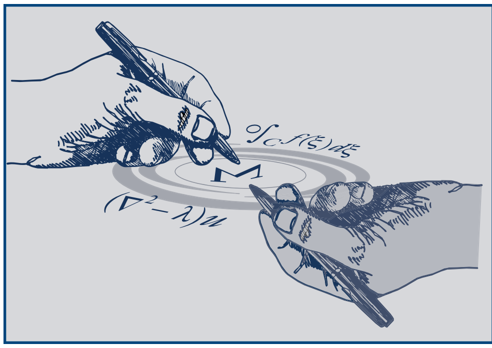
Summer 2008



Reckonings

Reckonings: (n. pl.)
1. Computations or summations
2. Acts of thought or reasoning
3. The newsletter of the Department of Mathematical Sciences at the University of Delaware

Chair's Message

Peter Monk

I shall remember this year for a very significant reason: after 33 years at Delaware, Professor Ivar Stakgold has left Delaware for the University of San Diego where he has been offered a position as an emeritus professor, and where he will be closer to his family. For as long as I have been at Delaware, Ivar has been a respected member of the Department. Ivar arrived at Delaware as Chair in 1975, serving as Chair until 1991. He retired in 1995 but remained an active emeritus faculty member through March of 2008. I think it is true to say that Ivar deserves a great deal of the credit for building the Department to its present position as a recognized research unit. His arrival coincided with a brave investment by the UNIDEL foundation in our Department and also with the hiring of several of our best known faculty. Under his leadership, Delaware became known as a center of excellence in areas such as Applied Mathematics, Analysis and Combinatorics.

Besides nurturing the Department (with an iron fist – at least from the point of view of a junior assistant professor when I arrived at UD in 1982!), he also added to our national stature by serving as President of the Society for Industrial and Applied Mathematics (SIAM) from 1989 to 1990.

To me Ivar exemplifies a love of applied mathematics, and scholarship in mathematics. But he could also give interesting advice. At one point when I was a junior assistant professor he told me not to work more than eight hours a day! He told me that if I could not do the job in that time, I wasn't up to the job. This was quite worrying advice – because it was clear to me at the time that tenure could only be obtained by working every hour of consciousness.

Besides Ivar's departure, we have also had an important arrival. Professor Alfinio Flores has joined us from Arizona State University. Alfinio is the first Hollowell Professor of Mathematics Education. This professorship was endowed by the great generosity of Drs David and Kathy Hollowell. Alfinio is currently Director of Secondary Mathematics Education in the Department and has been working hard to establish ties in the University, and settle into the Department.

At a higher level, the University has also welcomed as President, Patrick Harker from the University of Pennsylvania. Academically, President

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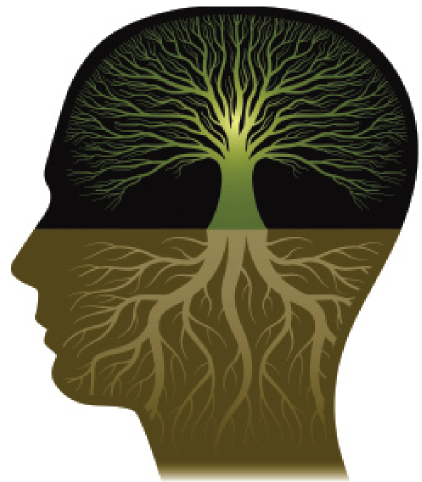
The Family Tree of Mathematics



Mathematicians have families too and now they can be tracked through the *Mathematics Genealogy Project*. In mathematics, family relationships are defined through the advisor-student relationship. If Professor Smith earned his Ph.D. under the advisement of Professor Jones, then Professor Smith is considered the mathematical son or daughter of Professor Jones. More than just a frivolous "six degrees of freedom" type exercise, tracking mathematical family trees allows one to trace mathematical influences and study the intellectual development of the various branches of mathematics. The Mathematics Genealogy Project was begun by University of Delaware alumni *Harold Coonce*. Professor Coonce, now an adjunct professor at North Dakota State University, completed his Ph.D. in 1969 under Professor *Malcom Robertson* in the area of complex variables. A quick search of the Mathematics Genealogy Project's database reveals that Professor Coonce is a direct descendent of Weirstrauss and an academic cousin of Erdos and Von Neumann! You can trace your own mathematical family tree or that of your favorite professor at www.genealogy.ams.org.

Chairs Message continued from cover

Harker works on operations research, and is in fact a "highly cited" researcher in mathematics according to the respected "Web of Science" database. So it is not too much of a stretch to claim that President Harker continues the tradition of having a mathematician as President of the University (both Presidents Roselle and Trabant were trained as mathematicians).

President Harker has initiated a program to review and determine strategic directions for the University. Significantly for our Department, early indications are that graduate education is one direction that will be emphasized much more strongly in the future. The graduate program is of enormous importance to both our educational and research missions. Currently, our graduate program has grown to 49 students, and this year we expect to graduate no less than eight PhDs (4 in pure mathematics and 4 in applied mathematics).

Some of our students graduate and move to non-academic careers, but most remain in academia. To help them prepare for their future teaching mission, we are creating a small number of "Stakgold Teaching Assistants". Students in these positions will be drawn from our most experienced assistants, and will be assigned to teach classes in our regular semesters under the watchful eye of faculty mentors. This will provide better preparation for future teaching jobs, and recognizes Ivar Stakgold's commitment to education.

When Ivar Stakgold first came to Delaware, one important step forward was to revamp the undergraduate calculus sequence with the aid of a Sloan Grant. In addition Discrete Mathematics was added to the curriculum. Our undergraduate program continues to evolve with two new degree programs: a BS in Quantitative Biology (in cooperation the Department of Biological Sciences) and a BS in Mathematics Education. The BS in Quantitative Biology is the most obvious manifestation of several years of cooperation with Biological Sciences by a team of faculty led by John A. Pelesko and consisting of Tobin Driscoll, Louis Rossi and Tobin Driscoll.

Supported by alumni donations, our undergraduate students have taken part in the Putnam Exam (one team ranked 66th) and the Mathematical Contest in Modeling (MCM). One interdisciplinary team in the MCM earned our first ever "Outstanding" award (one of 5 out of 568 contestants) and another team earned a "meritorious" rating. The Putnam and MCM contests are two examples of enrichment activities funded by donations to the Department. These are very important to us and allow us to put a "Delaware Stamp" on undergraduate and graduate education. I would like to take this opportunity to thank all our donors, particularly Kathy and David Hollowell, for their generosity this year.

One of the goals when Ivar Stakgold was hired as chair was to enhance the research level and visibility of the Department. Building on the work of the previous chair, Willard Baxter, he was extremely successful and our Department now has a thriving research enterprise and graduate program. We continue to improve with grant income up 13% last year and the faculty publishing roughly 70 papers over the year. In addition the Department has established a collaborative research program with Ecole Polytechnique in Paris, France (Professor Cakoni is heading the Delaware team). This will facilitate visits of graduate students and faculty in scattering theory between Delaware and Paris.

Looking forward, the Department will need to work inside President Harker's vision to continue to improve the scholarship, both teaching and research, in the Department to enhance our global reputation in mathematical sciences. We hope also to have a more active dialogue with alumni to help facilitate this growth.

To end these comments, I would like to take this opportunity to thank Ivar for everything that he has done for the Department and University, and to wish him the very best of good fortune in his new endeavors.

From the Editor

Dear Department Alumni, Students, and Friends,

It is my pleasure to distribute our fourth edition of *Reckonings*. As in our previous three issues, you'll find an update on the department from our chairman, a collection of news items highlighting the events and milestones of the past year, and profiles of new faculty and current students. In addition, you'll find articles profiling our distinguished alumni, and articles reporting on some of the exciting research being carried out by faculty in our department. Professor Sturm has contributed a fascinating article on her research in probability. The possible implications of this work are profound and as you'll see, address questions that concern us all. In the article "Optimization of Density Functional Methods for Atomic Structure Calculations," Professor Luke takes us on a tour of the atomic world and describes some of the neat experiments he's carried out in the department's MEC Lab. In this issue, you'll also get to learn how mathematicians follow their family trees and ways in which mathematics is considered a competitive sport.

I would like to thank all of the contributors to this newsletter, but especially Russell Luke, Anja Sturm, Peter Monk, Constantin Bacuta, Cristina Bacuta, and Fioralba Cakoni. I'd also like to thank Elizabeth Dunkle from UD's Office of Publications for all of her help with the design and layout of this and past newsletters.

I'd like to encourage everyone to regularly check the department's home page (www.math.udel.edu), where you'll find up-to-date news about the department and its activities. If you have news you'd like to share, either on the web page or in future editions of *Reckonings*, please feel free to send me an email at pelesko@math.udel.edu. I look forward to hearing from you.

Best wishes,

John A. Pelesko

New approaches in solving Saddle Point Problems

Constantin Bacuta

Modeling the air flow near a plane or modeling the flow near immersible objects involves the solving of complex partial differential equations (PDEs) including second-order elliptic problems, Stokes and Navier-Stokes systems.

In September 2007, I was awarded an NSF grant for my research on developing and implementing faster and more efficient computational methods for such PDEs and a new approach for Maxwell's equations with practical applications to computing modes for devices and to radar scattering.

My research for this project will focus on two areas: solving saddle point problems and discretization on non-matching grids. To build new and efficient algorithms, I will combine new ideas on solving saddle point problems with already known methods from distinctive fields of numerical analysis such as iterative methods, multilevel methods and adaptive methods for elliptic PDEs. The main technique will be based on the new spectral results for saddle point systems that I found in my previous projects. The proposed work for solving saddle point systems has scientific and technical applications in optimization, optimal control, computational fluid dynamics, linear elasticity, electromagnetism, electrical networks, linear models in statistics and image restoration. A second area of research will be to investigate multilevel discretizations and multilevel preconditioning techniques in the context of discretizations on non-matching grids based on the Partition of Unity method. The applications are to modeling fluid and gas flow near complex objects and fluid flow in porous media.

Where do we come from and where are we going?

Anja Sturm

My research interests lie in probability theory and its applications. The main focus of my work has been on probability models and stochastic processes that describe the evolution of interacting particle systems and population models forward and backward in time. Many of these models have implications for the applied sciences, especially for Biology and Physics. My particular interest has been on models in population genetics and ecology. Here, realistic mathematical models of the underlying processes that govern which genes are passed on from one generation to the next are of ever increasing importance as they are prerequisite to the correct quantitative analysis and interpretation of the unprecedented quantities of genetic data available today.

My own recent research in this area has centered on suitably chosen models of populations (individuals or genes) that realistically incorporate the influence of two factors which have a significant impact on genetic data: firstly, spatial substructure of the population manifesting itself through local reproduction and interaction as well as locally varying environments; secondly, variations in reproductive success as they may arise due to inherent randomness (plain "luck" or "bad luck") or a selective advantage or disadvantage stemming from the genetic type of an individual, its location, or its surrounding environment (e.g. competing individuals). Recently, I have received funding from the National Science Foundation to continue to develop the mathematical theory on various aspects of such spatial models with varying offspring laws.

Backward in time the focus is on analyzing the genealogical tree of a small sample from a population and their diffusion limits – i.e. as the population grows. These models of genealogies are also known as coalescent processes because the ancestral lines forming the genealogical tree of the sample coalesce as we follow them into the past. Such coalescent processes connected to populations models with singular offspring distributions - corresponding to potentially large individual families - have attracted much recent attention as several deep connections to different classes of stochastic processes have been discovered and exploited, albeit in a non-spatial setting. On the other hand, spatial settings arising from models with population subdivision and migration (and small offspring variances) have been studied for some time. In my work, one aim will be to bring these two directions of research together by studying the genealogies of spatial population models with larger offspring variances. For applications, the goal is to describe the distribution of genetic variability one should expect to see in the sample given these characteristic influences. Comparison with data then allows for inference of the population's history. On the level of individuals this answers to the question "Where did we come from?" On the level of genes it also sheds light onto the importance and function of particular parts of our genetic code.

Forward in time one of the central questions being addressed is to determine parameter regimes for long-term survival without explosion of the population size and -if multiple types of particles are present initially- of long-term coexistence of various or all types. Stochastic particle models that may exhibit such phenomena are generally spatial models with an interaction mechanism between particles that gives small populations (of a particular type) an advantage. Unlike these particle systems with self-regulation those with independent reproduction of all individuals, which are mathematically simpler and have been well-studied, do not have this property and are known either to go extinct or to explode. The ultimate goal is to determine whether there are phase transitions in the parameter space that separate survival of the populations from extinction and coexistence from dominance of single types. This allows one to conclude which mechanisms and forces lead to a stable population with lasting diversity.

Optimization of Density Functional Methods for Atomic Structure Calculations

Russell Luke

We address the numerical challenges facing simulations and reconstructions of molecules from first principles models at atomic scales; these are: dimensionality, nonlinearity, multiple scales, and model inconsistency. In simplest terms, the problem is to determine the "locations" of the electrons in a molecule given fixed nuclei. The governing equation is the Schroedinger equation and the electrons are described by vector-valued wavefunctions that minimize the energy of the molecule for a given temperature and fixed nucleus locations. Due to the dimensionality of the problems, current methods can only determine wavefunctions for molecules with several hundred atoms. Density Functional Theory (DFT) addresses the curse of dimensionality (by a factor of three) by exploiting the correspondence between the wavefunctions and scalar-valued electron density functions. DFT was the beginning of a new field of chemistry, computational chemistry, for which Walter Kohn and John Pople won the Nobel Prize in 1998. One of the first and most widely used DFT approximations is due to Kohn and Sham. Under the Kohn-Sham model, the density one seeks is the fixed point of a mapping of the densities that approximates the Frechet derivative of the Schroedinger Hamiltonian with respect to the electronic wavefunctions. Mathematically, its "just" a fixed point problem:

find ρ such that $F(\rho) = \rho$

where F is the Kohn-Sham operator and ρ is the electron density.

If F is contractive, then, by Banach's Fixed Point Theorem, the simple iteration

$$\rho_{v+1} = F(\rho_v)$$

will converge to a fixed point. Unfortunately, F is almost never contractive and seldom has even a closed-form representation. So numerically, we expect the worst and hope for the best.

In particular we focus on algorithms for nonlinear (more to the point, nonconvex), nonsmooth fixed point operators. We study regularized (for stability), preconditioned (for multiple scales), limited memory (for high dimensional problems) quasi-Newton (for nonsmoothness) methods in a trust region framework (linking local and global methods) for solving the Kohn-Sham equations. We look to mathematical and physical insight to determine scalings of quasi-Newton methods in order to avoid ill-conditioned matrices that slow convergence.

My first stab at the problem, together with Laurence Marks at the Department of Materials Science at Northwestern University, has been included in the latest release of the Wien2k computational chemistry software package out of the Technical University of Vienna which has over 1000 registered users. So far we've beaten the state of the art by, on average, a factor of three, and in some cases ours is the only method that works.

There are some nice connections to proximal point algorithms and operator splitting strategies that will be key to increasing the size of systems that can be solved. Projection algorithms (a special case of proximal point algorithms) are a promising alternative to conventional path-following techniques and open the door to the possibility of tackling the exact electronic structure equations without resorting to the approximations of density functional theory. These same techniques are used for solving the inverse problem of determining the electron density from diffraction images. In some cases this problem can be solved directly. Hauptman (mathematician) and Karle won the Nobel Prize in 1985 for solving this problem. Still, for large, nonperiodic molecules these direct techniques don't work, and projection algorithms start to shine. Fundamental mathematical questions about the behavior of proximal point and projection algorithms in nonconvex, inconsistent settings such as this remain open and must be addressed before further progress in algorithms is possible. Determining the weakest regularity requirements for achieving linear rates of convergence of simple projection algorithms is currently an active area of research in the variational analysis community and a topic that I am working on with Adrian Lewis of the School of Operations Research and Industrial Engineering at Cornell University. This offers a rare marriage of application and theory. So far, we can prove linear convergence of simple alternating projections between a closed set and a so-called prox-regular set (that is, a set for which the projector is locally single-valued). This, to date, is the most general statement on the matter. Whether this applies to the more complicated algorithms that I use for my inverse problem is still an open question.

The research project outlined here is integrated with graduate education and offers young researchers an excellent opportunity to combine fundamental mathematical research with high-impact practical applications and interdisciplinary work. Undergraduates are also encouraged to get involved through a hands-on diffraction laboratory up and running in our MEC Lab that allows students to create their own "crystals" on transparency film and measure the resulting diffraction patterns created by illumination from an ordinary laser.

Brief News Items from the Math Department

Professor Xiang receives NSF grant

Professor ***Qing Xiang*** has received a grant from the National Science Foundation to study the invariants of incidence matrices, difference sets and strongly regular graphs. This grant will support Professor Xiang and his collaborators in their efforts to develop the mathematics underlying technologies such as CD players, high speed modems, and cellular phones.

Professor Wenbo Li named to editorial board of Journal of Theoretical Probability.

Professor ***Wenbo Li*** has been named to the editorial board of the Journal of Theoretical Probability. The journal publishes high-quality, original papers in all areas of probability theory, including probability on semigroups, groups, vector spaces, other abstract structures, and random matrices. This multidisciplinary quarterly provides mathematicians and researchers in physics, engineering, statistics, and computer science with a peer-reviewed forum for the exchange of vital ideas in the field of theoretical probability.

Professor's Rossi, Driscoll and Luke awarded grant to expand mathematics teaching software.

Professors ***Louis F. Rossi, Tobin A. Driscoll*** and ***Russell Luke*** have received a grant from the University of Delaware's Center For Teaching Effectiveness to expand applications of the MapleTA software for use in pre-calculus, calculus, linear algebra and ordinary differential equations courses. MapleTA is a web-based automatic problem generation tool that provides students unlimited opportunities to hone their problem solving skills. The project is also supporting a pilot program this summer to see if ALEKS (another automated learning package) can improve the performance of incoming engineering majors who traditionally have trouble making the transition from high school pre-calculus topics to college level calculus courses.

Professor R. Luke receives NSF Grant

Professor ***Russell Luke*** has received a grant from the National Science Foundation to study the optimization of density functional methods for atomic structure calculations. This grant will allow Professor Luke and his collaborators at Northwestern University's Department of Material Science to address the numerical challenges facing simulations of molecules built upon atomic-scale physics and chemistry. This work has the potential to impact the design of nanostructured materials and efficient fuel cells.

Students speak at the department's annual Undergraduate Symposium

On April 7, 2007, the Math Department hosted its annual symposium for undergraduate summer research students. This year's speakers were ***Donald Knieriem, Lucero Carmona, Kyle Stern, Paul Parson, Peter Ucciferro, Van T. Lam,*** and ***Haozhu Wang.***

These students were supervised by Professors ***Richard Braun, John A. Pelesko, Louis F. Rossi,*** and ***Chien-Chung Shen.***

Professor Bacuta receives NSF Grant

Professor ***Constantin Bacuta*** has received a grant from the National Science Foundation to study new approaches in solving saddle point problems. This grant will support his research in the areas of both saddle point problems and discretization on non-matching grids. The new algorithms he will build have applications to problems in optimization, optimal control, computational fluid dynamics, linear elasticity, electromagnetism, electrical networks, linear models in statistics, and image restoration.

Professor Sturm receives NSF grant

Professor ***Anja Sturm*** has received a grant from the National Science Foundation to study spatial models for populations with variable offspring laws. This grant will support Professor Sturm's research in spatial stochastic processes that model self-regulation. The questions explored in this work are of interest in epidemiology, ecology, and genetics. The applications range from reconstructing the origin and history of humans to locating and identifying genes on the genome that are causative factors for diseases.

Professor Rossi receives NSF grant and Army SBIR grant

Professor ***Louis F. Rossi*** has received two grants, one from the National Science Foundation, the other from the U.S. Army SBIR Program. These grants focus on biologically inspired wireless networking and funding provided will allow Professor Rossi and his collaborator, Dr. Chien-Chung Shen, to study new and novel networks such as mobile ad hoc networks, wireless sensor and actuator networks, and large grid and point to point networks. In this project, Professor Rossi and Dr. Shen will take inspiration from biology, in particular, the behavior of swarms of biological organisms, to design adaptive network architectures for novel networks.

Professor Cai has been selected as an ACE Fellow

Professor ***Jinfa Cai*** has been selected as one of the 37 American Council on Education (ACE) fellows in 2007-2008 academic year. Professor Cai will spend the academic year at Temple University, working directly with President Ann Weaver Hart to observe and participate in key meetings and events, and take on special projects and assignments while under the mentorship of President Hart and other senior administrators. The ACE Fellowship Program was established in 1965 to strengthen leadership in American higher education by identifying and preparing promising faculty and staff members for responsible administrative positions.

Professor Roselle newest mathematics Professor Emeritus

Professor ***David Roselle,*** longtime president of the University of Delaware, and faculty member in the Department of Mathematical Sciences, has been granted the status of Professor Emeritus of Mathematical Sciences by the board of trustees of the university. In their May 2007 meeting they also granted Professor Roselle the status of President Emeritus.

Professor Rossi named to the editorial board of SIAM's newest journal

Professor ***Louis F. Rossi*** has accepted a position as a founding editor for the Society of Industrial and Applied Mathematics' newest journal, SIAM Undergraduate Research Online (SURO). The goal of SURO is to publish the best of undergraduate research in applied and

continued on page 6

computational mathematics. The new journal will publish papers authored solely by undergraduate students or teams of undergraduate students. The respected and experienced editorial board is charged with applying professional peer review to the unique needs of undergraduates, including a fast turn-around time from reviewers and a rapid acceptance-to-production time-line so that students will see their work published before they graduate.

Professor Cook elected to second term as SIAM Secretary

Professor ***L. Pamela Cook*** has been elected to a second term as Secretary of the Society for Industrial and Applied Mathematics. Professor Cook will continue in office for an additional two-year term: January 1, 2008 to December 31, 2009.

Prof. Lou Rossi recognized as exemplary assessment fellow

Professor ***Louis F. Rossi*** has been named as one of three faculty at UD named Exemplary Assessment Faculty Fellows. The award recognizes Prof. Rossi's activities working with his colleagues and the Office of Educational Assessment to develop a comprehensive assessment plan for our undergraduate programs and for his efforts to apply the same rigorous thinking and analysis used in mathematical research to our teaching activities.

Prof. Driscoll named to the editorial board of the SIAM Journal on Scientific Computing

Professor ***Tobin A. Driscoll*** has been named an associate editor of the *SIAM Journal on Scientific Computing*. The *SIAM Journal on Scientific Computing* contains research articles on numerical methods and techniques for scientific computation. According to ISI journal reports for 2006, *SISC* has the 6th-highest impact factor among all applied mathematics journals.

Professors Cakoni, Colton, and Monk receive Air Force Grant

Professors ***Fioralba Cakoni, David Colton,*** and ***Peter Monk*** have been awarded a three year grant from the Air Force Office of Scientific Research. This project is concerned with problems in electromagnetic imaging where weak scattering models and nonlinear optimization techniques are inappropriate. The specific problems to be considered are the non-destructive testing of dielectrics, the detection of caves and tunnels in the earth and imaging problems associated with anisotropic materials.

Mathematics Student Chosen as Goldwater Scholar

Congratulations to mathematics major ***Spencer Tofts*** who has won a prestigious Goldwater Scholarship. The scholarship program, honoring the late U.S. Sen. Barry M. Goldwater of Arizona, is designed to encourage outstanding students to pursue careers in the fields of mathematics, the natural sciences and engineering. The Goldwater Scholarship is the premier undergraduate award of its type in these fields and students compete nationally for the award.

Mathematics Department Graduates Nine New Ph.D's

In 2008, the Department of Mathematical Sciences graduated nine new Ph.D's. Students receiving their doctorate are ***Jon Regan Beckham, Craig Culbert, Todd Gutekunst, Alfa Heryudono, Derek Moulton, Zeying Wang, Noam Zeev, Xinyi Zhang,*** and ***Junhua Wu.*** Congratulations to all of our graduates.

Prof. Bettyann Daley receives degree in education.

Professor Bettyann Daley has received a Doctor of Education degree with a major in educational leadership. Her thesis was entitled: "A College Departmental Plan to Address the Deficient Algebra Problem in College Freshmen." In her work she studied the difficulties students have when transitioning from high school to college mathematics for students in majors that do not require more then one or two semesters of mathematics.

Connections – The Department and Local High Schools

The Department of Mathematical Sciences enjoys a unique relationship with high schools in the state of Delaware. Many of the state's mathematics teachers have been trained in our department, some of our faculty teach advanced courses in local high schools, and over the last few years, Professor's *John A. Pelesko* and *Cristina Bacuta* have worked to provide novel professional development training for in-service high school mathematics teachers. This past year saw two such workshops hosted by the department. In October, the mathematics faculty from McKean High School and the Charter School of Wilmington spent a day with faculty from the department exploring cutting edge research problems in mathematics. Professors *Richard Braun, Gary Ebert, Russell Luke,* and *Louis F. Rossi* shared their expertise and worked with faculty to develop new ways to inspire high school mathematics students. In November, *Cristina Bacuta*, along with *Christine Ebert*, organized a professional development day for the mathematics faculty of Newark High School. Professors *Kay Biondi*, *Christine Ebert*, and *Gary Ebert*, gave presentations and led interactive sessions for this group. Professor's *Peter Monk, John A. Pelesko*, and *Joseph Pika*, also participated in the day's activities.

In the coming years we hope to extend these type of activities and include the mathematics faculty from other local Delaware high schools. If you or your faculty are interested in this type of activity, I encourage you to contact either *John A. Pelesko* (pelesko@math.udel.edu) or *Cristina Bacuta* (crbacuta@math.udel.edu) to explore these possibilities further.

Seminar on stochastic processes conference 2008 at UD

Anja Sturm

From April 3-5, 2008 we have had the pleasure to host the Seminar on Stochastic Processes at the University of Delaware. These informal conferences have been held annually since 1981 and have become one of the most important regular conference series for probabilists in North America. The event at the University of Delaware, organized by Dr. Anja Sturm and Dr. Wenbo Li, has been a great success attracting over eighty participants, accomplished researchers and young investigators in probability and stochastic processes alike. Apart from informal sessions, in which in particular young Mathematicians had the opportunity to give short presentations on their research and present open problems, excellent talks were given by five invited speakers:

Amarjit Budhiraja, University of North Carolina

Xia Chen, University of Tennessee

Richard Kenyon, Brown University

Anita Winter, University of Erlangen-Nuernberg (Germany)

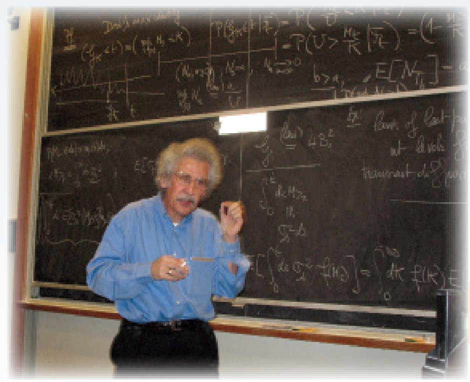
Marc Yor, Université Paris 6 (France)

University of Delaware participants with Professor Marc Yor (Université Paris 6) who lectured on "An interpretation of the Black-Scholes formula in terms of last passage". From left to right, graduate students Liquan Huang, Ang Wei, Dr. Xinyi Zhang are followed by Professor Marc Yor and Professor Wenbo Li.

Topics ranged from branched polymers over tree-valued processes with applications in genetics and stochastic games to large deviations of random walk intersection times and new interpretations of the famous Black-Scholes formula used in finance.

In addition, an afternoon session commemorating Frank Knight's life and work took place. Frank Knight, who died March 19, 2007, has made numerous creative contributions to probability theory and particularly to stochastic processes throughout his long research career. Examples include the Ray and Knight compactifications as well as the introduction and development of prediction processes. The session, led by Marc Yor and Ed Perkins (University of British Columbia), summarized Frank Knight's work and gave anecdote from his life.

The conference was generously sponsored by the National Science Foundation as well as by our own Department of Mathematical Sciences. This support contributed greatly to the success of the conference, not least by providing funding and thus making it possible for many graduate students and young researchers to attend.



Professor Marc Yor (Université Paris 6) lecturing on "An interpretation of the Black-Scholes formula in terms of last passage."

The International Conference on Inverse Scattering Problems which is taking place in Sestri Levante, Italian Riviera, May 8-10, 2008, is organized in celebration of 65-th birthday of David Colton and in recognition of the international leadership and outstanding scientific achievements of David Colton and Rainer Kress in the area of inverse scattering problems.

We will gather at this occasion researchers who have actively interacted with D. Colton and R. Kress and those who have been influenced by their achievements. The main sponsors of this event are the AFOSR London Office and INRIA Paris, with some contribution from the University of Delaware, the University of Göttingen, Germany and the University of Genova, Italy.

David Colton received his B.S. degree form California Institute of Technology, Ph.D. from the University of Edinburgh, Scotland and D.Sc. degree from the University of Edinburgh. He held the Chair of Applied Analysis at the University of Strathclyde, Glasgow before joining the University of Delaware as a Professor of Mathematics in 1978. He became Unidel Professor in 1996.

The research of D. Colton and R. Kress has essentially influenced the development of the mathematical foundations of inverse scattering theory. Together, they have written two research books that have become classics in this area each cited over 1000 times.

Fioralba Cakoni

On behalf of the Organizing Committee

Donald Marquardt (1929-1997)

Russell Luke

I was delightfully surprised to learn recently that one my favorite algorithms is the namesake of one of our department's very own. Donald W. Marquardt was a native of New York City and earned a Bachelors degree in mathematics and physics at Columbia University in 1950. Drafted during the Korean Conflict, he served in the U.S. Army Chemical Corps at Camp Detrick -- later upgraded to Fort Detrick-- in Maryland where he did statistical analysis related to biological research. This experience convinced the young Marquardt to pioneer a career in the new field of statistics. After the Army he took a job at DuPont as a research engineer and mathematician. He spent evenings and weekends working towards a Masters degree in mathematics and statistics at the University of Delaware, which he completed in 1956.

At DuPont Marquardt worked on a wide variety of problems, from nonlinear interpolation of thermodynamic models to help with plant design, to estimating heats of formation from laboratory data, to the optimization of manufacturing processes, and even safety statistics. Many of the problems he worked on, while from very different applications, boiled down to the same optimization problem: nonlinear least squares. Marquardt's problems were tiny by today's standards, only 2 or three variables, but the nonlinearity, together with primitive computers (46 word RAM and 3.75 floating operations per second!) provided the necessity that begets invention.

At the time, the state of the art for such problems was either the method of steepest descent with a line search or Newton-type methods. Gradient descent with an optimized step-length is extremely robust globally but it is only asymptotically linearly convergent, so it can be very slow. Newton's method, on the other hand, converges quadratically near a solution, but is unstable globally. Looking at every iterate on the path to the solution, Marquardt observed a characteristic behavior for hard problems: methods like steepest descent, which follow the gradient of the objective function, marched in a direction that was nearly orthogonal to that of Newton-like methods, which generate sequences based on a linearization of the first derivative of the objective function. This behavior is symptomatic of long, narrow, banana-shaped valleys in the objective function (Rosenbrock's function is the classical example). Ideally one would choose a descent direction between these two extremes. This, coupled with a strategy for finding a reasonable step length in the given direction would provide the means to quickly and robustly solve the nonlinear optimization problems that Marquardt was faced with.

Some ideas are singular points like a tree falling in the forest with no one to hear. Others seem to be part of a convergence of simultaneous discoveries like an inevitable avalanche that changes the landscape. Marquardt's algorithm for nonlinear optimization, published in 1963, was of the latter category, though it was preceded 19 years earlier by the same idea due to Kenneth Levenberg that landed without making a sound. The Levenberg-Marquardt algorithm is so named to honor both its inventors. And though Marquardt arrived independently at the same conclusion many years later than Levenberg, Marquardt's publication included two critical features that created some noise: a practical, though critical parameter "tweak" that made the algorithm fly, and, equally important, a free Fortran implementation.

In a nutshell, the idea is to add a scaling of the identity to the second derivative of the function one is trying to minimize.

For algorithms built on the second-order Taylor series approximation to the objective with such an adjustment to the second derivative term,

the larger the scaling, the more the next iterate rotates in the direction of steepest descent while at the same time becoming shorter; in the other extreme, as the scaling approaches zero the step is identical to the Newton step. This is one of the first instances of what are now known as trust-region strategies. The practical detail Marquardt added was a technique to dynamically adjust the scaling of the identity so that one gets robust performance far from the solution and quadratic convergence near the solution. This innovation was the product of a great deal of numerical experimentation, which Levenberg had not done (all available computers were occupied with more pressing matters in 1944).

Levenberg's work was ahead of its time, but Marquardt's work came when the same idea appeared in many different forms. A year before Marquardt's work appeared, J. J. Moreau published in French a paper on what he called proximal operators which have only recently gained the serious attention of numerical optimizers, and from which Levenberg and Marquardt's method can be derived. Indeed, Marquardt extended his ideas to reinvent proximal operators from a statistical perspective, what was later called ridge regression. Also in 1963, the Russian mathematician Alexei Tikhonov published two works on stable approximations of ill-posed linear operator equations, again a special case of Moreau's proximal operator approach. Tikhonov regularization, as it is known today, is central to the field of inverse problems and is a particular favorite in our department. For whatever reason, regularization was an idea whose time clearly had arrived. What made Marquardt's work rise above the others was the companion code that he made available to practitioners.

Marquardt continued to make valuable contributions to the field of statistics and in the last two decades of his life he focused on influencing beneficial changes in organizations. He was president of the American Statistical Association (1986), co-architect of international quality standards (ISO 9000), head of DuPont's Quality Management and Technology Center, and in 1991 founder of his own company, Donald W. Marquardt & Associates.

UD Math Students Score Big in the Putnam and MCM Competitions

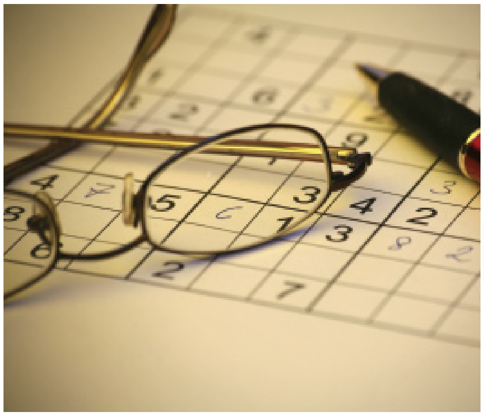
Sometimes mathematics is a competitive sport, and this year, teams of University of Delaware students scored big in two of the sports biggest tournaments. The annual ***Putnam Competition*** is organized by the Mathematical Association of America and has been held annually for sixty-seven years. Known as one of the most challenging and difficult mathematics competitions in the world, the list of past winners of the Putnam include two Nobel Prize Winners and three Fields Medallists. This year, University of Delaware team members ***Bobby DeMarco, Spencer Tofts*** and ***Alison Gordon*** ranked 66th in the competition. ***Stephen Johnson*** also participated and served as first alternate for the team. This year's competition included 3753 contestants from 516 institutions. The team was organized and coached by Professors ***David Bellamy*** and ***K. N. Ranganathan***.

In the world of applied mathematics, the most prestigious tournament is the ***Mathematical Contest in Modeling*** (MCM) sponsored by the Consortium for Mathematics and its Applications (COMAP). The University of Delaware has a close relationship with this special modeling contest. One of the past COMAP presidents is former University of Delaware President and Emeritus Professor of Mathematics *David Roselle*. For the last six years, Professor ***Louis F. Rossi*** has organized and coached teams from the University of Delaware. This year, one of his teams took top honors, a truly amazing achievement.

The MCM contest challenges teams of up to three undergraduates to solve an open-ended problem in four days. For 2008, more than 3800 teams registered for the contest, but only 1162 submitted a complete solution. Student teams must propose mathematical models supported by the latest scientific research and present a comprehensive analysis of the resulting solution. Two problems are posed during the contest, and students are free to choose either one. This year, the problems were "Take a bath" asking teams to model the effects of the melting of the North Polar Ice Cap due to global warming, and "Creating Sudoku Puzzles" asking teams to devise algorithms for constructing Sudoku puzzles of varying difficulties.

Undergraduates ***Matt Thies, Bob Liu*** and ***Zachary Ulissi*** earned an Outstanding designation for their work on the "Take a Bath" problem. The Outstanding designation was awarded to only 9 teams, placing UD in the top 1% worldwide. Their report will be published in the UMAP journal next fall. Undergraduates ***Donald Knieriem*** and *Robert A Mitchell III* earned a Meritorious designation for their project report on the Sudoku problem. The Meritorious designation is the second highest and has been given to the top 13% of completed reports this year. Undergraduates ***Stephen Johnson*** and ***Kyle Thomas*** earned a Successful designation, reserved for those who enter a complete project report.

Congratulations to all students participating in the Putnam and MCM competitions and to their coaches on a truly outstanding "math season."



New Faculty

The Department of Mathematical Sciences continues to hire new faculty to replace retirements and to add strength in new areas. In this newsletter, we are pleased to introduce our two most recent additions to the department.

Dr. Alfinio Flores is our new Hollowell Professor of Mathematics Education. He received his Bachelor of Science and Masters of Science degrees at UNAM, the National University of Mexico. He received his doctorate

degree in mathematics education from The Ohio State University. His primary interest is helping students and prospective and in service teachers develop their conceptual understanding of mathematics. He uses computers, calculators, and concrete materials to make mathematical abstractions more tangible and help students and teachers develop a network of connected mathematical concepts. He has published over 120 articles and book chapters in his field. He is an avid biker.

Dr. Dejun Xie joins us as a Unidel Postdoctoral Fellow. He is an expert in the area of financial mathematics and related fields. This includes ordinary and partial differential equations, functional analysis, asymptotic analysis, stochastic processes, and statistical modeling. Most recently, his work has focused on the free boundary problems that arise in mortgage contract valuations.

Featured Graduate Student:

Derek Moulton

Derek Moulton is originally from Littleton, Colorado. He attended the University of Denver where he received his Bachelor of Science in Mathematics in 2003. Derek arrived at the University of Delaware in the fall of 2003 and began working towards his doctorate in applied mathematics.

For the last several years, Derek has been working with his Ph.D. supervisor, Professor **John A. Pelesko**, on a variety of projects ranging from the study of heat transfer in coated bodies to the study of soap films subjected to electric fields. His first paper, "Thermal Boundary Conditions – An Asymptotic Analysis," appeared in the journal Heat and Mass Transfer last year. His subsequent papers have all focused on the behavior of soap films in electric fields. His most recent paper, "Theory and Experiment for Soap-Film Bridge in an Electric Field," is due to appear in the prestigious Journal of Colloid and Interface Science this year. Derek recently successfully defended his thesis, "Mathematical Modeling of Field Driven Mean Curvature Surfaces," and is now extending his work to magnetic soap bubbles.

Derek has become known as an excellent speaker. He has given numerous talks in the department's graduate student seminar series and has also given invited talks at the University of Maryland, Dickinson University, and at an International Conference on Non-linear Dynamics and Chaos. His speaking ability serves him well in the classroom and two year's ago his excellence in teaching was acknowledged with the Baxter-Sloyer Graduate Teaching Award.

Derek recently accepted the Hanno Rund Postdoctoral Fellowship at the University of Arizona and hence in the fall will be relocating to Tucson. We congratulate Derek on his outstanding achievements at the University of Delaware and wish him the best of luck in Arizona and with all his future endeavors.

2008 Student Award Recipients

The **Baxter-Sloyer Graduate Teaching Award** recognizing graduate teaching assistants who have demonstrated superior effectiveness in teaching and in the performance of their responsibilities was this year awarded to *Brian M. Rife.*

The **Stephen J. Wolf Memorial Scholarship** awarded to a student entering the senior year majoring in mathematics who has demonstrated both love and talent for the subject was awarded to *Spencer N. Tofts.*

The **Carl J. Rees and Eleanor K. Rees Scholarship** which is awarded to undergraduate students majoring in mathematics upon academic performance went to *Rachel E. Bailine, Michele L. Giuliano, Stephen T. Johnson, Mark W. Mackey, Angela M. Pollino, David J. Puliti, Leanna M. Shannon, and Spencer N. Tofts*

The **Outstanding Student Teacher Award** for an undergraduate student who has demonstrated outstanding performance in student teaching went *Caitlin M. Bogosta and Shannon D. Tingley.*

The **Mathematical Sciences Department Faculty Recognition of a Graduating Senior 2008** was given to *Alison M. Gordon and Robin A. Prescott.*

The **William D. Clark Prize** for a senior majoring in mathematics who has shown unusual ability in the area was this year presented to *Robert V. DeMarco..*

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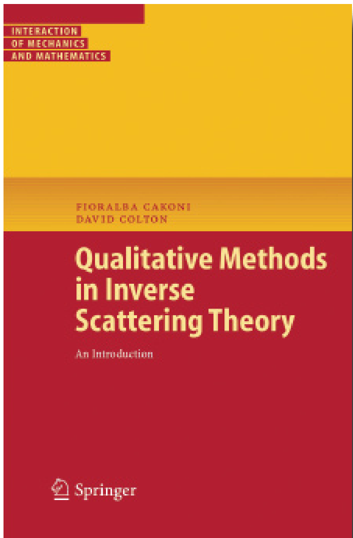

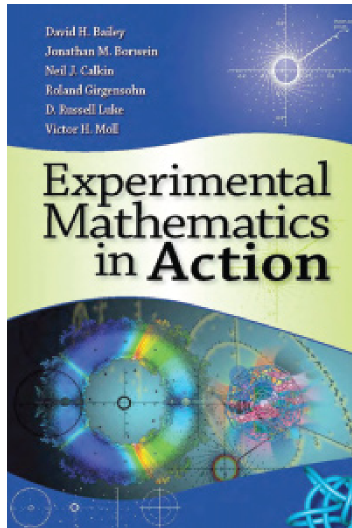

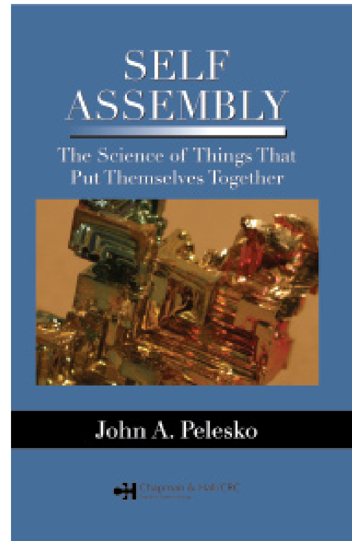

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