Spring 2009

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

UNIVERSITY OF DELAWARE

Chair's Message

Peter Monk

One of President Harker's strategic goals for the University is to enhance graduate education and to propel graduate programs to greater prominence nationally. This is an exciting opportunity for the Department to showcase our graduate program that has a long history of producing excellent PhD and Master students. The Graduate Committee, under the Director of Graduate Studies Professor Braun, is conducting open discussions in the Department to enhance the graduate curriculum. In addition to this we are organizing two exciting programs to help graduate students through critical transitions.

The first years of graduate school can be a difficult experience for many students: they need to adapt to the pace and content of graduate courses, make new friends, become comfortable in new surroundings and often get used to becoming a teacher. I think that those of you who have been graduate students will agree that smoothing this transition could help improve graduate student morale and retention rates. This past summer the Department, with funding from the College of Arts and Sciences, organized a "Boot Camp" for incoming graduate students. Held over three weeks in August and organized by Professor Braun, this camp invited American graduate students to campus for social and

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Inverse Problems in Scattering Theory

Fioralba Cakoni

Over the last two decades inverse scattering theory, a particular area of inverse problems, have developed into an important branch of mathematics. Roughly speaking, inverse scattering problems are concerned with extracting information about physical and geometrical properties of an object from the observed scattered data. For example, a transmitted incident acoustic or electromagnetic wave once it hits an object is disturbed (scattered, transmitted, diffracted) and one may want to determine the location and the shape of this object from the measured disturbed wave near or far away from the object (see Figure 1). Problems of this nature arise in many areas of application such as medical imaging, non destructive testing and underground interrogation.

The field of inverse scattering problems is a relatively new area of mathematical research having its origin in the fundamental papers of Tikhonov in the mid-1960s. The reason the area is so young is historical prejudice dating back to Hadamard who claimed that the only problems of physical interest were those that had a unique solution depending continuously on the given data. Such problems were called *well-posed*, and the problems that were not well posed were labeled *ill-posed*. In the mean time the success of radar and sonar caused scientists to ask if more could be determined about a scattering object than simply its location. Such problems are in the category of *inverse scattering problems* and it was slowly realized that these problems, although of obvious physical interest, are ill-posed. At the time, due to the lack of a mathematical theory of inverse problems together with limited computational capabilities, further progress was not possible.

Tikhonov's introduction of regularization methods for linear ill-posed problems dramatically changed this situation. More specifically, a common abstract framework for inverse problems can be constructed in terms of operator equations of the form $A\varphi=f$, where $A:X\to Y$ is a compact operator mapping a Hilbert space X into a Hilbert space Y. Since A is compact the inverse of A, if it exists (more generally the Moore-Penrose generalized inverse of A), is not continuous and hence the solution φ (more generally the least squares solution) does not depend continuously on the data f. The latter means that small changes on the data f produce large errors in the solution φ. Denoting by A^* the adjoint of A, the Tikhonov *regularized solution* is then the unique solution of the well-posed equation $(A^*A+\alpha I)\varphi_\alpha = A^*f$, where $\alpha>0$ is the regularization parameter which can

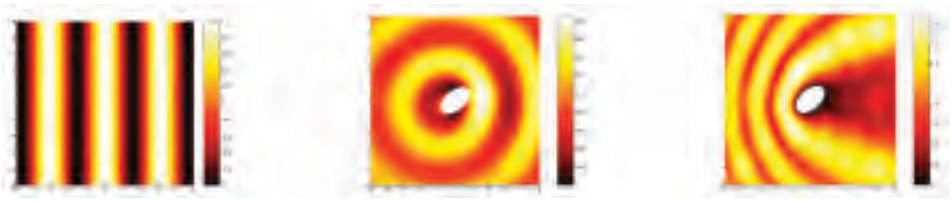

Figure 1. *The scatterer is an impenetrable object of ellipse shape. The figure shows the incident field u^i, scattered field u^s and total field u^i+u^s.*

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academic orientation (the foreign graduate students are already on campus during this time to attend the English Language Institute). Three leaders (Professors Olagunju and Rossi and Ms Pamela Kosick), each with a graduate assistant, worked with the students to recall specific mathematical topics relevant to the first semester courses. Although it has yet to be seen if the Boot Camp will increase the retention of incoming students, anecdotal comments suggest that it did succeed in helping the students form a mutually supportive cohort, and get settled in Newark. We intend to assess the outcome more formally and hold another Boot Camp (perhaps with a more inviting name!) this coming summer. Development funds will be used to help support this activity.

Continuing with the theme of transitions in graduate education and team building throughout the Mathematical Sciences, I am happy to report that the Department was the recipient of a $38,000 grant from the Office of Graduate Studies to fund our proposal for "Groups Exploring the Mathematical Sciences" (GEMS). Professor Pelesko, who will lead the program, wrote the proposal with help from Professor Braun. Teams, led by a faculty member and including at least one graduate student and one undergraduate, can apply for funding to support a research program during the graduate student's first full year at Delaware. The goal is to offer graduate students an early introduction to research, close contact with faculty, and experience working in a research team. Participating undergraduate students will benefit from faculty and graduate student mentoring, as well as from receiving the usual benefits of undergraduate research.

Already the GEMS project has a web page:

http://www.math.udel.edu/GEMS

which features initial project proposals from several faculty. Besides helping graduate students at a critical juncture in their training, the GEMS program is also intended to provide a springboard for grant proposals to government agencies to help support novel features of our graduate program. Such support has assumed greater urgency with the current financial crisis and likely reductions in the Department's budget in the coming years.

Over the last two years, I have helped organize a campus-wide seminar group interested in computational solutions to large scale problems; one answer to the question of how to further this common interest has taken shape. The Department has also taken a leadership role, again with Professor Braun serving to focus the effort, in developing an interdisciplinary certificate in "Computational Science and Engineering". This certificate, which we expect will be approved by the Faculty Senate this spring, will be awarded to students working on computer based simulations or numerical analysis who take a program of 5 courses, some being directly related to numerical simulation in their major, and some in basic computer science or numerical analysis. The certificate recognizes the extra work in attaining core competence in computational science, as well as the multidisciplinary nature of modern science. The certificate is of course open to part time students, and we hope to welcome our first students next fall.

Turning now to the undergraduate program, I would like to express my thanks to Professor Gilberto Schleiniger who has just stepped down from his long-standing position as Director of Undergraduate Studies. Amongst his many accomplishments in this position one stands out in particular, his development of the new undergraduate major: Quantitative Biology. This major, developed in conjunction with the Department of Biological Sciences, is intended to train a new generation of mathematically sophisticated biologists. We are forming an advisory committee from local industry for this major and hope this will be a springboard for greater community involvement in our programs. Fortunately, the undergraduate program is still in capable hands because Professor David Olagunju agreed to take over this demanding position at the start of this academic year.

This year we welcome one new faculty member: Professor Sebastian Cioaba who joins us from a post-doc position with Professor Fan Chung at the University of California, San Diego. Professor Cioaba is originally from Romania and did his graduate work at Queen's University in Kingston, Canada. He works on discrete mathematics and graph theory, using eigenvalue methods to prove connectedness properties of graphs or networks. These results have implications for network robustness.

As we look forward to 2009, I have to acknowledge some concerns. The financial problems that have engulfed the country over the last months will not pass by the University or Department. Nevertheless I am optimistic that the momentum we have gained in undergraduate and graduate education as well as faculty scholarship over the last years will be maintained into the next year. Indeed the University has taken the brave decision to continue hiring faculty, and we currently have two active searches in Mathematics Education and Mathematical Biology.

From the Editor

Dear Department Alumni, Students, and Friends,

It is my pleasure to present to you the fifth edition of Reckonings. I hope that it will provide you with an interesting and engaging update on some of the department's achievements and milestones over the past year as well as with a glance at future goals and events. Regular features include a message from the chair, profiles of new faculty, brief news items from the department regarding grant activity, collaborative programs, awards and publicity, two featured graduate students as well as donor support.

This year we also welcome a contribution from Alumnus Dick Postles who writes about the relationship between UD's mathematics department and DuPont's world class statistics group from the 60's to the 80's. Research interests and focuses in the department have evolved since then but the department has over the last two decades once again been in a leadership role regarding another type of inverse problem: inverse scattering theory. Professor Cakoni's article in this issue describes this area and its impact on everyday life as well as our faculty's contributions to this rapidly growing field. A graduate school on "The Mathematics of Inverse Problems" will take place at UD this summer. You will find more detail on this and other upcoming conferences and workshops held on our campus such as the "Mathematical Problems in Industry Workshop 2009" in this newsletter.

As already mentioned by the chair the department is making great efforts to further improve its graduate program. One such effort is a summer workshop for incoming graduate students which took place for the first time in the summer of 2008 and is highlighted in a piece written by Professor Rossi.

Finally, Professor Schleiniger focuses in his article "Quantitative Biology at UD - Math meets Biology" on a new and innovative addition to our undergraduate program: an interdisciplinary major for students who are interested in applying complex and sophisticated mathematical tools in the biological and life sciences - a trend that has recently revolutionized the latter areas by bringing fascinating possibilities within reach and which is sure to only grow in importance.

I would like to thank all of the contributors to this year's newsletter as well as Liz Ihrig from the Office of Communications and Marketing at UD who has once again done the design and layout. I would also like to encourage everyone to keep checking the department's web pages (www.math.udel.edu) throughout the year for current news items and events. The department is in the process of redesigning and restructuring the web pages, and we hope that you will find them an even more attractive and useful resource in the future.

If you have news or other contributions that you would like to share either on the web pages or in future editions of Reckonings please feel free to send me an email at sturm@math.udel.edu. I am looking forward to hearing from you.

Anja Sturm

Inverse Problems continued from cover

be determined for instance by using the Morozov discrepancy principle. Further development of the mathematical theory of ill-posed problems, together with the rapid development of computing facilities, set the stage for the subsequent mathematical investigation in inverse scattering which has now become one of most rapidly growing areas of research in applied mathematics.

Scattering theory plays a central role in mathematical physics. Indeed, from Rayleigh's explanation of why the sky is blue to Rutherford's discovery of the atomic nucleus, through the modern medical applications of ultrasound imagining and nondestructive testing, scattering phenomena have attracted and challenged scientists and mathematicians for more than a century. Broadly speaking, scattering theory is concerned with the effect of an inhomogeneity on an incident particle or wave. In particular, if the total field is viewed as the sum of an incident field u^i and a scattered field u^s then the *direct scattering problem* is to determine u^s from knowledge of u^i and the differential equation governing the wave motion (see Figure 1). Of possibly even more interest is the *inverse scattering problem* of determining the nature of the inhomogeneity from knowledge of u^s, i.e. to reconstruct the differential equation and its domain of definition from its solution. In particular, the aim of research in inverse scattering is to not only detect but also to identify unknown objects through the use of acoustic, electromagnetic or elastic waves. Although the success of such techniques, for example for ultrasound and x-ray tomography in medical imaging, has been truly spectacular, much more mathematical research is needed in other areas of application which are forced to rely on different modalities using limited data in complex environments.

Until a few years ago, essentially all existing algorithms for target identification were based on either a weak scattering approximation or on the use of nonlinear optimization techniques. However, as the demands of imaging increased, it became clear that incorrect model assumptions inherent in weak scattering approximations impose severe limitations on when reliable reconstructions are possible. On the other hand, it was also realized that for many practical applications nonlinear optimization techniques require a priori information that is in general not available. Hence, in recent years alternative methods for imaging have been developed which avoid incorrect model assumptions but, as opposed to nonlinear optimization techniques, only seek limited information about the scattering object. Such methods come under the general title of *qualitative*

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methods in inverse scattering theory. The first method in this class is the *linear sampling method* which was developed here in Delaware in 1996 by UD professor D. Colton and his collaborator A. Kirsch. The main idea is to construct an indicator function for the support of the scattering object by exploring singular solutions and solving an appropriate ill-posed first kind integral equation with the kernel being the measured multi-static data. The linear sampling method reconstructs the support of the scattering object without the need of any a priori information on the physical properties of the scatterer and it is easy and fast to implement. Further research in this direction, part of which is conducted in our department, includes the determination of boundary coefficients using the linear sampling method, the reciprocity gap function method (see Figure 2), factorization methods, transmission eigenvalues in nondestructive testing etc. My book with D. Colton entitled *Qualitative Methods in Inverse Scattering* provides a detailed introduction to the area.

Inverse scattering is a rapidly growing area which still has many open problems. It is an area where beautiful and innovative mathematical analysis comes together with modeling and scientific computation to solve problems that impact everyday life. What more can one ask of *applied mathematics*?

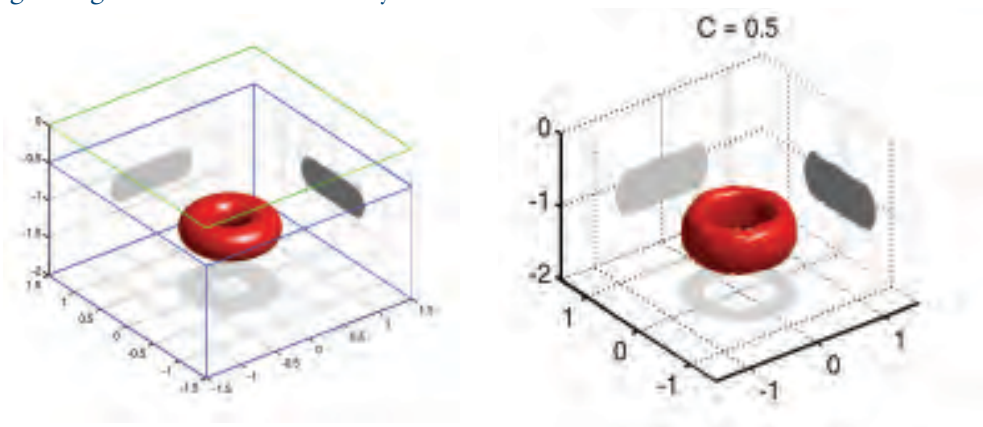


Figure 2. *Reconstruction of a torus buried in a layered medium using the reciprocity gap functional method and near field data; left is the exact torus and right is the reconstruction.*

Math Department offers workshop to incoming graduate students

Lou Rossi

Last year, the department received a grant from the Provost's Office to create a new workshop for incoming graduate students to ease the transition between undergraduate and graduate studies. Prof. Braun, Director of Graduate Studies, with the help of the Graduate Studies Committee designed a workshop consisting of four modules in analysis, ordinary differential equations, linear algebra and matlab, respectively. Each module is a self-contained mini-course. The purpose of the workshop (affectionately termed "mathematical boot camp") is to help students review material from their undergraduate studies and explore concepts at depth closer to what might be expected in their first year of graduate studies. Each module has a leader and a graduate student helper. The matlab module has been a successful offering for many years, and all participants would be required to take the matlab module. With the new workshop, students choose any two of the remaining three new modules. Student participation is essential for each module which consists of mini-lectures, problem sets and presentations.

The August 2008 workshop came together smoothly and feedback from all parties has been positive, so we expect our boot camp to become a permanent part of our graduate program. The 2008 workshop leaders were Profs. Driscoll (Matlab), Olagunju (ODEs), Rossi (Analysis) and graduate student Pamela Kosick (Linear Algebra). The workshop helpers were graduate students Luyen Nguyen, Bryan Petrak, Liwei Xu and Qinghua Zhu. The inaugural boot camp inductees were Nicholas Brubaker, Donna Mark, Jonathan Nuckols, Michael Shoushani, Rachael Todd, Wisely Wong and Matt Zumbrum. Calculations and derivations were punctuated by snack breaks, happy hours and an occasional field trip to have an ice-cream at Woodside Farm Creamery.

(Photo shows workshop participants at Woodside Farm Creamery)

Brief news items from the Math Department

New Delaware student chapter of the Association for Women in Mathematics (AWM) founded

The Association for Women in Mathematics (AWM) is a non-profit organization with over 3000 members that serves two purposes: first, to encourage women and girls to study and to have active careers in the mathematical sciences and second, to promote equal opportunity and the equal treatment of women and girls in the mathematical sciences. With the support of the Department of Mathematical Sciences, a student chapter of AWM was started in November 2008 with undergraduate student **Rachael Bailine** as president, and graduate students **Kara Maki** as vice president, **Pamela Kosick** as treasurer, as well as **Jen Miller** as secretary. The faculty advisor for the student chapter is **Dr. Pamela Cook.**

The Delaware AWM student chapter is open to all undergraduate and graduate students, regardless of gender and major. Its purpose will be to educate and provide information about career opportunities in mathematics, to facilitate networking with professional mathematicians and the Delaware community itself, and develop leadership skills. The chapter fosters the exchange of not only research ideas, but also personal experiences providing Delaware graduates with an edge in the early stages of their career.

The Delaware AWM student chapter will conduct monthly meetings and sponsor activities throughout the academic year. Sponsored activities include invited talks by students or professional mathematicians on either their research or their career path; establishing a mentoring program between junior and senior students as well as students and faculty; informal panel discussions about experiences as women in mathematics; participation in local conferences; organizing stress-free, non-academic group outings; and outreach to local high school students. The top priority for Spring 2009 is to establish the infrastructure for an effective mentoring program. For more information please consult the student chapter's web site at www.math.udel.edu/AWM/index.html

Visiting assistant professor Vysotsky receives prestigious award

Dr. Vlad Vysotsky, who is a Visiting Assistant Professor in our department working in the area of probability and stochastic process, was one of the two recipients of the The Young Mathematician Award 2008 given by the St.-Petersburg Mathematical Society of Russia. The award was established in 1962, when it was given to the well known mathematician V.G. Maz'ya. Y.V. Matiyasevitch (1970), who solved Hilbert's tenth problem, and G.Ya. Perelman (1991) (one of the 2008 Fields medalists) are among the previous recipients, many of whom have became well known mathematicians (the Fields Medal is said to be the "Nobel Prize" of mathematics) .

More information is available at: http:/www.mathsoc.spb.ru/mol_mat.html. Dr. Vysotsky.

Professor Braun named to the editorial board of the SIAM Journal on Applied Mathematics

Congratulations to **Professor Richard J. Braun** for having been named an associate editor of the *SIAM Journal on Applied Mathematics.* He will serve for a three year term beginning January 1, 2009. The *SIAM Journal on Applied Mathematics* contains research articles on mathematics applied to the physical, engineering, financial and life sciences. According to the 2007 ISI journal citation reports, SIAP is at the top quartile in citations for all journals in applied mathematics.

Professor Pelesko elected to serve as President-Elect for the CAS Senate

Associate Professor **John A. Pelesko** has been elected to the position of President-Elect of the College of Arts and Sciences Faculty Senate. The senate is a democratic forum responsible for the creation and review of policies concerning curriculum, promotion and tenure, and student academic issues. The senate represents college-wide issues to the college administration, the University Faculty Senate, and the university administration. The President-Elect serves for one year under the mentorship of the current president and assumes the duties of president in the following academic year.

The Physics of the Tear Film and Magnetic Soap Bubbles

Two research groups from the Department of Mathematical Sciences have been featured for work presented at the Annual Meeting of the American Physical Society's Division of Fluid Dynamics. This meeting, held in San Antonio, Texas, November 23-25, attracted well over 1000 scientists from around the world. Presentations by **Richard Braun, Kara Maki, John A. Pelesko,** and **Derek Moulton**, have attracted the attention of the scientific community. An article about the work by Braun and Maki on human tear films appeared on the LiveScience web site. In the article, graduate student Kara Maki is featured for her work on the dynamics of the tear film when reflex tearing occurs. Slicing an onion is a classic cause of reflex tearing; when the increased tear production starts, the tear fluid may overcome normally occurring barriers to flow across the middle of the eye. Maki and her PhD advisor, Dr. Richard Braun, quantified this phenomenon with an simplified mathematical model, which was solved on a computer. They are currently extending the models to more realistic geometries and conditions. More information can be found in the article at

http://www.livescience.com/health/081120-teardrop-physics.html.

Dr. John Pelesko and his recent PhD graduate Dr. Derek Moulton, now at the University of Arizona, were invited to prepare a lay-language version of their work on magnetic soap films for the American Physical Society's virtual press room. Pelesko and Moulton have added magnetic nanoparticles to a standard soap film and recorded the results when a magnetic field is applied. A variety of exciting effects are observed, including having the soap film drain upward

against gravity. The striking visual patters observed in the experiments are available in the APS virtual pressroom at http://www.aps.org/units/dfd/pressroom/papers/bubbles.cfm.

Professor Cook receives collaborative research grant from NSF

Under her grant entitled "Time-Dependent and Inhomogeneous Flows of Entangled Polymeric and Micellar Networks" which is collaborative with Gareth H. McKinley at MIT the material properties of complex fluids such as those constituting shampoos, liquid detergents, molten plastics and fluids utilized in enhanced oil recovery will be studied. On the microscopic scale these polymeric fluids consist of large aggregates or macromolecules and the shape and orientation of these molecules control the properties of the fluid and how it performs in the desired application. It is very difficult to characterize these fluids experimentally because their flow properties, unlike those of Newtonian fluids such as water, become inhomogeneous even in simple geometries. This means that the usual types of measurements (in which the fluid properties are measured at the flow boundaries) are not sufficient to understand and characterize the material response. The PIs have formulated a new model or equation of state that more fully describes the microstructural properties of these fluids and how they flow. They now investigate the predictions of this model in various flows.

UD receives NSF award to enhance recruitment and retention of female faculty in sciences

Funding from the National Science Foundation will help to transform the culture for women faculty in science, technology, engineering and mathematics (STEM) fields at the University of Delaware by educating faculty and administrators in best practices for recruitment and retention. The $307,936 grant was awarded through NSF's ADVANCE program, which is aimed at developing systemic approaches to increase the representation and advancement of women in academic science and engineering careers, thereby contributing to the development of a more diverse workforce in these areas. The UD project team includes Pamela Cook-Ioannidis, professor of mathematical sciences. Professor Cook-Ioannidis has a secondary appointment in Chemical Engineering and is also associate dean of engineering. The specific goals of the project are to develop a cohort of faculty to prepare and lead workshops for STEM faculty and administrators on recruitment and mentoring, implement a mentoring and educational process for tenured faculty, and increase awareness and understanding of gender issues among faculty leaders and administrators. UD has already made great advances in recent time: as an example, the proportion of tenured/tenure track women faculty within the College of Engineering increased over the past 10 years from 5 percent of the total faculty to 15 percent, and the number of tenured female faculty in engineering more than doubled in the same timeframe.

Department Receives Graduate Program Improvement and Innovation Grant

The Department of Mathematical Sciences has received a $38,000 grant from the University of Delaware's Provosts Office. The grant was awarded under the Graduate Program Improvement and Innovation Project, sponsored by the Provost's Office. This grant will allow the department to finance the formation of five GEMS, or Groups Exploring the Mathematical Sciences, in each of the next two summers. These groups will be led by a faculty member and employ both graduate students and undergraduate students to work for ten weeks on a research project. The program will also include mentorship training for graduate students. Details of eligibility for the program will soon be available on the GEMS web page http://www.math.udel.edu/GEMS/index.html.

Quantitative Biology major, Laura Sloofman, takes top prize at HHMI Summer Symposium

Laura Sloofman takes first place in the HHMI summer research symposium. The first place award is sponsored by Sigma Xi, the scientific research society, and includes a $100 cash prize and a year's membership in the honorary society.

Laura Sloofman is a Quantitative Biology major, the Math Department's newest degree program designed in close collaboration with faculty in Biological Sciences and Chemical Engineering. Her advisor was Professor Catherine Kirn-Safran, Department of Biological Sciences.

Professor Li receives NSF Grant

Professor Wenbo Li has received a grant of $160,000 from the National Science Foundation for a three year project titled "Small Value Theory in Probability," In this project, Professor Li will develop methods and theory for the study of both typical behaviors and rare events of the type that positive random quantities take smaller values. The major objective is to extend the understanding of related areas and build a general small value theory based on systematic study of various techniques and applications.

Professor Pelesko receives NSF Grant

Professor John A. Pelesko has received a grant of $139,621 from the National Science Foundation for a three year project titled "Modeling Electro-Elastocapillary Systems." In this project, Professor Pelesko will explore the interaction of electric fields with capillary and elastic systems. In creating mathematical models of these systems, Professor Pelesko aims to speed the development of micro- and nanoscale systems based on the principles of electro-elastocapillarity. This project also has an educational component and the funds will be used to support the MEC Lab and to fund an undergraduate student to help with local high school outreach efforts.

Professor Ebert receives NSA Grant

The proposal deals primarily with the construction and classification of finite semifields, and the construction and enumeration of unitals embedded in semifield planes and regular nearfield planes. A semifield is an algebraic structure satisfying all the axioms of a field, except possibly commutativity

and associativity under multiplication. In recent years there has been renewed interest in semifields, which have fascinating connections to many areas of finite geometry and combinatorics, such as translation planes, flocks of a quadratic cone, q-clans, translation generalized quadrangles, skew Hadamard difference sets, and pseudo-Paley graphs. A major part of the proposal is to use certain subspaces of linearized polynomials to produce new infinite families of semifields, and then use the associated "linear sets" to classify all finite semifields that are two-dimensional over their left nucleus and six-dimensional over their center.

A unital is the natural design theoretic generalization of a Hermitian curve in a Desarguesian square order projective plane. Many infinite families of non-Desarguesian square order planes also are known to contain embedded unitals, and it seems that unitals play a significant role in the basic understanding of all square order projective planes. F. Buekenhout has developed two general techniques for constructing unitals in certain translation planes, but the only enumeration of embedded Buekenhout unitals occurs in the Desarguesian plane. A second major part of the proposal involves the investigation and enumeration of Buekenhout unitals embedded in the regular nearfield planes. Hopefully, any techniques developed will naturally generalize to other translation planes, such as the Hall planes and certain families of semifield planes.

Professor Seraphin honored with College of Arts and Sciences Outstanding Service Award

Professor Anthony Seraphin has been honored with this year's College of Arts and Sciences Outstanding Service Award. This prestigious award is given annually to one faculty member in the College whose level of outstanding service to the College, the University, and their profession rises far above the norm. Professor Seraphin was cited for his work on numerous committees including the AAUP Steering Committee, the CAS Steering Committee, the CAS Committee on Diversity in Faculty Recruitment and Retention, numerous faculty search committees, and for chairing the CAS Educational Affairs Committee. Congratulations to Professor Seraphin on this well-deserved award.

Professor Pelesko inducted as member of Phi Kappa Phi

On May 9, 2008, **Professor John A. Pelesko** was inducted as a member of the Phi Kappa Phi Honor Society. The Honor Society of Phi Kappa Phi is the nation's oldest, largest, and most selective all-discipline honor society. The University of Delaware's chapter was the fifth chapter founded. Now, the society boasts over 300 chapters worldwide. This year's other faculty inductees included Thomas Apple, Dean of the College of Arts and Sciences, Chrystall Mouza, School of Education, and Tatyana Polenova, Chemistry and Biochemistry. Dr. Pelesko wishes to thank Dr. Christina Bacuta and Susan Serra for nominating him for membership in Phi Kappa Phi.

Professor Laszlo Babai gives Rees Lectures 2008

Professor Laszlo Babai from the Department of Computer Science and Department of Mathematics at he University of Chicago gave the Carl J. Rees Distinguished Lecturer Series in memory of Professor Carl Rees on May 14 and 16, 2008. His first lecture entitled "The Abelian Sandpile Model" focused on a diffusion process on a grid, the analysis of which has fascinated physicists, mathematicians, and computer scientists for two decades. The process under consideration starts with an empty checkerboard and puts "grains of sand" successively on selected "sites" (cells). When the "pile" at a site has 4 grains, it "topples," passing a grain across each side of the cell. (In the case of boundary cells, one or two grains fall off the board.) Some neighbor may now have acquired 4 grains; we repeat the process until the configuration stabilizes ("avalanche"). Then we add another grain at some site and start all over.

This process was introduced in 1988 by Bak, Tang, and Wiesenfeld as a model of the phenomenon of "self-organized criticality" in statistical physics. The evolution of the system is a "visual feast" (Creutz, 1991), and the dynamics gives rise to remarkable mathematical structure (Dhar, 1990).

The second talk on "Symmetry and Structure of Finite Graphs" discussed the implications of vertex-transitivity (all vertices are equivalent under automorphisms) on the connectivity, isoperimetry, growth, and other parameters of the graph; these properties have applications to group theory, probability theory, number theory, the analysis of algorithms, and differential geometry.

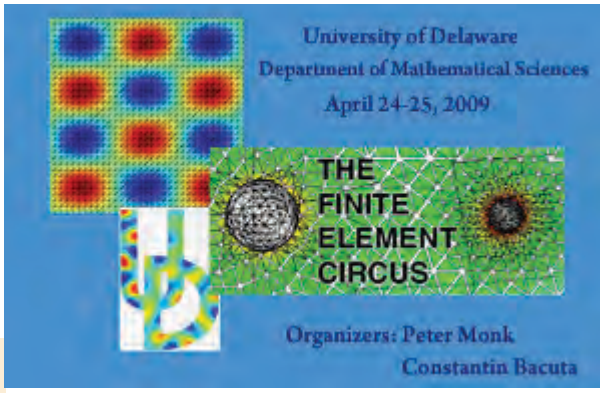
Professors Braun and Rossi receive NSF Grant for Mathematical Problems in Industry Workshop

The Department of Mathematical Sciences is excited to have received a National Science Foundation Special Meeting award to expand the Mathematical Problems in Industry (MPI) workshops. This project is a joint effort involving work between mathematics departments at the University of Delaware, Rensselaer Polytechnic Institute (RPI) and Worchester Polytechnic Institute (WPI). The MPI workshops have a long and successful history of bringing together mathematical challenges from industry and cutting edge mathematical techniques from the academe in an intense week-long workshop during the summer. In its evaluation of the project, the panelists comment, "The MPI workshop is very effective and innovative at bridging the gap between academia and industry". UD's Department of Mathematical Sciences is proud of its history of providing a core of active participants to the MPI workshops and being a regular host for these activities. The project also expands a Graduate Mathematical Modeling Summer camp at RPI to prepare students for the workshop. The Principal Investigators at the University of Delaware are **Professors Lou Rossi** and **Rich Braun**. More information about MPI in 2008 can be found at http://www.math.wpi.edu/MPI2008/. The University of Delaware will host MPI in the summer of 2009.

Research team formed with INRIA at Ecole Polytechnique, France

A collaborative program has been established between the Inverse scattering group at Delaware and a research team at the Department of Mathematics in the Ecole Polytechnique in Paris, the premier scientific institution in France. This program will focus on the use of qualitative methods in electromagnetic inverse scattering theory and will last for five years with funding being provided by the French "Institut National de Recherche de Informatique en Automatique" (INRIA). In particular, funding will be available for the exchange of graduate students, postdoctoral students and faculty members during this period. The research team at Delaware is headed by **Professor Fioralba Cakoni** and at Ecole Polytechnique by Dr. Houssem Haddar.

The collaboration between the inverse scattering group of F. Cakoni, D. Colton and P. Monk at the University of Delaware and H. Haddar at INRIA was initiated by the appointment of Dr. Haddar to a Post-Doc position at the University of Delaware in 2001 followed by continuous collaboration since then. This collaboration has been intense and fruitful: it has led to the development of the linear sampling method in inverse electromagnetic scattering theory, the introduction of the gap reciprocity method for the detection of buried objects and an investigation of the basic theory of transmission eigenvalues and their application in electromagnetic inverse scattering theory. The research team at Delaware together with Dr. Haddar at INRIA has now become recognized as among the leading researchers in the world in the emerging field of qualitative methods in electromagnetic inverse scattering theory. The present program between the research groups at the University of Delaware and the Ecole Polytechnique is designed to encourage further progress in this field as well as to facilitate interaction with the active optimization group at the Ecole Polytechnique.



Finite Element Circus will be held at the University of Delaware

The Spring 2009 Finite Element Circus will be held at the University of Delaware on April 24-25, 2009. The Finite Element Circus is a regular conference devoted to the theory and applications of the finite element method, and related areas of numerical analysis and partial differential equations. This year's conference will be organized by UD Professors Peter Monk and Constantin Bacuta. More information is available on the conference web site http://www.math.udel.edu/~bacuta/circusUDSpring09.html.

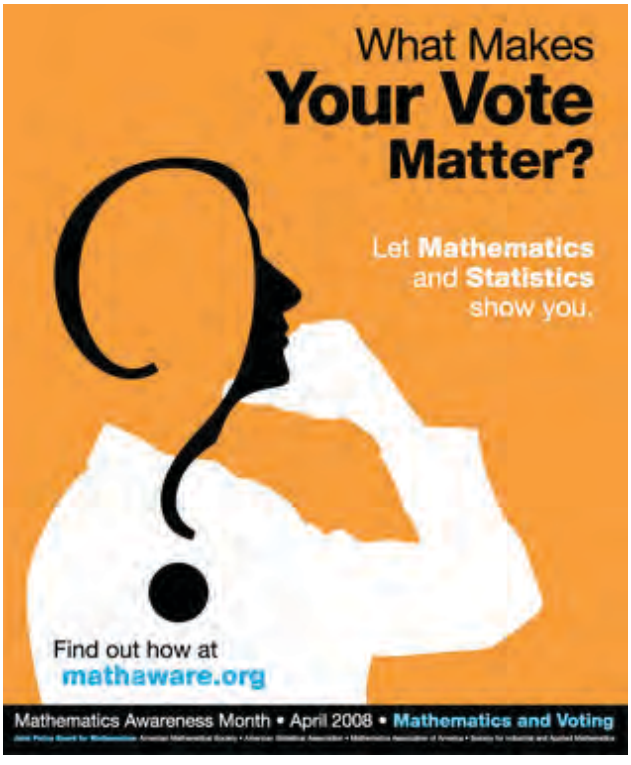
Mathematics Awareness Month presentation by Steven J. Brams

Steven J. Brams gave a colloquium talk on "Mathematics and Democracy - How Democracy Resolves Conflict in Difficult Games", on Wednesday, April 9, 2008.

Steven Brams is a Professor of Politics at New York University and the author, co-author, or co-editor of 16 books and about 250 articles. His recent books include Theory of Moves (1994) and co-authored with Alan D. Taylor, Fair Division: From Cake-Cutting to Dispute Resolution (1996) and The Win-Win Solution: Guaranteeing Fair Shares to Everybody (1999). His latest book, Mathematics and Democracy: Designing Better Voting and Fair-Division Procedures, appeared in 2008.

Brams has applied game theory and social-choice theory to voting and elections, bargaining and fairness, international relations, and the Bible and theology. He is a former president of the Peace Science Society (1990-1991) and the Public Choice Society (2004-2006). He has been a Fellow of the American Association for the Advancement of Science since 1986, a Guggenheim Fellow (1986-1987), and a Visiting Scholar at the Russell Sage Foundation (1998-1999). http://politics.as.nyu.edu/object/stevenbrams.html

The colloquium was part of the activities dedicated to the Mathematics Awareness Month, with the 2008 year's theme on "Mathematics and Voting". Mathematics Awareness Month, held each year in April since 1986, was created to increase public understanding of and appreciation for mathematics. The theme for Mathematics Awareness Month, April 2009, is Mathematics and Climate, **see** http://www.mathaware.org/mam/09/



The **Mathematical Problems** in **Industry** Workshop 2009

The 25th Annual Mathematical Problems in Industry Workshop (MPI09) will be held June 15-19, 2009 at the University of Delaware. The workshop is a lively 5-day interaction between academic problem solvers and problem presenters from industry and government; more than 60 faculty and graduate students are expected to attend. On the first morning, presenters from the private sector and government agencies bring leading edge problems that require mathematical expertise. A typical workshop will have four or five problems. Ad hoc teams form and work on the problems during the week; results are presented to the entire workshop on Friday morning. Reports are written subsequent to the workshop.

Participants from the 2007 MPI Workshop

Past problems have included modeling and analyzing paper making, crystal growth for solar cell manufacture, air bearings, filtration, social network models of alcohol-related problems and many other topics. The workshop is funded by an NSF grant headed by Principal investigators Professors Rossi and Braun. The grant is collaborative with Rensselaer Polytechnic Institute and Worcester Polytechnic Institute, who have also hosted this rotating workshop. This is the fifth time that UD's Department of Mathematical Sciences is hosting the meeting. Information about MPI09 can be found at www.math.udel.edu/MPI. It is sure to be an exciting and productive week!

UD to Host **IMA Summer Graduate** Program

From Monday, June 15, through Friday, July 3, 2009, the University of Delaware will be the host of the Institute for Mathematics and its Applications (IMA) Summer Graduate Program in Mathematics. The course will bring roughly 40 graduate students and young researchers to the UD campus who will concentrate on The Mathematics of Inverse Problems.

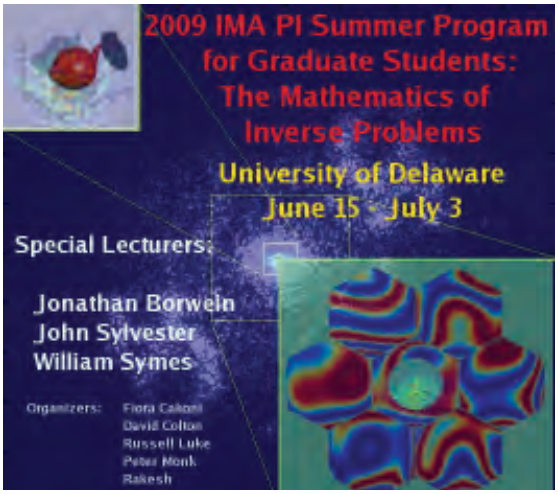
Inverse problems is a fast-growing area involving a broad range of disciplines from the most abstract and pure mathematics to practical engineering. The 2009 summer program on inverse problems covers three different types of inverse problems: inverse problems for hyperbolic PDE's, inverse scattering in the frequency domain, and variational inverse problems. The program will cover the techniques used to tackle problems at the cutting edge of mathematical research in each of these areas. This is a unique and timely synthesis of disciplines that will position future researchers for the next step in inverse scattering from waves that, we believe, will combine variational methods with direct qualitative techniques.

The first week of the summer school will be led by William Symes and UD's Rakesh. Bill Symes is the Noah Harding Professor in the Department of Computational and Applied Mathematics at Rice University and Managing Editor of Inverse Problems. Symes and Rakesh will focus on inverse problems for hyperbolic PDEs for one and higher space dimensions. They will consider theoretical and computational issues for inversion from the Dirichlet to Neumann map as well as from smaller subsets of this data, including formally determined data.

The second week of the summer school will be led by John Sylvester and UD's David Colton. John Sylvester of the University of Washington is one of the world leaders in the theory of inverse scattering in the frequency domain. He and Colton will give a series of lectures on the mathematical foundations of acoustic scattering theory together with qualitative methods in inverse scattering theory. Supplementary lectures will be given by UD's Fioralba Cakoni and Peter Monk on regularization methods for ill-posed problems and inverse scattering for electromagnetic waves. Numerical methods in inverse scattering theory will be a common theme.

The final week of the summer school will be led by Jonathan Borwein and UD's Russell Luke. Jonathan Borwein is a Canada Research Chair in IT at Dalhousie University and Laureate Professor of Mathematics at Newcastle University in Australia. He is one of the 250 most highly cited mathematicians from 1980-1999 (ISIHighlyCited) and the co-inventor of the Borwein-Preiss variational principle, among other achievements. Borwein and Luke will focus on fundamentals of variational analysis, notions of well-posedness and regularity, and finally ill-posed problems which are at the frontiers of analysis. Practical and timely applications to optics and crystallography will be explored.

For more information on the graduate program please see http://www.math.udel.edu/IMA-PI/index.html.



Quantitative Biology at UD
Math Meets Biology

Gilberto Schleiniger

"Sounds more like the goddamn Spanish Inquisition." – McCoy to Captain Kirk, after listening to two 20th century doctors discussing treatments in an elevator (Star Trek).

If there was ever a time when a glimpse at the forthcoming science fiction-sounding

advances in the medical sciences was possible, that time is now. New knowledge of the inner workings of living systems, from molecular structures to ecosystems, afforded by great advances in experimental techniques – the "omics revolution" – opens up exciting and challenging possibilities and promises for the future. These include tailor made drugs for treatment of diseases, faster and less expensive discovery and production of drugs by the pharmaceutical industry, sophisticated diagnostic and surgical techniques, and regeneration of organs via stem cell technology. Many believe that such promises can only be realized if math becomes the language of biological and life sciences, just as it is the language of physics, engineering, economics and other disciplines. To promote such a connection between math and the biological and life sciences, University of Delaware faculty in the Departments of Biological Sciences, Chemical Engineering, Chemistry, Biochemistry, and Mathematical Sciences, with support of an HHMI grant (see www.udel.edu/chem/white/HHMI3/HHMI06.html), have designed a new major program, the BS in Quantitative Biology (QBIO).

Such an interdisciplinary major acknowledges the role of mathematics in describing the complex systems in areas of recent great advances such as space travel, nuclear technology, modern aeronautics, computer technology, medical imaging, the internet and sophisticated search engines. Development of new mathematical structures, mathematical modeling, and advances in mathematical analysis and computational science have been key to the successes in those areas.

Such an interdisciplinary major also responds to the fact that research in the life sciences during the 21st century has to focus on complex systems. Mathematical models are essential to promoting comprehensive understanding of such systems. Math models serve as organizers of the relevant information available for each system. Mathematical analysis of those models leads to new predictions and hypotheses that can guide experiments and lead to new discoveries, as well as to predictive capabilities which can not be achieved by other means.

UD's new major also responds to requests from nationally recognized scientific research organizations who have voiced concerns about educational preparation of students in the life sciences. In 2000, at the request of the National Institutes of Health (NIH) and the Howard Hughes Medical Institute (HHMI), the National Research Council (NRC) convened a panel of experts and produced a report, *Bio 2010 – Transforming Undergraduate Education for Future Research Biologists* (2003), that addressed the education of students in preparation for research in the life sciences in the 21st century. The Bio 2010 Report recommended: **"Life sciences majors must acquire a much stronger foundation in the physical sciences (chemistry and physics) and mathematics than they now get**. Connections between biology and the other disciplines need to be developed and reinforced so that interdisciplinary thinking and work become second nature."

In addition, UD's new major addresses a whole cadre of students whose talents and interests may have been overlooked or who may have rejected the "life sciences as being too soft." For example, the Bio 2010 Report observes:

> *The lack of a quantitative viewpoint in biology courses can result in students who are mathematically talented losing interest in studying the life sciences. While not all students who pursue an education in the biomedical sciences have an equal interest or predilection for mathematics, it is important that all students understand the growing relevance of quantitative science in addressing life-science questions. Thus, a better integration of quantitative applications in biology would not only enhance life science education for all students, but also decrease the chances that mathematically talented students would reject life sciences as too soft.*

The new major, housed in the Department of Mathematical Sciences and offered in close collaboration with the Department of Biological Sciences, offers a unique and exciting opportunity for students who love math and science to learn and work at the interface of the two disciplines. The QBIO major prepares students for the challenges facing the medical and life sciences in exploiting the wealth of data and new insights into the inner workings of very complex biological systems.

QBIO students take courses in biology, chemistry, computer science, math and physics, and they are exposed to hands on experiences of mathematical modeling in biology throughout their program. In addition, new courses aimed at integration of different disciplines, and a capstone course in systems biology, complete a well-rounded education. Undergraduate research under the supervision of two faculty, one representing math and one biology, is strongly encouraged, and funding for these activities is made available through a variety of competitive research fellowships.

Students graduating with a UD Bachelor of Science in Quantitative Biology will have a wide range of

possible paths to follow, from graduate studies, to medical school, to academic and government jobs, and to industry employment working in several areas of the life sciences, as well as in other fields.

The QBIO Program benefits from the advice and collaboration of UD faculty in several departments, as well as from a larger UD community of experts, including an advisory board. Members of the QBIO Advisory Board include experts in pharmaceutical and medical research. More complete information about the QBIO major at UD is available at the program's web site www.udel.edu/qbio/.

New Hires

New assistant professor

Professor Sebastian Cioaba

received his PhD from Queen's University at Kingston, Ontario, Canada, in 2006. He did his undergraduate degree at the University of Bucharest, Romania. Before joining the University of Delaware, he was a Postdoctoral Fellow at the University of California at San Diego and the University of Toronto. He also visited Tilburg University in the Netherlands.

Sebastian Cioaba's research interests are in discrete mathematics with emphasis on algebraic graph theory and extremal combinatorics. He is especially interested in studying the connections between the eigenvalues of a graph and its structure. The topic of expander graphs is one of many examples which show the power of eigenvalue techniques in discrete mathematics. Expanders are sparse highly connected graphs which are used in many applications in coding theory, network communications and computer science. From the work of Alon, Cheeger, Milman, it follows that a graph is an expander if and only if the gap between its first and second largest eigenvalue is large. This property is used in most known constructions of expanders.

In his free time, Sebastian enjoys reading, watching movies and traveling. He likes most sports and he loves playing soccer and tennis.

New post-docs

Dr. Roland Griesmaier joined us as a Unidel Postdoctoral Fellow. He did his undergraduate work at the University of Innsbruck, Austria, and received his Ph.D. from the Johannes Gutenberg University Mainz, Germany, in 2008. Roland's research interests are in applied and computational mathematics with an emphasis on inverse problems for partial differential equations. His thesis work focused on the reconstruction of small buried objects from near-field measurements of electromagnetic fields. For part of this work he received the SIAM Student Paper Prize 2008. In his free time, Roland enjoys traveling, music, and sports.

Dr. Vlad Vysotsky joined the department of Mathematical Sciences as visiting assistant professor this year. He is a native of St. Petersburg, Russia, and received his MSc from St. Petersburg State University, where he also completed his PhD in 2008 under the advisement of Prof. Mikhail Lifshits. His research interests are in probability theory and include interacting particle systems and particle motion in random media. He is the recipient of a number of academic awards including the Euler prize and the Moebius prize in the Russian Mathematical Contest for papers submitted by PhD students. Most recently, in 2008, he received the prestigious Young Mathematician Award by the St. Petersburg Mathematical Society. In his spare time he enjoys various sports, especially basketball, as well as traveling, theater, and music.

Dr. Christopher Raymond was educated at Caltech (B.S. in Applied Math) and Northwestern (M.S. and PhD. in Applied Math). He did a postdoc at the University of Wisconsin and then spent several years at the New Jersey Institute of Technology. He is currently a visiting assistant professor at the department of Mathematical Sciences working on a class of reaction-diffusion problems in which the reaction is spatially localized. These systems have applications to certain labeling techniques in microscopy as well as techniques for determining reaction constants for surface-volume reactions.

Featured Graduate Students:

Pam **Kosick**

Pam grew up in West Berlin, New Jersey, and did her undergraduate work at the College of New Jersey in Ewing, NJ. In December 2002 she graduated with a Bachelor of Arts in Mathematics. She was part of the honors program throughout her undergraduate career in Mathematics, which she enjoyed so much that it shaped her plans to pursue a graduate degree. The "deal was sealed" after she was selected to participate in a Research Experience for Undergraduate (REU) at Penn State during the Summer of 2001: "It was so interesting and challenging; I knew that's what I wanted for my future."

Pam did not have a set research interest when she started in the graduate program at the University of Delaware in the Fall of 2003. She ultimately settled on pursuing discrete Mathematics and will soon complete her thesis entitled "Planar Dembowski-Ostrom (DO) polynomials and finite commutative semifields" under the supervision of her adviser Prof. Robert Coulter. A finite commutative semifield is essentially a finite field in which multiplication is not necessarily associative. The approach she has taken in her thesis is to view the multiplication using polynomials over finite fields, in particular planar DO polynomials. Finite commutative semifields of odd order are closely related to planar Dembowski-Ostrom (DO) polynomials over finite fields as their multiplication gives rise to a planar DO polynomial and every planar DO polynomial gives rise to a finite commutative semifield. A special form for these planar DO polynomials was developed and is detailed in her first publication, "Planar polynomials for commutative semifields with specified nuclei," which appeared in Designs, Codes and Cryptography in 2007.

During the summer of 2007 she attended and spoke on her research at the 8th International Conference on Finite Fields and Applications in Melbourne, Australia. This summer she hopes to attend the 9th International Conference on Finite Fields in Ireland.

Pam has gained lots of teaching experience during her time at UD as well, both as a teaching assistant and a lecturer. She plans to apply for postdoctoral positions or junior faculty positions in the near future.

During her time in graduate school Pam has picked up running as a hobby. The first race she ever ran was the 2006 Philly Distance Run, a half marathon, with her husband to celebrate their first wedding anniversary. The two continue to run races together and completed their first full marathon in May 2008. She adds "I also enjoy working on home improvement projects, photography, traveling, and spending time with friends."

Asked on role models that have influenced her interest in Mathematics early on, Pam remembers her high school Mathematics teacher, Mrs. Jane Windle: "She was a strong, dedicated, and intelligent woman. She really pushed us as students to exceed and I looked to her as a role model." Through her successful career and also by starting a student chapter of AWM jointly with Kara Maki she is bound to be such a role model to other students of Mathematics.

Kara Maki

Kara Maki grew up on Cape Cod in Massachusetts. She received her Bachelor of Science in Mathematics with a minor in Women's studies from the University of New Hampshire in May 2003. Subsequently, she was a graduate student in the Department of Mathematics at the University of Rhode Island for one year before transferring to the University of Delaware in the fall of 2004. She chose to come to Delaware following a visit to the department in which she met energetic faculty, learned about current research relating to industrial problems, and toured the MEC lab.

Kara remarks that she has always enjoyed the subject of mathematics, and from early on had a particular interest in scientific computing problems coming from the physical sciences or industry. For the past years she has been working with Prof. Rich Braun on her thesis entitled "A moving overset grid method for the study of human tear film dynamics". Kara explains that the human tear film is a multilayer

structure playing a vital role in the health and protection of the eye. In her work, she combines physical modeling alongside analytic techniques to derive the simplest nonlinear partial differential equation determining the tear film thickness. This evolution equation is solved numerically using an overset grid method. The mathematical results obtained are then compared with experimental tear film measurements taken by P.E. King-Smith and collaborators at Ohio State University. This work is in collaboration with William Henshaw, a scientist at Lawrence Livermore National Laboratory and supported by the National Science Foundation.

In her first few years in Delaware Kara also worked on matrices with large growth factors under the advisement of Prof. Tobin Driscoll resulting in a SIAM publication entitled "Searching for rare growth factors using multicanonical Monte Carlo methods". She also worked on limit memory multisecant methods for computational chemistry applications under the advisement of Prof. Russell Luke. She has been an invited speaker and presenter at international conferences on her research.

Kara loves teaching and has found her teaching experience at Delaware filled with rewards from fostering academic success. Her enthusiasm and talent for teaching has been noticed and, in May 2006, she was awarded the Baxter-Sloyer Graduate Teaching Award from the department of Mathematical Sciences.

Apart from her academic pursuits Kara has also tackled her dream of running a marathon during her time at UD. In fact, she has run five marathons in five different states. In her spare time she also enjoys watching New England sports teams.

Kara intends to pursue an academic career and she is currently applying for tenure-track and postdoc positions. She would thus like to follow in the footsteps of her older cousin and mentor Catherine Roberts, who is a faculty member in the Department of Mathematics and Computer Science at the College of Holy Cross. Kara is keen to be a role model herself and to encourage women and girls to study Mathematics. Together with fellow featured graduate student Pam Kosick, and along with undergraduate Rachael Bailine as well as faculty advisor Prof. Pam Cook, she has just initiated a student chapter of AWM (Association of Women in Mathematics) at UD.

2009 Student Award Recipients

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 *Michael Alexander Tait*.

The **Carl J. Rees and Eleanor K. Rees Scholarship** which is awarded to undergraduate students majoring in mathematics upon academic performance went to

Erica Leigh Brow, Alyssa Nicole Colby, Patrick Robert Devlin, Joseph William Falandays, Michele Lyn Giuliano, Leo Vincent Marianiello, Nicholas Paul Messina, Abby Kristen Williams

The **Mathematical Sciences Department Faculty Recognition of a Graduating Senior 2008** was given to *Scott William Ohlmacher*

Do you have any feedback (comments, questions)? Or let us know any current events or info not covered by the data sheet below.

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Strong ties between **UD Math and DuPont's statistics group** during exciting times

Alumnus Dick Postles (MS - Statistics 1963) writes about the relationship between UD's mathematics department and DuPont's statistics group from the 60's to the 80's. His contribution was prompted by the 2008 *"Reckonings"* article about UD alumnus Don Marquardt's work on nonlinear estimation and ridge regression. Don Marquardt was an important innovator and contributor to DuPont's statistics work and considerable status in the industrial world at the time, and Dick Postles worked with and for him for a number of years.

DuPont's mathematics and statistics program in the then Engineering Department's Engineering Services Division was managed in the 60's to the 80's by Dr. Robert W. Kennard, who spent the 1961-62 academic year on UD's full-time mathematics faculty where I first met him. Bob was himself an earlier alumnus of UD's MS -Statistics program, going to Carnegie Mellon after UD for his PhD, and later joining DuPont (he was one of its few native Delawareans, and was frequently introduced as such). He was on the adjunct faculty at UD for some years before and after his full-time year, teaching probability and linear modeling.

At DuPont he and another man with later UD faculty connections, Art Hoerl, a mathematician from Southern Cal, jointly developed "ridge regression", a method of linear analysis which minimizes mean-square-error instead of the then more usual variance error to estimate model parameters. I believe Bob would credit Art with the first heuristic notions of ridge regression and himself with the mathematical formality of it, but in any case their joint collaboration produced the elegant algorithm it became. Their seminal article, published in Technometrics in Februar 1970, regularly has made the most-cited list of analysis techniques from its time of publication to the present day.

Art and Bob came to the issue of ridge regression via the industrial applications route of linear statistical modeling of multivariable phenomena wherein the predictor variables are seriously intercorrelated. The advent of the computing age had by that time made the residual least-squares fitting of multidimensional linear regression models commonplace. However, it was not commonly appreciated that the computerized shotgun wedding of generic models to data sets ill-designed to support them was fraught with peril. Hopefully, in analyst heaven, all data sets would derive from experimental design patterns that are optimal vis a vis the model form chosen. Sadly, in analyst practice, most historic data sets are undesigned, having just "growed like Topsy". It is not unusual, then, when fitting linear models to historic data by usual least-squares, that the combination of (i) the specific model form used and (ii) frequent multicollinearity of the predictor variables stemming from the pattern of experiment by which the data arose, causes the resulting parameter estimates to be seriously inter-correlated. This intertwining of the various slope estimates has very unfortunate practical ramifications, they are frequently bloated in absolute value and are unstable in that very small changes in the input data can lead to large changes in the parameter estimates. As a result, what seem like, and are valued as, valid insights into the structure underlying the data can be merely artifacts of an unfortunate data-design/model combination. It was this situation that attracted Hoerl & Kennard's attention and led to their pioneering work in ridge regression. They addressed this issue by using mean-squared-error (MSE) as the objective function, adding bias error to the usual variance error (MSE = Bias**2 + Residual Sum-of-Squares), from the notion that a parameter estimator with some smallish bias can have less variance error and be more accurate overall than an unbiased one.

Both ridge regression and Marquardt's nonlinear work have since been shown to be part of a more extensive and more formal mathematical structure. The Tikhonov regularization described in the previous "Reckonings" article addresses the same theoretical issue via a more purely mathematical bent while ridge regression can now be viewed more formally in a more recent role as Bayesian prior. But both Marquardt's nonlinear analysis algorithm (NLIN) and Hoerl & Kennard's ridge regression algorithm were motivated by the practical aspects of locating the minimum of a quadratic surface over a highly intercorrelated parameter space, the correlations arising in Hoerl & Kennard's because of the ill-design of the data and Marquardt's because of the inherently stricter nature of most nonlinear models as well. The pragmatics of this minimization when the parameter estimates are highly intercorrelated is that the minimum of the objective function occurs along a diffuse, elongated angular trough rather than at a sharp cusp. The resulting difficulties are that (i) although mathematically there is a distinguishable minimum to be found, practically speaking many other estimates, with very different implications, fit almost as well, and (ii) the various numerical procedures to locate the minimum misbehave in different ways, some (steepest descent) when near the trough line and others (Taylor expansion), when far away. The hope of numerical improvement suggested that a mix of both gradient and linear expansion methods be used. Both ridge and NLIN use the same heuristic shrinkage of the diagonal elements of the parameter product moment matrix to interpolate between them and this close connection of the two methods led to an extensive and enlightening collaboration among Don, Bob, and Art throughout the '70's.

Don contributed to the statistics world also through work on mixture models, in turn inspired by Ron Snee, a

colleague from Rutgers whose specialty it became and who also later served on UD's adjunct faculty. Bob in work predating ridge regression had also brought the field of experimental design into the computer age by an algorithm to generate coverage sets of the design space. Since the various slope estimates of linear models are minimum variance optimal when the data points are located at the "ends" of their ranges, Bob's notion in his algorithm CADEX was to start with 2 extrema and add points sequentially to the design, the points staying as far apart from each other as possible. As far as I know, that article in Technometrics was the first such computer design generating algorithm to appear publicly in print.

Art Hoerl later joined the UD faculty full-time and served as thesis advisorof a DuPont colleague and friend, Bernt F. Winkel (TCU & Kansas State), who did his work in time series analysis. I believe also that Jim Lucas (Penn State & Texas A&M), Wim Schaffers (Delft, his advice to his calc students… "Make ALL the problems!"), and Norm Howe (WPI) were others from DuPont's math/statistics group who served as UD adjunct faculty. I should also mention Dave Doehlert (Swarthmore) who preceded me at UD bringing from his work at DuPont an interest in preference testing and paired comparisons that intrigued my UD thesis advisor, Bill Thompson, and thus launched my own work.

I later migrated from DuPont but bear with me to this day my high regard for the innovative and competent people in that statistics group, all of whom had an intensely practical bent as well as theoretical expertise. And as for practical, I remember Bob Kennard's wry comment as I left DuPont for the literally greener pastures of Virginia and sheep, he going later to Florida for oranges … "Trees do better than animals". How prescient he was in so few words.

Donor Support

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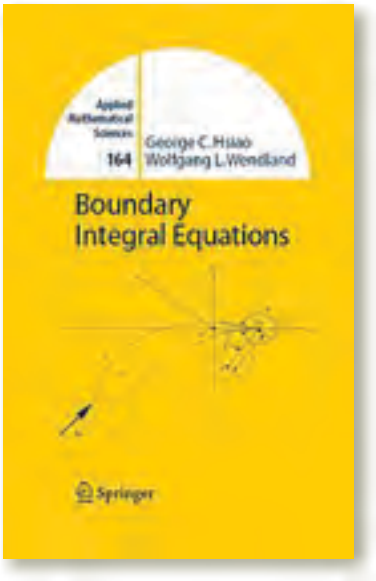
Correction by the editor: In last year's list of donors acknowledgements should have gone to "Dr. Danuta Tkaczynska" instead of "Dr. Katarzyna Hallenbeck".

Recently Published Books by Math Department Faculty

Edited by Alfinio Flores



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