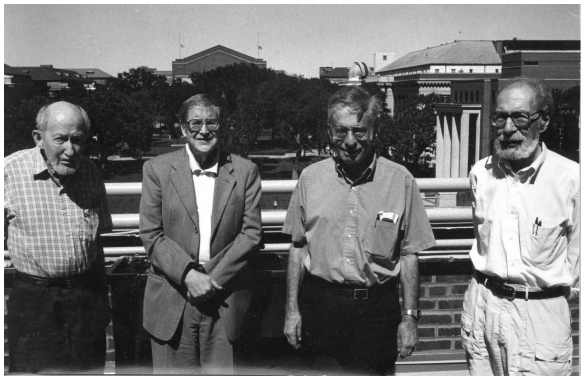
The Emergence of Partial Differential Equations at the University of Minnesota

The strong national ranking of the School of Mathematics is due in part to the prominence of our faculty in the area of Partial Differential Equations (PDE). This historical note provides a brief perspective on the period when the PDE group was established here.

Before 1950, the School of Engineering contained a small Department of Mathematics and Mechanics that was principally a service department for engineering students. Its sole research mathematicians were Hugh Turrittin, an expert on ordinary differential equations, and Fulton

Koehler, who worked on the approximation of vibration frequencies. In 1950, at the suggestion of Neil Amundsen, who earned his Doctorate under Turrittin and then switched fields to become a chemical engineer, Stefan Warschawski, an expert on conformal mapping by analytic functions, was brought into the department.

In 1953 Athelstan Spilhaus became Dean of the School of Engineering. He had a vision of the interdependence of Engineering and the Physical and Mathematical Sciences. In 1953 Spilhaus renamed the School of Engineering the Institute of Technology (IT), and proceeded to absorb the physical sciences, which were then in the College of Science, Literature, and Arts. He appointed Professor Warschawski as the chairman of the Department of Mathematics in IT, with a mandate to build a strong research department that could also serve the Engineering and Science community.



Four first-round draft picks (left to right): Leon Green, Jim Serrin, Hans Weinberger, Don Aronson

The years following the end of the Second World War provided a golden opportunity as well as a challenge for universities throughout the country. A great influx of students created a demand for greatly increased faculties. This increase created a shortage of qualified people, so that excellent faculties could only be obtained by offering some attraction. Professor Warschawski decided to meet this challenge by hiring extremely strong mathematicians in a few important areas, so that excellent prospective job candidates would be attracted by the people already in place. Warschawski decided to make Partial Differential Equations one of the fields of concentration. With this purpose in mind, he attracted Paul Rosenbloom and Arthur Milgram. These were both well established research workers in PDE. With the support of the Department Head and the Dean, they began to hire many excellent young people who later became well-known mathematicians.

The PDE faculty developed during this period included James Serrin (1954), Donald Aronson (1957), Norman Meyers (1957), Johannes Nitsche (1957), Avner Friedman (1959), Walter Littman (1960), Hans Weinberger (1960) and Howard Jenkins (1962). Professor Milgram was instrumental in nurturing the scientific talents of these young mathematicians and the group acquired an international reputation as a center in PDE along with others in New York, Paris and Moscow.

On the basis of this reputation the University could attract new faculty members and internationally prominent visitors. Among the latter were H. Lewy, L. Hörmander, G. Stampacchia, S. Agmon, and O. Oleinik. There was also a steady stream of seminar and colloquium speakers.

While many analysis positions in the Department of Mathematics were filled by experts in PDE, excellent appointments were made in other, related, areas. Strong groups arose in Differential Geometry, including Eugene Calabi, Leon Green and Hidehiko Yamabe and in Dynamical Systems, including Lawrence Markus and Yasutaka Sibuya.

This was a time of intense activity in the foundations of PDE. New methods and connections with other areas of mathematics, including functional analysis and harmonic analysis, were being developed. At the same time there was a shift of focus from local results, such as Cauchy-Kovalewski-type existence theorems, to global existence and uniqueness theorems and to problems arising in the calculus of variations with an attendant emphasis on weak solutions and regularity theory. Milgram and Rosenbloom were knowledgeable about many of these fields and their enthusiasm was a key element of the research environment. For example, Jim Serrin learned about the seminal work of Sobolev in Russia from Rosenbloom.

Milgram's office, the door always open, was a magnet for the PDE students and faculty, a place to learn and to test new ideas. A continuous working seminar emerged. Either Milgram or one of the other participants would choose a recent paper (by De Giorgi, Moser, Ladyzhenskaya etc.)

that they wanted to understand and would work through it in detail. At the conference in honor of Don Aronson's 70th birthday, held in June 2001 in Amsterdam, Hans Weinberger recalled that in the fall of 1960 the seminar topic was Moser's new proof of a famous regularity theorem of De Giorgi that had just become available. Many people were excited by this breakthrough result, but none more so than Don and Jim, whose work over the next few years was heavily devoted to expanding on these ideas, particularly for weak solutions of divergence form equations.

Unfortunately Art Milgram died suddenly, in his prime, in 1961. It may give some consolation that he saw the first growth of the seed he helped to plant. Paul Rosenbloom switched his focus of interest to mathematics education in the early 1960s and moved to Teachers College at Columbia University, another loss to the department[2].

Until 1963 the University of Minnesota had two mathematics departments, one housed in IT and the other in the College of Science, Letters, and Arts (CLA). The two departments operated on quite separate lines, the CLA department having, for example, a strong group in the area of probability theory, including Robert Cameron, Monroe Donsker, Harry Furstenberg, Steven Orey and Glen Baxter. That department also included Warren Loud in ordinary differential equations and Adriano Garcia, an analyst with an interest in PDE. In 1963 the two departments were merged into the School of Mathematics in the Institute of Technology, a merger that broadened the reputation of the department. Nevertheless, a severe loss at the time was the departure of Stefan Warschawski for La Jolla, where he began the development of another important mathematical center at the University of California, San Diego.

The accomplishments and major recognitions of the faculty in the early period are too extensive to be dealt with in detail. We confine ourselves to fairly brief comments.

Don Aronson is famous for his work on the porous medium equation, on dynamical systems theory, and pioneering work on linear and nonlinear parabolic equations. He has had many prestigious speaking invitations, including an invited address at the 1987 AMS annual meeting in Salt Lake City. Some of his contributions include joint work with Serrin on the Harnack Principle for parabolic equations and the derivation of Gaussian bounds for the fundamental solution of divergence structure linear parabolic equations, which in turn were influenced by the results of Littman-Stampacchia-Weinberger on elliptic equations. In addition, Aronson obtained the quasi-convexity estimates for the porous medium equation, jointly with Phillipe Benilan, and did joint work with Hans Weinberger on traveling wave solutions of reaction-diffusion equations. This latter work was the start of a never-ending traveling wave industry!

James Serrin's research encompasses many areas of ordinary and partial differential equations, calculus of variations, fluid and continuum mechanics, as well as foundations of thermodynamics. Some specific contributions include the Harnack inequality for non-uniformly elliptic quasilinear equations and the first use of the moving plane method for symmetry problems in elliptic equations. In 1959 Jim contributed a major monograph, *Mathematical Principles of Classical Fluid Mechanics,* to the Springer-Verlag Handbuch der Physik. Other contributors included H. Bethe and W. Pauli, to mention only the best known. His important results in the calculus of variations, generalizing those of C.B. Morrey, Jr. and L. Tonelli, were prominently featured in Morrey's 1966 monograph *Multiple Integrals in the Calculus of Variations*. In 1963 Jim became the co-editor, for 23 years, of the prestigious Archive for Rational Mechanics and Analysis. In 1969 he was named Regents' Professor.

In 1973 Jim was awarded the G.D. Birkhoff Prize in Applied Mathematics by the American Mathematical Society "for his fundamental contributions to the theory of nonlinear partial differential equations, especially his work on existence and regularity theory for nonlinear elliptic equations, and applications of his work to the theory of minimal surfaces in higher dimensions". He was a two-time invited speaker at the International Congress of Mathematicians, and was elected to the National Academy of Sciences in 1980.

Hans Weinberger is a leader in many areas of pure and applied mathematics: fluid mechanics, calculus of variations, dynamical systems, eigenvalue problems and maximum principles. He has had many prestigious speaking invitations. He was the founding director of the Institute for

[2]Professor Rosenbloom passed away one year ago in April 2005.

Mathematics and its Applications, serving in this position for six years (1981-1987) and establishing a pattern for its continued success. Hans was named IT Professor in 1992. Hans wrote the classic text *A First Course in Partial Differential Equations* and the influential monographs *Variational methods for Eigenvalue Approximation* and *Maximum Principles in Differential Equations*, the last with Murray H. Protter.

Johannes Nitsche earned international recognition for his leadership role in the theory of the minimal surface equation and for his monumental monograph on this subject in the Springer "Yellow Series". His beautiful paper on the two-dimensional Bernstein theorem on entire solutions of the minimal surface equation (Proc. American Mathematical Society, 1959) is a pearl of mathematics.

Walter Littman is a leading contributor in partial differential equations and related areas, especially control theory. Of his celebrated papers, one with Stampacchia and Weinberger is so well-known that it is always referred to simply as "Littman, Stampacchia and Weinberger". He also played an important role in establishing our program in industrial mathematics. His book *Industrial Mathematics*, written jointly with A. Friedman, did much to make the subject popular.

Norman Meyers is the author of the foundational paper "H = W", with Serrin, and is famous for his groundbreaking work on Bessel potentials.

Avner Friedman was on the early faculty and later returned as the Director of the Institute for Mathematics and its Applications and founding Director of the MCIM. While at Minnesota he obtained many important results on linear and nonlinear parabolic equations as well as many groundbreaking results for the Stefan problem. His book on parabolic equations is a classic reference for the subject. Friedman subsequently left Minnesota to become the Director of the Mathematical Biology Institute at the Ohio State University.

These founders of PDE at Minnesota have left a profound imprint on mathematics and on the School of Mathematics at the University of Minnesota. Their influence lives on in the present School of Mathematics and in the Institute for Mathematics and its Applications.

(The newsletter committee is grateful for all the help we received in preparing this article.)

Symposia

The Ninth Rivière-Fabes Symposium on Analysis and PDE

The Symposium is held annually to honor the memory of our former colleagues Nestor Rivière and Gene Fabes. For additional historical information please visit the web site `http://www.math.umn.edu/conferences/riv_fabes_06/`

The ninth Symposium was held April 7-9, 2006 at the School of Mathematics. The principal speakers and titles of their lectures were: Charles Fefferman (Princeton University), "Fitting a smooth function to data I, II" (two one-hour lectures); Isabelle Gallagher (Universite Paris 7), "Mathematical analysis of equatorial waves"; Alexandru Ionescu (University of Wisconsin), "Low-regularity solutions of nonlinear equations"; Diego Maldonado (University of Maryland), "On the Monge-Ampere equation and its linearization"; and Wilhelm Schlag (University of Chicago), "Spectral theory and applications to nonlinear PDE I, II" (two one-hour lectures). For the schedule and abstracts please see `http://www.math.umn.edu/conferences/riv_fabes_06/schedule/` and `http://www.math.umn.edu/conferences/riv_fabes_06/abstracts/`

The Organizing Committee consisted of Naresh Jain, Carlos Kenig, Nicolai Krylov, Daniel Spirn and Vladimir Sverak (Chair).

Third Yamabe Memorial Symposium

The Symposium, sponsored by the National Science Foundation and the Yamabe Memorial Fund at the University of Minnesota, will be held September 15-17, 2006 at the University of Minnesota. The title of the Symposium is "Geometry and Symplectic Topology". The principal speakers will include Professors Denis Auroux, Massachusetts Institute of Technology; Yasha Eliashberg, Stanford University; Mikio Furuta, University of Tokyo; Helmut Hofer, Courant Institute; Dusa MacDuff, SUNY Stony Brook; Peter Ozsvath, Columbia University; Yongbin Ruan, University of Wisconsin; and Ron Fintushel, Michigan State University.

The history of the Symposium, in honor of Professor Hidehiko Yamabe (1923–1960), can be

linked to from the Symposium's web site (see below). Organizers: Bob Gulliver, Conan Leung, Tian-Jun Li, and Jiaping Wang.

Please visit the Symposium's web site (`http://www.math.umn.edu/yamabe/`) for additional details as they become available.

Notable Activities of the Faculty

We are grateful to those colleagues who have provided some details about their recent activities, thus helping us to give our readers a glimpse of the multifaceted scientific work of our faculty. We know that many of our other colleagues have significant achievements and we hope to report on those in future newsletters.

Professor Doug Arnold serves as the IMA Director - see the IMA Related News section. He also has a very active research program of his own. He has recently given plenary lectures at the following conferences: Midwest Numerical Analysis Conference, Iowa City, IA, May 20, 2005; Foundations of Computational Mathematics, Santander, Spain, July 7, 2005; and Frontiers of Applied Analysis (Center for Nonlinear Analysis 15th anniversary conference), Pittsburgh, PA, September 10, 2005.

Doug is also very much involved in spreading information about the IMA accomplishments, and mathematics in general, through the media. He has twice been a guest on the Science and Society program, and he also has frequent requests from the popular press and electronic media to comment on such issues as the powerball lottery and the recently popular puzzle game of Sudoku. He has even been asked, by a fishermen's hall of fame, to render an opinion on the size of a record muskie caught in 1949 on the basis of a photograph. (Unfortunately, the results are inconclusive: the length could be anything between 54 and 63 inches. Two other well known mathematicians, also approached by the hall of fame, concur with Doug.) It is clear that Doug is an example of someone who can fit 25 hours of activity into a 24-hour day. Links to many of these articles in the popular press are at `http://www.ima.umn.edu/press_info/andwww.ima.umn.edu/~arnold/press/`

In January 2006, **Professor Mark Keel** delivered an invited series of four lectures at the Institute of Applied Physics and Computational Mathematics, in Beijing, China. He is also a co-organizer of the upcoming conference "Hyperbolic Equations and Oscillations", at the University of Bordeaux, France, in May 2006. He gave invited lectures at the November 2005 conference "Geometric and Analytical Aspects of Nonlinear Dispersive Equations" at MSRI in Berkeley, and the June 2005 conference "Nonlinear Evolution Problems" in Oberwolfach, Germany, as well as departmental colloquia at the Universities of Maryland and Indiana in 2005 and 2006.

Professor Mitchell Luskin is the project principal investigator of a large DOE project dealing with sophisticated numerical methods and their applications. We report on this project elsewhere in the newsletter.

In March 2006 **Professor Peter Olver** taught a course at the African Institute of Mathematics (AIMS) Capetown, South Africa. The Institute brings young faculty from all over Africa for an intensive one year course in graduate and research mathematics, with the aim for them to help build the academic and scientific infrastructure in their home countries. See `http://www.aims.ac.za/english/` for more information about AIMS.

Peter is a member of Applied Mathematics Editorial Board, Cambridge University Press, which oversees the applied math texts published by the Press, as well as a member of SIAM Classics Book Series Editorial Board, which publishes reprints of classic out of print texts, and of the EPSRC Peer Review College, which evaluates grant proposals in the UK.

He also served on the Organizing Committees for: International Conference on Symmetry in Nonlinear Mathematical Physics, Kiev, Ukraine, June 20-26, 2005; Foundations of Computational Mathematics, Santander, Spain, June 30 - July 9, 2005; and is currently serving on the Organizing Committee of Abel Symposium, Alesund, Norway, May 25-27, 2006.

Professor Victor Reiner was one of the principal lecturers at the two-week Summer School on Geometric Combinatorics held July 18-29, 2005 at the University of Vienna, and sponsored by the Algebraic Combinatorics in Europe network. The web site for the sum-

mer school is http://www.mat.univie.ac.at/~teisenko/summer05.html and you can find Vic's lectures linked at http://www.math.umn.edu/~reiner/Talks/transparencies.html

Professor Arnd Scheel was one of the organizers of an ARCC workshop at the American Institute of Mathematics, Palo Alto, on "Stability Criteria for Multi-Dimensional Waves and Patterns", May 16-20, 2005. He delivered a Distinguished Lecture at the IAS Workshop, in conjunction with the Newton Institute, on "Theoretical Aspects of Pattern Formation", September 20, 2005. And he was the main speaker for a minicourse at the workshop "Singularities Arising in Nonlinear Problems (SNP2005)", held in Kyoto, Japan, November 28-30, 2005.

Thanks to our Friends

Our students and programs have benefited greatly from many donations made to the School of Mathematics over the years, by alumni, faculty, friends, foundations and corporate supporters. Often these are made in memory of former faculty or friends of the School, and in many cases we are requested not to publish the names of donors.

A donated endowment supports the Samuel G. Ordway Chair in Mathematics, and also provides for our Distinguished Visitors program. Current donations to the School of Mathematics are used to support about 25 scholarships for our undergraduate mathematics majors. (Other donations made to the Institute of Technology are used to fund approximately the same number of additional undergraduate scholarships in math.) Donations to the School of Mathematics also support fellowships for graduate students in math. This year three graduate fellowships were provided in this way. The Rivière-Fabes Symposium, which is held here each year in memory of Gene Fabes and Nestor Rivière, is also generously supported by donors. Other gifts fund the Yamabe Symposium which we share with Northwestern University.

The School of Mathematics is grateful for all the gifts that have been made in support of our teaching and scholarship mission. We are committed to providing the best mathematical environment possible for our students at all levels.

Undergraduate Program

The North Central Team Competition and the Putnam Mathematical Competition

Professors Bert Fristedt and Marta Lewicka, who lead the practice sessions for these competitions, report below on the excellent results achieved by our undergraduates. The practice sessions meet for two or more hours weekly during the fall semester, with students being expected to put in extra work between these sessions. All of us join in congratulating our contestants, as well as Professors Fristedt and Lewicka, on their very strong showing in both competitions. We also note that several of the contestants are graduates of the IT-CEP's UMTYMP program.

The **North Central Team Competition** took place on November 12, 2005. There were 65 teams from 27 colleges and universities in Minnesota, North and South Dakota, and Manitoba, including 7 teams from the University of Minnesota, Twin Cities campus. One of our teams, the Loons, obtained the perfect score of 100 points, tying for the first place with one of the Macalester College teams. Our other six teams all finished in the top 23 out of 65. Congratulations to all 20 U of M, Twin Cities contestants!

3545 undergraduates entered the **Putnam Mathematical Competition** given on December 3, 2005 to students throughout Canada and the United States - 12 problems, 6 in each of two 3-hour sessions.

100 out of 120 was the highest score earned, and, as is often the case in this competition consisting of very difficult problems, the median score was low, 1 out of 120.

12 students from the University of Minnesota, Twin Cities Campus, entered. Five of our students did extremely well, with scores ranging from 167th to 483rd out of 3545.

Our team, consisting of 3 students, chosen by us in advance, placed 33rd out of 500 (although it is possible that several of those 500 teams did not have as many as three competitors). The team score is obtained by summing the scores of the 3 students on the team.

We are looking forward to Fall practice with those who are returning for the 2006 competition

together with others who did not compete in 2005. Reminder: Students do not have to be mathematics majors to compete. So if you know of undergraduates - any major - who you think might like to be involved in either the Putnam Competition or the North Central Team Competition in Fall 2006, please inform them about these contests and ask them to let us know so that we can place them on our mailing list.
Bert Fristedt
Marta Lewicka

Undergraduate Projects

Senior projects involve substantial one-on-one student-faculty interaction and enhance greatly the students' learning experience. Below is a list of the faculty members who recently supervised such projects, together with the titles of the projects.

John Baxter

- "The aggregate claims process"
- "Modeling accidents and loss random variables"
- "Linear programming and the simplex method"
- "Infinite random walks in one and two dimensions"

Mark Feshbach

- "Cryptography and Fermat's theorem"

Paul Garrett

- "A history of zero"
- "An enrichment mathematics curriculum targeted at talented middle-school girls"

Max Jodeit

- "The function called Exponential"

Richard McGehee

- "Integrating the integrated curriculum: an evaluation and application"
- "An evaluation of the published data on hormone replacement therapy"

Rick Moeckel

- "Groebner bases and integer programming"
- "Complex dynamical systems"
- "Linear algebra and special relativity"

Karel Prikry

- "Some constructions in the theory of vector spaces"

Victor Reiner

- "C computation of Tutte polynomials" (UROP mentoring)
- "The four color theorem"

Currently Vic is supervising five(!) students.

Joel Roberts

- "The history of zero"
- "The hyperbolic plane, and Matlab sketches of curves on a hyperboloid of one sheet"

The project "C computation of Tutte polynomials" was carried out by Michael Barany, under Professor Reiner's supervision, under the aegis of the University of Minnesota Undergraduate Research Opportunities Program. Michael wrote a computer program, in the language C, which computes the Tutte polynomial of a matroid. He tested the program extensively on machines that run under Linux, but says in the manual, which he also wrote, that "if you're really really clever you can make the program work on another machine [as well]". The program can be accessed from Professor Reiner's web page `http://www.math.umn.edu/~reiner/Tutte/TUTTE.html`

Much ado about Nothing!

An astute reader might notice that Professors Garrett and Roberts both supervised projects on the history of zero (different students). While this is, of course, a bit of a coincidence, the topic itself is quite intriguing. It is a subject of a great deal of scholarly research by historians of mathematics, and excites the curiosity of the general public as well. In April 2005, Deane Morrison of UMNnews interviewed Mathematics Professor Emeritus Alfred Aeppli and Astronomy Professor Terry Jones on this subject.

She starts out by, humorously, calling her column "a column about nothing at all". She soon turns serious and points out that the concept of zero was invented a number of times in different places, making its way to Europe in the Middle Ages. But, according to the historian Karl Menninger, it took a long time before the concept filtered down to ordinary people. Morrison's column is at `http://www1.umn.edu/umnnews/Columns/SciFri/Zero_Tolerance.html`

Graduate Program

By Scot Adams, Director of Graduate Studies in Mathematics

This year there are twenty-five incoming students. Nineteen are international; seven are women.

We congratulate our recent graduating Ph.D. students (Jan. 2005 to Sept. 2006). We list them below with thesis topics, advisors, and positions after graduation.

Fatih Celiker, "Discontinuous Galerkin Methods for Structural Mechanics", Bernardo Cockburn, advisor; ICME at Stanford

Jeongoo Cheh, "Symmetry Pseudogroups of Differential Equations", Peter Olver, advisor; University of St. Thomas

Min-Hung Chen, "High-Order Runge-Kutta Discontinuous Galerkin Methods for Computational Electromagnetics", Bernardo Cockburn, advisor; Chung Kung University in Taiwan

Sungwon Cho, "Boundary Behavior of Solutions to Second Order Elliptic and Parabolic Equations", Mikhail Safonov, advisor; Michigan State University

Hongjie Dong, "On Some Problems Related to the Regularity Theory for Second-order Elliptic-Parabolic Equations and Their Numerical Approximation", Nicolai Krylov, advisor; University of Chicago

Dapeng Du, "Three Regularity Results Related to the Navier-Stokes Equations", Vladimir Sverak, advisor; Institute of Mathematics, Fudan University in Shanghai

Fatih Ecevit, "Integral Equation Formulations of Electromagnetic and Acoustic Scattering Problems: High-frequency Asymptotic Expansions and Convergence of Multiple Scattering Iterations", Fernando Reitich, advisor; Max Planck Institute MIS in Leipzig

John Hall, "Combinatorial Deformations of the Full Transformation Semigroup", Dennis Stanton, advisor; U of California - San Diego

Thomas Hoft, "An Inverse Problem in Nondestructive Evaluation of Spotwelds", Fadil Santosa, advisor; Coherent Technologies

Minchul Kang, "Temporal and Spatial Aspects of Calcium Dynamics in Astrocytes", Hans Othmer, advisor; Vanderbilt University, Department of Biomathematics

Doyoon Kim, "Partial Differential Equations in Sobolev Spaces with or without Weights", Nicolai Krylov, advisor; Teaching Specialist, University of Minnesota

Jonathan Rogness, "Homotopical and Homological Algebra of Exact Couples", Donald Kahn, advisor; University of Minnesota, ITCEP

Catalin Turc, "High-order Integral Equation Methods for High-frequency Rough Surface Scattering Applications", Fernando Reitich, advisor; Caltech

Pang-Yen Weng, "On Sobolev Spaces of Divergence-Free Vector Fields and Their Applications", Vladimir Sverak, advisor; Ramapo College

Bayram Yenikaya, "Adaptive Methods for Hamilton-Jacobi Equations", Bernardo Cockburn, advisor; Invarium, Inc. in San Jose, CA

Jian Zhang, "Scattering Problems in Inhomogeneous Scalar Wave Equation", Fadil Santosa, advisor; Penn State University

According to an analysis done by the Graduate School, our graduate program's completion statistics have a favorable comparison with the general results in Engineering, Physics, etc. For example, the seven year completion rates for our

Applied dynamical systems at the math department picnic

Ph.D. graduate students entering in 1994, 1995, 1996 and 1997 are, respectively 67%, 67%, 85% and 82%. The general figures for the same years are 50%, 56%, 56% and 47%.

Application for admission to our graduate program continues to show a favorable trend. According to the Graduate School, we had 176 completed applications in 2000-2001, then 207 in 2002-2003 and then 249 in 2003-2004. The number dropped slightly in 2004-2005, to 228, but is now higher than ever for 2005-2006, at 294. The quality of the applicants is also up.

Last year, we began a long process of trying to determine the current whereabouts of our 302 Mathematics Ph.D. graduates since 1981. To date, 89 of these students have responded to our requests for information, and we have also (by other routes) found out about several others. See `http://www.math.umn.edu/grad/PhDs/` and `http://www.math.umn.edu/grad/PhDs/details.html` for all the public information we've been able to accumulate. If you have information about our graduates, and would like to share it, please write to `gradprog@math.umn.edu`. We won't make public any email address without the graduate's consent.

A recent departmental external review conducted by the Graduate School has recommended a change to our Ph.D. program requirements. Our current practice requires students to demonstrate knowledge in eight semester courses before beginning specialization, and the review committee found that to be unusually stringent. We are now working to address that concern, and may well change our requirements.

Finally, the department has submitted, to the Graduate School, a proposal to begin a professional Master's program in Financial Mathematics. That proposal is now under review by a Graduate School committee.

Minnesota Center for Industrial Mathematics (MCIM)

Professor Fadil Santosa, Director of the MCIM, has kindly provided the following report on MCIM activities.

A number of very successful internships were arranged through MCIM during the summer of 2005. Students were assigned to various locations including Los Alamos National Laboratory in Los Alamos, NM, and Schlumberger Doll Research in Ridgefield, CT. We highlight some of the projects the interns worked on during the summer of 2005.

Haiying Wang worked at Schlumberger Doll Research on inverse problems for Laplace's equation. In her research, she explored various regu-

larization strategies, some of them based on statistical methods, to invert noisy data collected in the field. She reports that working on this project gave her the opportunity to work on a real-world mathematical problem, which she found to be very different from those she encounters in the classroom. The experience has given her a deeper appreciation for statistical approaches to problem solving.

At MCG (Minneapolis Consulting Group), Yanlai Chen helped build software to analyze electrical network data. A lot of the work involved the solution of large sparse systems and data analysis. Aside from learning the modeling aspects, Yanlai became an expert on linear algebra software.

Viktoria Averina, whose internship was at Guidant, worked on a signal classification problem for the purpose of predicting heart failure. Her work included the use of statistics, signal processing techniques, and dynamical systems. One aspect of industrial research Viktoria learned is that the nature of a project evolves, so there is always a lot to learn. She found the environment at Guidant to be very dynamic and exciting, and the experience has helped her define her career objectives. She reports "What was the most exciting is that I found a very interesting field where I can apply my knowledge of mathematics. It led to my participation in research on hypertension led by U of M professor Dr. John Osborn. Hopefully my work on this research will become the foundation of my thesis. And last but not least, I got a job offer from the company."

For Mariya Ponomarenko, the internship was a chance to plunge into the world of hedge funds. At Alternative Strategy Advisers, she analyzed historic treasury and LIBOR data. The mathematics she used in this work were statistical techniques for data analysis. To aid the traders she built MS Windows tools. "Looking back, this experience provided me with a good perspective on the world of finance and financial math and helped make a more informed decision on my career path", she said.

The MCIM, in conjunction with the IMA, continued to run the Industrial Problems Seminar. The seminar brings industry speakers from various companies, and provides an opportunity for our students to find out about industrial research and to discuss career options in industry. We report on some of the talks below.

A fascinating talk on the search engines was given by Dr. Ruchira Datta from Google. Datta, who got her Ph.D. in Mathematics from the University of California at Berkeley, discussed various challenges that arise in text-based information retrieval. A major difficulty is due to the small amount of information, often riddled with typos, provided as search words by the user. She also discussed how linear algebra is used in Google's Page Rank, which rates a web site for its importance.

Research on an active night-vision system to aid drivers was the topic of the presentation given by Jeff Remillard from Ford Scientific Research Lab. Remillard gave an overview of this rapidly developing technology, including some innovations that have appeared, or will soon appear, in passenger vehicles. In the system he developed, an infrared source is used to illuminate the scene. Image processing plays a big role in his work. He demonstrated a night-vision system that is capable not only of seeing in pitch-black darkness, but also through smoke and snow. The next stage is to develop an intelligent system that recognizes danger in the captured images and takes over the control of the vehicle in order to avoid collision.

John Hamilton gave a presentation on algorithms used in digital cameras. While many of us have digital cameras, few are aware of the image processing tasks that go on inside these devices when we take pictures. For example, the first step in recording an image is color interpolation. This step is required because the pixels in a camera detector are divided into three groups: those sensitive to the colors red, blue, and green, respectively. Most cameras have 50% green sensors, and 25% each of red and blue sensors. In order to assign the RGB value to a pixel, an algorithm reads the levels of red, green and blue in nearby pixels and calculates the appropriate RGB value for that pixel. Hamilton, whose Ph.D. degree is from Indiana University, wrote a thesis on Lie groups. At Kodak, where he is a Research Fellow, he has been a key player while the company transformed itself from a photographic film and paper manufacturer to a digital imaging company.

Many of the talk materials, and in some cases, talk videos, are available for viewing from the IMA web page.

MCIM continues to collaborate with the IMA in organizing the popular "Mathematical Modeling in Industry" workshops. In the workshop, stu-

dents work in teams of five or six under the mentorship of an industry scientist on problems from industry. The teams have 10 days in which to arrive at a solution. Final reports, both oral and written, are expected at the end of the period. The types of problem the students work on are quite varied. This year, the projects range from image processing to cell biology. More information about this program is available on the IMA web page (`http://www.math.umn.edu/mcim/`).

IT Center for Educational Programs (ITCEP)

ITCEP programs have a major impact on education throughout Minnesota. Our Master's Degree Program in Mathematics with Emphasis in Education is administered in cooperation with ITCEP, with ITCEP's Director Professor Harvey Keynes serving as advisor for the students enrolled in the program. Our faculty and graduate students are also enthusiastic participants in the UMTYMP (the University of Minnesota Talented Youth Mathematics Program) and other ITCEP programs.

These academic year and summer programs provide students in grades 3-12 with a supportive environment in which to explore challenging mathematics at the University. Information about all these programs can be found at ITCEP's web site (`http://www.itcep.umn.edu/`). We are grateful to ITCEP's Communications Coordinator Alexandra Janosek who has given us very informative contributions about current activities in these programs, including their three new mathematics enrichment programs: "Mathematical Circle", "Girls Excel in Math" (GEM), and "Exploring Careers in Engineering and Physical Science". She also reports on the 15th Family Fun Fair which she organized. Alexandra's reports appear below in a somewhat condensed form.

Mathematics Programs for Promising Youth

In 2005-2006, 506 students are taking part in UMTYMP, a five-year premier academic program. The program offers a rigorous mathematics curriculum for highly motivated, talented students in grades 6-12. College-level courses are taught by post-doctoral fellows Simon Morgan and Jonathan Rogness and overseen by Professor Harvey Keynes. The first two years of Calculus have very high enrollments of 79 and 68 students respectively. 64 of these students are in the ninth grade or below.

In addition to UMTYMP, ITCEP offers enrichment programs for students in grades 3-12 during the school year and during the summer. About 450 students are enrolled in the 2005-2006 academic year programs. In addition, about 170 students enroll annually in the 14 summer classes offered in conjunction with the Youth & Community Programs of the University's Department of Recreational Sports. These programs provide opportunities to learn and enjoy mathematics, and to introduce students to the role of mathematics in society through meeting and working with scientists, engineers and mathematicians.

Three New Mathematics Enrichment Programs

Mathematical Circle

Mathematical Circle, meeting on Saturdays during the school year, is led by two exceptional Twin Cities high school teachers, Tom Kilkelly (Wayzata Senior High) and Mike Huberty (Mounds View School District). There are also guest speakers from our department. According to Tom, students should "experience some interesting topics, have their curiosity piqued, and improve their ability to discuss mathematics with one another". During the pilot year 2005-2006 the focus is on geometry, "because there are a lot of investigations and topics that extend and enhance the high school and UMTYMP geometry curricula", Tom says.

Math Circles were initiated in Hungary more than a century ago by leading Hungarian mathematicians of the period to help young students broaden their mathematical knowledge. The concept spread throughout eastern Europe and led eventually to the creation of national and international mathematical competitions for high school students. Many well known mathematicians have taken part in these competitions.

Girls Excel in Math

The goal of the Girls Excel in Math (GEM) is to encourage young girls to study, and achieve in mathematics, as well as to build and nurture a

community of fourth through seventh grade Twin Cities girls who are interested in math. During 2005-2006 the participants are investigating how mathematical patterns relate to art and nature.

Forming lasting friendships and a strong student-mentor bond with a teacher are important goals for the GEM program. Spending time with other girls who enjoy challenging math activities reinforces a girl's own pleasure in and enthusiasm for the subject. To this end, GEM is working with 5 dedicated elementary and middle school teachers from the Anoka-Hennepin, Apple Valley, Centennial, and Roseville Public School Districts who have each recruited 6 to 16 girls from their classes or their school. In this way, the teachers and students continue working together between and after program events.

In fall 2005 and winter 2006, the teachers participated in professional development sessions with ITCEP staff before leading their girls through workshops designed to appeal to young girls aged 10 to 12. In late March 2006, teachers, students and parents took part in a brief reception and the ITCEP Family Fun Fair (see below in this section).

The program is supported in part by the Minneapolis-based Center for Energy and Environment (CEE).

Exploring Careers in Engineering and Physical Science

Exploring Careers in Engineering and Physical Science is a new one-week summer program for girls being developed by ITCEP in cooperation with the Department of Chemistry, the National Center for Earth-System Dynamics, the School of Mathematics, the Institute for Mathematics and its Applications, and the Center for Distributed Robotics. The program will give 20-25 girls in grades 10-12 the opportunity to come to the University and explore majors in engineering, math and the physical sciences.

During the five days of the 2006 pilot program, girls will start with a tour of the Minneapolis Campus, an orientation by IT personnel and various tours and presentations about the girls' areas of interest. During the following days the students will interact with the cooperating IT Centers and Departments. Among other planned activities, girls will participate in hands-on math workshops, attend sessions of an international conference on robotics, and discuss chemistry careers with a panel of local professional women. If the 2006 pilot program meets its planned goals, a recently awarded 3M grant to IT will provide major support for this program over the next three years (2007-2009).

Family Fun Fair: Science and Math activities add up to a day of fun

The fifteenth Annual Science and Math Family Fun Fair was held from 10am to 3pm on Saturday, March 25 at Coffman Union, for students in grades 3-12, teachers of grades 3-6 and their families. It attracted over 700 people.

We recommend the web site `http://www.itcep.umn.edu/funfair/` that has links to stories on the 2006, as well as the 2005 Fun Fair. The pictures are excellent. The 2006 link leads to the Minnesota Daily's fine story on the event.

Harvey Keynes, Ezra Miller and Simon Morgan from the School of Mathematics presented at the Fair, as well as Brad Lucier and Alison Malcolm from the IMA. (We regret omitting others who may also have attended.)

Also presenting were girls and their teachers participating in ITCEP's Girls Excel in Math program, mentioned earlier. They came to share with other children and parents what they learned about origami and tessellations during the program.

Participating organizations volunteer their time to bring exhibits and activities that combine learning with activities and demonstrations on math, science, engineering, and technology. Several University of Minnesota departments and centers participated, including the Department of Neuroscience, the Department of Biobased Products, and the Army High Performance Computing Research Center.

Key points of interest during the Fair were a series of exciting demonstrations by **Physics Force: Next Generation** and stunning chemistry demonstrations by **Women in Science & Engineering (WISE)**. Honeywell, IBM, Medtronic, Inc. and Xcel were among the companies that enhanced the event.

Contents

The Newsletter Committee is composed of John Baxter, Max Jodeit, Donald Kahn (Chair) and Karel Prikry.

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