RECKONINGS SPRING 2011

NEWSLETTER OF THE DEPARTMENT OF MATHEMATICAL SCIENCES AT THE UNIVERSITY OF DELAWARE

Boundaries at the **Boundaries** of **Computation**

Francisco-Javier Sayas

Models on unbounded domains

When learning continuum mechanics and physics, we are always split between concentrating on the model equations (state equation, conservation laws, conservation of momentum), or setting up a fully detailed model (a uniquely solvable problem that requires boundary conditions). This can be easily seen in any of the multiple textbooks on continua, call

it Introduction to Partial Differential Equations, to Applied Mathematics, etc. The same problem is often presented twice, with and without boundary conditions. (Actually, physicists and engineers recognize that very often the real difficulty is finding the correct boundary conditions for a model and that it is unfortunately common to write simple conditions for lack of expertise to write better ones. For those who are in disbelief, please have a look at boundary conditions for such an over-exploited model as the Navier-Stokes equation for incompressible viscous fluid flow.)

Furthermore, some models need so small scales in comparison with the region where they take place or happen in so extended regions that one is led to consider the problem as occurring in free space, as if we could stretch all space dimensions to infinity. Electromagnetism and acoustics are examples of this. Seismic models are often presented in half-bounded domains (the boundary being the surface of the earth and the unbounded dimensions going inwards, in a flat world that exists in modeling habits but not in reality). Commonly used equations have water waves arriving to the coast from an infinitely wide ocean.

Rebounding the unbounded

After admitting the convenience of working on a model in free space, in the exterior of a bounded domain or in a half-unbounded domain, the practitioner is faced with a new difficulty: what are the continuum solvers for unbounded problems? Probably the only method that has been developed with a sight on discretizing the entire space is the infinite element method, which has not had that much predicament between practitioners.

continued on page 2

Mathematical Research in **Biomechanics**

Miao-Jung Yvonne Ou

With decades of continuous development of new imaging technology, researchers in biology and biomechanics are able to visualize/observe biological activities at smaller and smaller scale. For example, micro- and nano-indentation technique to measure elastic property of tissue or cell that is at micro- or nano-scale and confocal imaging are applied to observe how microtubules transport chemicals between nuclei and membrane. With this explosive amount of data available, our understanding of activities at different scales have improved greatly. However, how the activities at the cell level relate to those at the tissue level and organ level is not fully understood. We are mostly interested in their effect on the macroscopic level because obviously this is the scale where we function. The multiscale nature of biological and biomechanical

continued on page 5

Chair's Message

David Edwards

This year has been full of exciting changes for the department. Dr. Peter Monk concluded his term as chair, and is now enjoying a well-earned research sabbatical. On behalf of the department, I thank Dr. Monk for his service. Under his leadership, the department's graduate program and research profile grew tremendously. I began my term as interim chair in September, and an internal search is currently underway to name a new permanent chair.

The University has weathered the financial crisis reasonably well, and as a result we have been able to hire faculty when other universities could not. This advantage has led us to be able to attract top-notch talent from around the world. In particular, last year the College of Arts and Sciences undertook a multidepartmental search in computational science. We were very fortunate in that all three hires were in math. Two of them, Dr. Francisco Sayas, and Dr. Yvonne Ou, have written articles for this edition of the newsletter. The third, Dr. Petr Plechac, joins us from the University of Tennessee, Knoxville. In addition to the new permanent faculty, we also welcomed four new temporary faculty as well: Charles Hague, Idris Mercer, Chetan Pahlajani, and Jenny Peng. Their profiles can be found in the "New Hires" section.

The Department is also undertaking several searches this year. We are searching for a continuing non-tenure-track instructor and a tenure-track assistant professor in applied stochastics. In addition, the Department has redesigned its temporary faculty program to make it more attractive to research-interested postdocs. The department is looking to hire at least three tempo-

continued on page 2

Inside *Reckonings*

Chair's Message, continued from cover

rary faculty in these positions. Hard-working search committees have identified top-notch candidates, and I am confident that all the searches will conclude successfully.

The Department is also bidding a fond farewell to several retiring faculty. Dr. Gary Ebert officially retires in August; his wife, Dr. Christine Ebert officially retires in May. Dr. Robert Gilbert officially retires in February. Dr. George Hsiao and Ms. Margaret Donlan will begin their retirement leaves in September. The Department thanks them all for their years of faithful service.

I want to especially thank Dr. Christine Ebert for her work with the Webber Award, which biannually honors Delaware mathematics educators. Last year's award recipients were Dr. James Hiebert of the School of Education and Jan Shetzler of Caesar Rodney High School. (For more details about our efforts in mathematics education, please see the article by Dr. Cirillo in this issue.)

This year our graduate program was honored by the National Research Council as among the top quartile of graduate programs nationwide. This ranking (between 11th and 40th with a 90% confidence interval) was based upon statistical analyses of various objective and subjective indicators of quality. In particular, the department led the nation in citations per faculty member. The last NRC ranking in 1995 rated UD's mathematics department as 80th in the nation. This dramatic improvement reflects the department's continuing emphasis on scholarly activity during that time frame. Our strong showing has been favorably noted both on-campus and off.

One population showing interest in our ranking has been our graduate student applicants. Our graduate program has grown by nearly 50% in recent years, as more and more faculty have obtained external graduate student support. Our GRIPS summer preparatory program, GEMS summer research program, and Winter Research Review continue to be successful in preparing our students for graduate school and beyond. But there's time for play as well: the department sponsors an annual bocce tournament in spring, and every fall the graduate students and faculty battle it out in a no-holds-barred soccer game at the department picnic.

With the addition of these new graduate students, some are tripled up in offices. A recent College space survey will hopefully alleviate the overcrowding. Those of you who remember the widely varying temperature of Ewing classrooms will be interested to know that the climate control system in Ewing will be upgraded this summer. Though the project will be disruptive, it should make the building a more comfortable place to work and learn.

The department's undergraduates have also made the department proud this year. One of our teams in the Mathematical Contest in Modeling finished in the top 1% worldwide. Members of the math club are volunteering their tutoring services to the Boys and Girls Club in Newark. We also fielded a team in the annual Putnam examination.

Many of the activities I have described (the Webber award, undergraduate math activities, graduate student support, etc.) are only possible because of the continued financial support of donors like you. If you are interested in supporting activities in the department, I encourage you to read the instructions on the last page of this newsletter, or give me a call at (302) 831-7180 so we may discuss your interests. I look forward to hearing from you.

Boundaries at the Boundaries, continued from cover

(I will leave for later the Boundary Element Method, which is, up to a point, a way of discretizing up to infinity.)

Otherwise, users have to choose one of the three main (non-disjoint) extended families of PDE solvers: (a) any of the million variants of Finite Element Methods (including spectral methods, Discontinuous Galerkin schemes, etc), based on a weak formulation of the underlying PDE or system thereof; (b) methods based on cell averaging and discretization of conservation principles, a.k.a., the Finite Volume Method; (c) methods based on approximation of derivatives to build up a discrete system of point approximations of the unknowns, that is, Finite Difference Methods. All of these methods work on finite domains, forcing the practitioner to introduce a new artificial boundary to surround the computational domain. What is now complicated is finding the correct boundary condition for this interface between the computational world and the void.

A mathematical aside. Let us illustrate this with the very popular Laplace equation. Physically relevant harmonic functions in the exterior of a bounded domain in three-dimensional space decay at a rate that is proportional to the distance to the real boundary. This is actually a very precise assertion as can be shown by asymptotic analysis. Cutting-off the domain at a distance R of the boundary and imposition of a zero boundary condition creates a modeling error of order O(1/R), which is going to dominate unless R is really large, the computational domain thus becoming unmanageable. The price is higher in two dimensions. Asymptotics of exterior solutions to the Laplace equation include non-decaying behavior and even logarithmic growth. Even counting that asymptotics of bounded solutions are of the form c+ O(1/R), imposition of a simple boundary condition at an artificial boundary is not easy, because the leading term of the asymptotic expansion is not known. For problems related to time-harmonic waves (the Helmholtz equation), decay is also very slow, although the asymptotics are different, controlled by radiation conditions that can be used as simple (but not very precise) approximations.

For those who had the patience and the energy to read through the preceding paragraph, the morale should be the following: even textbook examples of problems in unbounded domains do not lead to a naive cut-off strategy of the computational domain with imposition of a nice and simple boundary condition. Not working well this part of the model destroys the balance of equal effort of approximation in all parts of it: if we had decided to work on an unbounded domain (because it seemed natural at the time), we cannot impose poor boundary conditions just because we want to compute with the first method that comes to our hands.

continued on page 4

From the Editors

Dear Department Alumni, Students, Colleagues and Friends,

It is with great pleasure that we present the seventh edition of *Reckonings*. In this edition you will 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. 2010 was a productive year for the Mathematical Sciences Department bursting with activities and events, and we tried to capture as many as possible.

You will find articles describing different areas of exciting research that are being conducted by our faculty. This year, Prof. Francisco Sayas's article gives an overview of computational trend and impact in the fasting growing technological world. Prof. Yvonne Ou has contributed a fascinating article about her recent research on dehomogenization for composite materials, time-reversal for elastic composites, and applications in study of trabecular bones. In addition, we have a contribution from Prof. Cirillo who gives an update on recent developments on mathematics teaching.

Other regular features include profiles of new faculty and current students, as well as a list of brief news items highlighting math (and non-math) events, grant activity, awards, etc. of the past year.

You will note in particular an interview with Prof. Gilbert about his lifelong career, achievements, and about his advice for the new generation of mathematicians. We thank him for taking time to answer our questions, with best wishes for many more successful years to come.

Our department is expanding academically and socially, and we hope that this year's newsletter will again keep you updated on our recent achievements and transformations. We have a new website and we hope to further improve it and keep on adding good news and good reviews.

We would like to thank all of the contributors to this seventh edition, as well as Daniel Wright from UD's Office of Publications for his help with the design and layout of this newsletter. We also would like to encourage everyone to regularly check the department's web pages (www.math.udel.edu) for current news items, activities and events.

Sincerely,

Philippe Guyenne, Pak-Wing Fok and Constantin Bacuta

Outreach Committee of the Department of Mathematical Sciences

Bridging Research and Practice: A Professional Development Model of Research on Mathematics Teaching

Michelle Cirillo

H. Wu, emeritus professor of mathematics at UC Berkeley, opened his March, 2011 *Notices* article, "The Mis-Education of Mathematics Teachers," by posing this question: "If we want to produce good French teachers in schools, should we require them to learn Latin in college but not French?" (p. 372). Wu went on to argue that there is a gap between the mathematics that secondary teachers learn in their undergraduate courses and the mathematics that they need to understand to teach school mathematics. Providing specific examples, he went on to say that mathematicians can play an important role in the preparation of secondary mathematics teachers by taking steps toward relating university mathematics to school mathematics. Wu additionally claimed that teachers must not only understand mathematics content but must also know "a methodology for teaching [it]" (p. 381). This topic is typically given attention only in the methods course. As a result, beginning teachers often leave their undergraduate programs feeling confident in their content knowledge but not having had enough opportunities to acquire sufficient mathematics knowledge for teaching, for example, knowledge about school mathematics content and processes such as conceptions about congruence and similarity or reasoning and proving. Professional development models of research with practicing teachers have the potential to address this preparation gap.

I am currently working on two funded grant projects designed around the professional development research model. One of these projects, *Mathematics Discourse in Geometry (M-DIG),* is funded by the Knowles Science Teaching Foundation, a private foundation whose mission is to support beginning mathematics and science teachers. After learning that many high school teachers feel ill-prepared to teach proof, I proposed a two-year study around teaching proof in Euclidean geometry. This study progresses over several phases.

This past fall my research associate and I collected over 50 hours of baseline data in six classrooms. I was interested in observing each teacher during the first week that they introduced proof to their students and then for a second week later in the semester once they had progressed to more complex proofs. At the end of the semester I interviewed the teachers to learn more about their overall approach to teaching proof, the challenges that they face when teaching proof, and their beliefs about teaching proof. This semester, the teachers and I have been meeting regularly as a group to reflect on how proof is taught, both in the general and the individual sense. Some of the activities designed to engage the teachers in this reflection include: reading professional literature on teaching proof, examining curriculum materials, watching video data from the fall, and engaging in discussions around these artifacts. Early indications from these activities point to shifting beliefs about what teaching proof can and should look like. For example, several of the teachers have voiced a willingness to be more open to forms of mathematical arguments that are not written in two columns (e.g., paragraph or flow proofs). Our group will continue to meet this summer to develop new tools for teaching proof. In the fall, a second round of classroom data will be collected to determine if and how the professional development impacted practice. Next spring, we plan to present to both teachers and researchers at the annual meeting of the National Council of Teachers of Mathematics.

A professional development model of research such as the one described here has the potential to impact mathematics education in several ways. For example, research based on a professional development model affords the researcher engaged time spent working *with* teachers to better understand and subsequently address some of the specific challenges of mathematics teaching. Additionally, what is learned from the research will be published for and presented to classroom teachers, mathematics teacher educators, and mathematics education researchers. The more we know about the specific knowledge needed for and challenges of teaching mathematics, the better equipped we are in improving teacher preparation programs in the future.

Boundaries at the Boundaries, continued from page 2

The options

At present time, the options for the creation of artificial boundary conditions can be taxonomized in three groups:

Perfectly Matched Layers are based on the creation of a mathematical material (a buffer-zone or damper) surrounding the computational domain. Requirements are twofold: nothing that should go away should ever come back; the damper should make solutions decay so strongly that a naive boundary condition on the other side of the damper should no be a problem. PMLs have been devised and developed for wave propagation problems, where the physics mingle easily with the pseudo-physics of the mathematical-computational material and provides much intuition on what to expect.

Differential Absorbing Boundary Conditions try a different approach. They focus on transporting away parts of the solutions that cross the computational interface controlling as many possible solutions (propagation directions) as practicable. In their very particular way, they can be understood as differential approximations of the ideal boundary conditions, which solve exactly what occurs around the computational interface.

Boundary Integral Equations are the clear winners in terms of modeling, at least in the cases where they can compete (boundary integrals are not a method for all ages; they solve what they can solve, and that's it). The advantages are many: arbitrary closeness of the computational boundary to original boundaries (and thus reduction of the size of the computational domain), no requirements on convexity or connection of the interface (so that several interfaces can be placed around different parts of the domain) and exact physics. The picture would be too flattering if we did not mention its disadvantages: they are difficult to program and relatively expensive in computational terms and, as already mentioned, they work for a limited set of relevant equations (where they do a very good job) but their scope of applications is limited to those ones.

The challenges and the future

For those of us who have focused in the many applications and attractions of the integral world, be it for scattering problems or to construct boundary conditions, the challenges are multiple. Varied philosophies coexist in the areas of computational science (a fuzzy world that surrounds numerical analysis, scientific computing and many non-mathematical fields). Even agreement on whether to create the ultimate code that solves everything (a code to rule them all) or to learn how to communicate packages created by different authors in different styles is scarce. One of our current aims is the development of a full black-box ideal of time domain integral boundary conditions and integral solvers that can easily communicate with all kinds of methods for the space variables and time-stepping strategies in time. The level of difficulty of the task ahead is not to be minimized and many of the habits (good or bad) or the usual training of numerical analysts are being revised these days in order to face a program whose mathematical foundation uses all the paraphernalia of modern functional and mathematical analysis while the sheer coding of toy examples for illustration can mean years of work.

The excitement of the problem is not to be minimized either. For those of us who grew up in the happy philosophy of the model problem, the two and three dimensional acoustic wave equation is a continuous source of amazement, because of the richness of the phenomena it models (and interacts with), the difficulty of computing solutions with precision even at moderate time intervals and the possibility of enjoying, from time to time, of a nice color animation, to show your colleagues, your sponsors, your students and yourself.

2010 Student Award Recipients

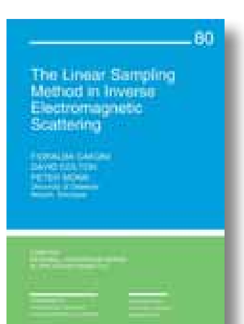
The **Baxter-Sloyer Graduate Teaching Award**, presented to graduate teaching assistants in mathematical sciences who have demonstrated superior effectiveness in teaching and in the performance of their responsibilities, is awarded to ***Matthew Zumbrum.***

The **Stephen J. Walf Memorial Scholarship**, awarded to a student entering the senior year majoring in mathematics who has demonstrated both love and talent for the subject, is awarded to ***Patrick Devlin.***

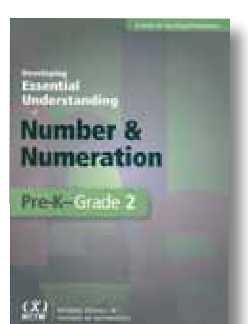
The **William D. Clark Prize**, presented only when a senior majoring in mathematics has unusual ability in the area, is awarded to ***Michael Tait,*** who is acknowledged by the Department as the best graduating senior.

The **Faculty Recognition Award**, given to a graduating senior who has excelled in mathematics and has contributed valuable service to the department, is awarded to ***Michael Bauer.***

Recently Published Books by **Math Department Faculty**



The Linear Sampling Method in Inverse Electromagnetic Scattering, by Fioralba Cakoni, David Colton and Peter Monk, CBMS Series, SIAM Publications 80 (2011).



Developing Essential Understanding of Number and Numeration for Teaching Mathematics in Pre-K-2, by Barbara J. Dougherty, Alfinio Flores, Everett Louis and Catherine Sophian, National Council of Teachers of Mathematics (2010).

Mathematical Research, continued from page 1

research poses a great challenge not only in modeling but also in numerical analysis and applied analysis. For instance, if we know exactly how each bone cell affects the bone structure nearby, how do we predict the influence of the five types of bone cells on the microstructure of the bones? How do we assess bone quality even if we know the exact microstructure of trabecular and cortical bones? We need to know how to model at each scale and most importantly, we have to study how upscaling to macroscopic level can be carried out in not only a mathematical consistent but also a computationally effective and feasible way.

My main interest in mathematical biology focuses on bones and can be summarized into three topics

1. Integral Representation Formula (IRF) and dehomogenization
2. Computation of effective properties of composite from μ-CT image data
3. Numerical computation of wave propagation in composite materials

With a brief description of these topics, I would like to show what we can contribute to biology and biomechanics as applied mathematicians.

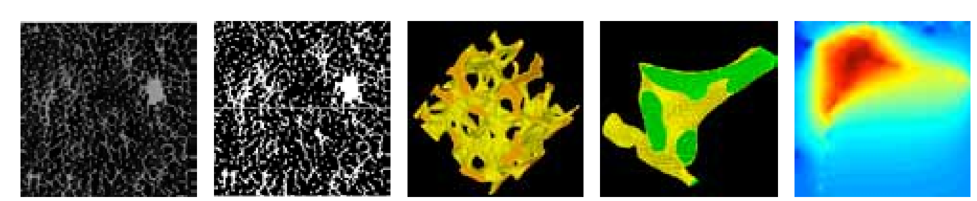
IRF and Dehomogenization

The motivation of this research subject is from the fact that quality assessment of composites such as bone requires measurement of effective properties of the composite and statistics of the microsrtucture. For example, in the early stage of osteoporosis, it is observed that patients develop more and more anisotropic structure in the trabeculae of their neck bone; this means changes in 2-point correlation functions of microstructure. The fundamental question we ask is "can we represent the effective property of interest in terms of an expression which separates the influence of microstructure from that of contrast of constituent material properties?" As was shown in the '80s by Bergman and Golden & Papanicolaou, the effective property of composites of two isotropic dielectric materials can be represented by an integral representation formula with Hilbert transform kernel and positive Borel measure in [0,1]. The kernel contains information of the contrast and the measure contains all contribution from microstructure; the zero moment of the measure gives the volume fraction and higher moments are related to N-point correlation functions (N¿1) of the microstructure. The IRF provides the mathematical foundation for the inverse problem that infers microstructural information of composites from measurement of effective properties at different temperatures or frequencies; this process is called *Dehomogenization*. Recovering the moment is much less ill-posed than reconstructing the measure and is insensitive to the choice of regularization schemes. Since the moments are all positive, we can apply non-negativity regularization. These moments can be used for efficient extrapolation of effective properties for frequency outside the experimental data.

We recently extended the IRF to composites of elastic material and viscoelastic materials. In this case, theorems from theory of several complex variables are applied and the Borel measure lives on a torus; this is due to the fact that forisotropic elastic materials, we need two Lamé constants to describe the material property.

Computation of effective properties of composite from µ-CT image data

This is a good example about how we can utilize the images and modern computational power to study effective properties of bones. The main motivation is that in the homogenized version of wave equation such as Biot's equations, the coefficients depend on microstructure. The definition of effective dielectric tensor is based on energy equivalency. It involves solving a piece-wise constant elliptic equations with kinematic boundary conditions. The computational domain in our simulation is on the 3D structure reconstructed from μ-CT scans of trabecular bone with resolution of $15\mu m$. The main challenge is that the trabecula is very thin so boundary element method is more suitable for this problem. See Figure 1c. The meshed piece is shown in Figure 1d and the numerical result is in Figure 1e. Our numerical strategy is to formulate this problems as two homogeneous Laplace equations in each material and iterate through the Dirichlet-to-Neumann map on the interface. The convergence rate is currently under investigation.

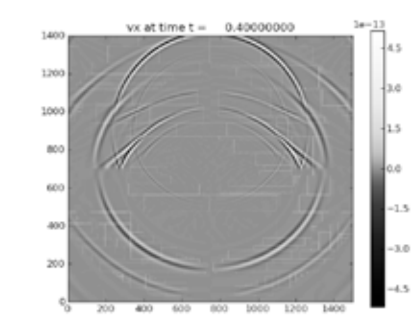


(a) raw µ-CT Scan (b) digitalized data (c) 3-D structure (d) meshed piece (3) numerical result

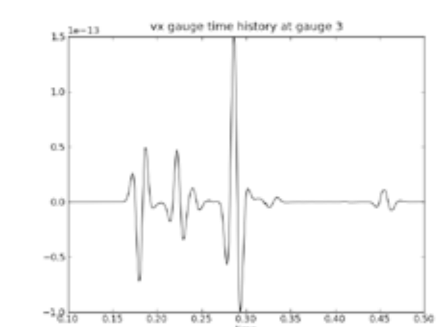
Figure 1: Our preliminary results *Ou, Nintcheu, Mak and Xu, 2010*

Numerical computation of wave propagation in composite materials

For wavelength much larger than the scale of micostructure, wave propagation in poroelastic materials can be well approximated by effective equations. For cancellous bone (the spongy bone with pores filled with bone marrow), a commonly used model for modeling ultrasound wave propagation in it is the set of equations of Biot's type. The numerical challenge in solving this equation is that it has several modes of shear (S) waves and compressional (P) waves that convert to one another when the waves get reflected or deflected. For isotropic poroelastic materials, there can be two P-waves and one S-wave propagation at different speed and with one of the P-waves traveling at a speed one order smaller than the others. For materials with orthotropic symmetry such as cancellous bone and shale rock, it will have four different modes with one travelling much slower than the rest. When ultrasound is used as a clinical device, reflection and deflection is inevitable due to the shape of bones. Numerically, this means mesh refinement is necessary in order to capture the wave propagation correctly. Figure 2 shows the reflection of solid velocity near interface at z = 700 with Finite Volume Method. The materials are orthotropic and the plot is on longitudinal plane. The boxes are the AMR (Adapted Mesh Refinement) mesh.



(a) x-component of solid velocity



(b) velocity at a fixed point

Figure 2: Wave simulation for poroelastic materials (*Lemoine, LeVeque and Ou, 2011*)

Featured Graduate Students:

Nicholas **Brubaker**

Nicholas Brubaker grew up in Lancaster, Pennsylvania and did his undergraduate work at nearby Millersville University. In May 2008, he graduated with his Bachelor of Science in Mathematics with a focus in Applied Mathematics. While at Millersville, Nick participated in various research opportunities. Specifically, he worked with Professors Ron Umble and Frank Morgan on Double Bubble conjectures, Professors Joceline Lega and Predrag Punosevac on the formation and dynamics of sand dunes and Professor Zhoude Shao on center manifold theory. With his interest piqued by the exposure to research, Nick decided to pursue an advanced degree in applied mathematics. After reviewing numerous programs, the Department of Mathematical Sciences at UD was a natural choice considering its strong applied math program.

During his first summer, Nick worked in the Groups Exploring the Mathematical Sciences program with Professor John A. Pelesko in which he learned about modeling mircoelectromechanical systems (MEMS). Since then he has continued working with Professor Pelesko, his advisor, on analysis of various approximations made on the standard MEMS model. In particular, he has been looking at soap bubbles in an electric field, which couples minimal surfaces with electrostatic forcing. To carry out his research, Nick uses various mathematical techniques including calculus of variations, perturbation methods and nonlinear analysis. Along the way Nick applied for and received a prestigious NSF Graduate Research Fellowship.

Nick has presented work at various conferences including the 2010 SIAM Annual Meeting in Pittsburgh. This summer he is going to attend the 7th International Congress on Industrial and Applied Mathematics. In addition to his research, Nick is active member of the SIAM student chapter at UD and previously served as its vice president.

Outside of research, Nick enjoys taking care of plants—an interest that started from growing up on a farm—and has a collection that includes citrus, pomegranate and coffee trees. He also enjoys traveling, reading and playing sports.

After graduate school, Nick plans to pursue a career in academia where he can continue to work on problems in applied mathematics. While many people have influenced him inside and outside mathematics, Nick appreciates the inspiration and guidance provided by his advisor, Prof. John A. Pelesko, and is grateful for the the unwavering love and support of his family and fiance, Laurel Kegel.

Jing **Li**

Jing Li grew up in Guilin, China, a city that is famous for its beautiful scenery, and did her undergraduate work at Nanjing University in Nanjing, China. In June 2008, she received her Bachelor of Science in Computational Mathematics. While at Nanjing University, she was the leader of the department's women's volleyball team and a crucial member of the badminton team.

At the time Jing graduated she decided to pursue an advanced degree in mathematics abroad and the math department at UD was her choice because of the strong faculty and nice environment. And indeed, she enjoys the easy life at Delaware. After two years, Jing got her master's degree here and became a Ph.D. candidate after a while.

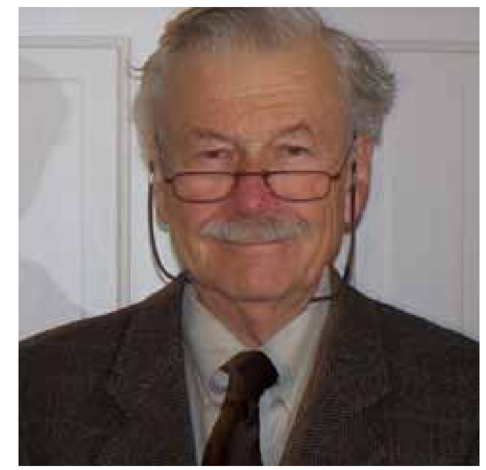
Applied mathematics is always the area that Jing wants to study, but she didn't really learn that there are so many different topics in applied math until she came to Delaware and attended a lot of seminars. In June 2009, Jing worked with Prof. Philippe Guyenne in the Unidel summer program. During that time, she read a paper about seismic wave propagation and adapted the numerical scheme in there to a model which was built by Prof. Robert Gilbert and his collaborators, describing ultrasound wave propagation in bones. At the end of the month, she has written a code for solving the equation but unfortunately it didn't run very well. The valuable experience during that summer made her really interested in the problem. In June 2010, Jing attended the 7th Graduate Student Mathematical Modeling Camp at RPI. In the camp, she worked with five other students in modeling a cadaver decomposition island to estimate time of death. This is again a problem involving numerical simulation and she felt she really likes it. So she had a talk with Prof. Gilbert and Prof. Guyenne, and decided to focus her research on numerics and continue the simulation of ultrasound wave propagation through

cancellous bones. This problem has important application in the sense that ultrasound test can help people detecting osteoporosis in early stage. After another years working, she has done with the coding of the solid frame, the next thing she wants to do is to extend the results to the fluid phase of which the equation takes a similar discretization, and finally, come to solving a composite system with random solid and fluid composition. Besides research, Jing also enjoys teaching. "My mom is also a math teacher, I have been seeing her teaching and tutoring students with all her love ever since my childhood." Jing says. Now she has her own classes and she also shows all her love and patience to her students.

During her spare time, Jing still loves playing badminton and volleyball. She joins a group of badminton lovers that play every Saturday afternoon, and she happened to find that her advisor, Prof. Guyenne, is a really good badminton player. For volleyball, Jing played with other students in the math department as a team in university intramural several times and got a second place once. She also played Newark winter volleyball games in 2009–2010. Jing always considers volleyball and badminton are smart sports, because you should have not only strong body, but also clear mind to have control over the field.

Q&A Interview with **Robert P. Gilbert**

On December 3, 2010, the department's Colloquium entitled "A Personal Mathematical History" was given by our own Professor Robert P. Gilbert who went over his 40-year academic career. His talk, which can be found at www.math.udel.edu/~gilbert, was nicely supplemented with illustrations of his early research papers together with photographs of collaborators (including senior UD colleagues in their younger years) and pictures taken during his numerous trips around the world.



Robert P. Gilbert received his Ph.D. from Carnegie-Mellon University in 1958. After holding positions at the University of Maryland, Georgetown University and Indiana University, he joined UD in 1975 as the Unidel Professor of Applied Analysis. During his tenure at UD, he directed the Applied Math Institute from 1975 to 1986.

Robert P. Gilbert has been a very prolific mathematician, having authored or co-authored 17 monographs and more than 300 research papers on topics as diverse as Inverse Problems, Ocean Acoustics and Biomechanics. He is particularly well known for his work on function theoretic methods applied to PDEs. His current research (in collaboration with UD colleagues Philippe Guyenne, George C. Hsiao and Yvonne Ou) focuses on the modeling of ultrasound propagation through cancellous bones, in view of retrieving mechanical properties and microstructural information necessary for a better diagnosis and treatment of such diseases as osteoporosis.

Among his numerous awards, he received the prestigious Senior von Humboldt Fellowship three times. He has also been a prolific mentor, having supervised 21 Ph.D. students (for a total of 28 descendants) as well as post-docs, many of which have embraced a successful academic career as well.

Below, Professor Gilbert kindly agreed to play a short question-answer game with us.

HHMI Quantitative Biology Education held at **UD**

From June 9–11, 2010, the University of Delaware was host to a national conference that aimed to address important issues arising in quantitative biology education. The conference was jointly organized by faculty from the Department of Mathematical Sciences (John Pelesko, Tobin Driscoll, Gilberto Schleinger), Department of Biological Sciences (David Usher) and Chemistry and Biochemistry (Hal White). The conference was sponsored by the Howard Hughes Medical Institute Undergraduate Science Education Program at UD.

"Education on the Edge 2010" attracted over 60 participants from all over the country and included Rob Phillips from the California Institute of Technology as the keynote speaker. Louis Gross from the University of Tennessee, Laurie Heyer from Davidson College and Pak-Wing Fok from the University of Delaware gave presentations on interdisciplinary education and research in quantitative biology.

After the talks, the participants broke up into four smaller groups to discuss specific topics. A problem-based learning session was led by Patricia Marsteller (Emory University); a group focused on teaching calculus in the life sciences was led by Pak-Wing Fok; Hal White and Laurie Heyer led a discussion on the assessment of quantitative skills in Biology; and Deborah Allen (National Science Foundation) led a group that was concerned with writing effective proposals.

Hal White oversees a session on assessment of quantitative skills in Biology

The conference was enjoyed by all who attended and we thank the organizers for all their hard work. UD will host the meeting again in 2014.

Deborah Allen leads a session on writing effective proposals to NSF

- **Tell us how you became interested in mathematics and why you decided to pursue an academic career in mathematics?**

I was always interested in mathematics, even as a 4-year-old I could count in my head by 2, 3, 5, 7, 8, 9, 12, etc. I could multiply three digits by three digits. When I was 12 I "invented" a scheme for computing cube roots of any number to whatever accuracy desired.

In high school I joined the mathematics club and the astronomy clubs. I built my own telescope and whenever I was sick and stayed home I read books on astrophysics and stellar structure. I knew about nuclear fusion from about my 12th year, years before U.S. detonated a fission bomb. I recall everyone was mad at me when I was 13 because I declared to all that it was terrible for us to have dropped such a bomb. In any case I wanted to become a physicist and did a double major in mathematics physics at college. In graduate school I continued to take both mathematics and physics courses. I gravitated to mathematics as I wanted to study Cosmology. The cosmologist Alfred Schild left Carnegie and I switched to Analysis and worked with Zeev Nehari.

- **You have written over 300 research papers on various topics. Are there one or two papers you are particularly proud of?**

Here are three favorite papers:

– Multivalued harmonic functions of four variables, *J. d'Analyse Math., 15* (1965), 305–323.

– Generalized hyperanalytic function theory, *Trans. Amer. Math. Soc., 194* (1975), 1–29 (with G. Hile).

– Acoustic propagation in a random saturated medium: The monophasic case, *Math. Mehods Appl. Sciences, 33* (2010), 2206–2214 (with A. Panchenko and A. Vasilic).

continued on page 10

Brief News Items
from the Math Department

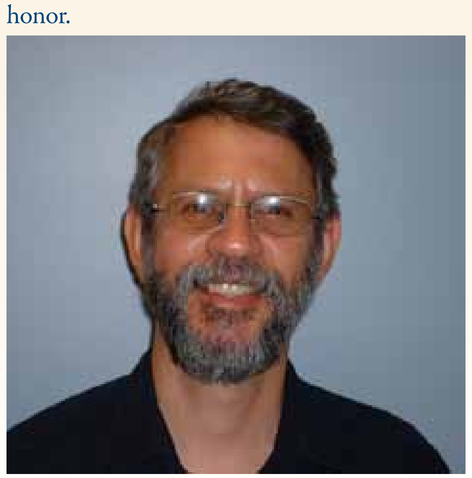
UD shines in COMAP's Modeling Contest

The results from the 2011 Mathematical Contest in Modeling (MCM) have been posted. As you may know, this is the premiere mathematical modeling contest involving over 2,700 teams from around the world. Strong performances over the last decade have improved our visibility as a top undergraduate mathematics program. Both teams completed the contest and submitted excellent reports. One team, consisting of **Eric Sabo, Mike Queppet** and **Robert Deaton** earned a Meritorious rating, putting them in the top 15% worldwide. The other team, consisting of **Mark Lin, Evan Kimpel** and **Ricky Shum** earned a Successful rating. While this is the rating received by the bottom 55%, it should be pointed out that this team tied the best and only team fielded by MIT this year. It's tough contest and attracts the best and brightest from around the world. In MCM, effective teams must produce a paper that spans the golden triangle (modeling, analysis and computation) of mathematics to produce unique insights into a complex problem. To do well, students must pull together knowledge from many different areas of study. Teams choose one of two problems. This year, both teams chose the snowboarding problem. This year, the contest officials posted more information than usual about the problems and the judging. Also, there is a new media contest and they have posted top entries in this area as well.

http://www.comap.com/undergraduate/contests/mcm/contests/2011/results/

Prof. Flores receives Arts & Sciences Excellence in Advisement Award

Prof. Alfinio Flores, Hollowell Professor of Mathematics Education, has won the College of Arts and Science Excellence in Advisement Award for 2011. Congratulations to him on this honor.



Undergraduate Stacey Watro receives City of Newark Community Service Award

Leslie McGowan from the Boys and Girls Club nominated **Stacey Watro** for the City of Newark Community Service Award. On May 12, 2011, Stacey will be receiving the award for her leadership and service to the club. Stacey enthusiastically spearheaded the newly developed partnership between the Math Club and the Boys and Girls Club by recruiting Math Club members to tutor and providing them with transportation to the club a few times a week. She is also working to put plans in place for this partnership to continue next year once she is gone. Please congratulate Stacey on this well-deserved award.

Prof. Coulter receives University Excellence in Teaching Award

Congratulations to **Prof. Robert Coulter** for being selected a recipient of the University Excellence in Teaching Award. This comes with a money prize and Robert Coulter will have his portrait hung in Morris Library for five years and have a brick, inscribed with his name, installed in UD's Mentors' Circle.

Prof. Cirillo receives Outstanding Publication Award

Prof. Michelle Cirillo received the inaugural Linking Research and Practice Outstanding Publication Award for the journal Mathematics Teacher, published by NCTM, the most important professional organization in the field of mathematics education. Michelle's article "Curriculum vision and coherence: Adapting curriculum to focus on authentic mathematics," co-authored with Corey Drake and Beth Herbel-Eisenmann, and published in August 2009, was selected by NCTM's Research Committee.

Prof. Ou receives NIH COBRE Pilot Grant for studying Osteoarthritis

In January 2011, **Prof. Yvonne Ou** was awarded the NIH COBRE Pilot Grant in the amount of $50,000 for 17 months for the research project titled "Numerical Method for Computing Stress Distribution in Multi-scaled Bone-Joint Systems from μ-CT Scans." The specific outcome of the proposed research is the ability for identifying high stress areas in the cartilage through numerical computation. This approach can potentially provide information on how the alignment of joints and bones should be corrected in order to slow down the deterioration of the joint tissue. A more general outcome is the availability of a state-of-art computational tool for studying mechanical properties of composite tissues from μ-CT images, which can be easily accessible nowadays. This grant will provide funding for two students and research visits between collaborating institutions, which include University of Delaware, The Ohio State University and Oak Ridge National Laboratory.

Prof. Driscoll joins the Editorial Board of the Journal of Engineering Mathematics

On Feb. 1, 2011, **Prof. Tobin Driscoll** joined the Editorial Board of the Journal of Engineering Mathematics as an Executive Associate Editor. The Journal of Engineering Mathematics promotes the application of mathematics to physical problems particularly in the area of engineering. It emphasizes the intrinsic unity, through mathematics, of the fundamental problems of applied and engineering science.

Prof. Rossi named the Section Editor for SIAM Review's Education Section

Prof. Louis Rossi has been named the Section Editor for SIAM Review's education section. SIAM Review is the flagship journal for the Society for Industrial and Applied Mathematics with an 2009 two-year Impact Factor of 3.391, ranking 2nd out of 202 measured journals in the Applied Mathematics category. SIAM Review's education section consists of individual modules that are self-contained presentations of specific topics in applied mathematics, scientific computation, or their applications. Prof. Rossi is looking forward to continuing the tradition of bringing the best materials to SIREV's readership and pursuing new directions.

Prof. Braun joins the Editorial Board of the Journal of Engineering Mathematics

As of January 1, 2011, **Prof. Richard Braun** accepted an invitation to be an Executive Associate Editor for the Journal of Engineering Mathematics (JEM) for an initial three-year term. The JEM web site states that the journal "promotes the application of mathematics to physical problems particularly in the general area of engineering science. It also emphasizes the intrinsic unity, through mathematics, of the fundamental problems of applied and engineering science." He will be working with JEM's new Editors-in-Chief Tom Witelski (Duke) and Stephen Wilson (Strathclyde).

Collaborative research grant with Ecole Polytechnique (France) renewed for three years

The collaborative research grant between the inverse scattering group of **Profs. Fioralba Cakoni, David Colton** and **Peter Monk** and DeFI Group at the Centre de Mathématiques Appliquées at Ecole Polytechnique, Paris has been renewed for three more years, 2011-2013. This collaborative program has been successfully running since 2008 and was highly regarded by the midterm evaluation panel. The panel recognized the research teams at Delaware and Ecole Polytechnique as among the leading researchers in the world in the emerging field of qualitative methods in electromagnetic inverse scattering theory. The funding is provided by the French "Institut National de Recherche de Informatique en Automatique" (INRIA) and is 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 the École Polytechnique by Dr. Houssem Haddar.

Prof. Li becomes a Professor in the ECE department

Prof. Wenbo Li becomes a Professor in the Dept. of Electrical and Computer Engineering. The joint academic appointment starts on Jan. 1, 2011, is renewable every three years, and comes with the expectations of continued collaborations in the form of research and/or consultation.

Undergraduate mathematics majors help fill void at Newark Boys & Girls Club

For the past several years, The Greater Newark Boys & Girls Club has offered one-on-one tutoring sessions for students in many disciplines. Recently, however, due to record numbers of students seeking help in mathematics, the need for qualified tutors has risen. According to volunteer coordinator Leslie McGowan, in the past, tutors who are comfortable helping with middle and high school math have been hard to find. This year the Math Club at the University of Delaware is helping to fill that void. After becoming involved as a volunteer tutor at the Boys and Girls Club and recognizing the need for additional help, **Prof. Michelle Cirillo** teamed up with McGowan and Math Club President, **Stacey Watro** to recruit six UD math majors to tutor this fall. The tutors, five of whom are secondary education majors, meet for one hour each week to work with students in grades 4–9. McGowan observed that the benefits of tutoring are two-fold, particularly for the education majors: "Not only are they helping our members achieve academic success, but they are gaining valuable experience that will help them in their future endeavors." McGowan is extremely grateful that volunteers like sophomore **Carly Toth** are helping the club's members achieve academic success. Toth is finding the work to be rewarding and has enjoyed seeing the impact her efforts are having on her student. She noted, "Last week the girl I have been tutoring told me she was doing something in class that we worked on, and she really understood it." Toth plans to continue tutoring for the organization in the spring. To find out how to get involved with volunteer tutoring, please contact Stacey Watro (sawatro@udel.edu) or Michelle Cirillo (mcirillo@math.udel.edu).

Profs. Braun and Driscoll awarded a new NSF grant to study the tear film

Profs. Richard Braun (PI) and **Tobin Driscoll** (CoPI) have been awarded a three-year NSF grant from the Division of Mathematical Sciences; the project is funded for about $444,000 from the Program in Mathematical Biology and the Cyber-enabled Discovery Initiative. The grant includes support for two graduate students and support to travel to meetings to disseminate the results. The project will study dynamics of the thin liquid film that coats the front of the eye during and after each blink: the tear film. This thin layer is critical for clear vision and a healthy eye. The spreading and dynamics of the tear film will be studied with a hierarchy of new mathematical models and will develop new computational methods to solve them. There will be two thrusts for the project, with one involving stationary eye-shaped domains and the other on moving but simpler-shaped domains. Successful application of these methods will bring new capabilities for understanding tear film dynamics. New understanding of tear film dynamics would benefit a large number of people. As of 1998, up to ten million Americans required use of artificial tear preparations; nearly 5 million Americans age 50 or older suffer from moderate to severe dry eye symptoms. This project will improve accepted mathematical models from our group to include more physiologically important effects, particularly osmolarity, the combined concentration of certain salts and sugars in the tear film. Osmolarity is suspected by physicians of being crucial in the development of dry eye, and the model yields new insights into tear film and osmolarity dynamics. The project benefits from synergy in the intensive collaboration with optometrists at the Ohio State University, and the computational approaches benefit from continued collaboration with Lawrence Livermore National Laboratory.

UD teams score top ratings at the Mathematical Contest in Modeling

Congratulations to both of UD's 2010 Mathematical Contest in Modeling (MCM) teams for their achievement! MCM is the premiere mathematical modeling contest involving over 2,200 teams from around the world. For those unfamiliar with MCM, teams of up to three students have four days to solve an open mathematical problem. One of our teams, consisting of **Eric Sabo, Robert Deaton** and **Patrick Stengel** earned a Finalist ranking putting them in the top 1% worldwide. Teams are designated Outstanding (top 1/2%), Finalist (next 1/2%), Meritorious (next 19%), Honorable Mention (next 24%) and Successful (next 55%). The Finalist ranking is a new category introduced this year. To reach this point, the students' work must survive seven rounds of judging. Our second team, consisting of **Soham Gandhi** and **Dariusz Murakowski**, was hindered by the loss of its third member on short notice but still managed a very respectable Successful designation. Considering that most cars won't even start with an 8V battery, this is quite an achievement. In MCM, effective teams must produce a paper that spans the golden triangle (modeling, analysis and computation) of mathematics to produce unique insights into a complex problem. Typically, students need to pull together knowledge from many different areas of study. Teams choose one of two problems. This year, the first problem concerned strategies for hitting a baseball and the second problem required students to apply geometric reasoning to criminology. The press release provides more detailed information. A great university measures itself by its students. UD has had a very long run of placing teams in the upper echelons in the MCM rankings and this year was no exception. In 2008 and 2009, UD had teams with Outstanding designations. From 2005–2007, our teams scored Meritorious designations. If you are interested in participating in the content next year, or you know a student who might be a good fit for it, please let me know.

Prof. Cook becomes an Associate Editor of the Expository Research Papers section of the SIAM Review

As of January 1, 2010 **Prof. Pam Cook** has become an Associate Editor of the Expository Research Papers section of the SIAM Review. The SIAM Review consists of five sections (Ex-

continued on page 10

Brief News Items, continued from page 9

pository Research Papers is one of these sections), all containing articles of broad interest.

2010 Webber Award Ceremony held on May 5

Dr. James Hiebert, School of Education, University of Delaware and **Jan Shetzler**, Caesar Rodney High School, will receive the 2010 Webber Award at a ceremony to be held Wednesday, May 5th in the Trabant Theater (lower level of the Trabant University Center).

The award is given "in memory of G. Cuthbert Webber, Ph.D., Chicago 1934, pedagogue and Professor of Mathematics, University of Delaware (1937–1981), an award consisting of a plaque and a financial gift is presented to a member of the University community or a mathematics educator in the State of Delaware for work in advancing mathematics education." **Jose Alfredo Jimenez**, Pennsylvania State University will be the keynote speaker. The title of his talk is The Development of the Euler Characteristic.

Department of Mathematical Sciences annual picnic

This year, our departmental picnic took place on September 18, 2010 in the White Clay Creek Park. Faculty, staff and students together with their friends and families gathered around delicious food and sports activities on a beautiful Saturday. The student team lost to an impressive faculty team in the soccer game.

Gilbert, continued from page 7

• Describe to us your past and current research?

I started in complex analysis, found some applications to quantum mechanics and quantum field theory. This lead to a study of the so-called function-theoretic method for PDEs. This work was extended to the studying of generalized hyperanalytic functions and applications to elasticity. This is seen by the number of papers published in elasticity journals.

I also worked on Inverse Problems as they appear in Underwater Acoustics. These problems are quite difficult as the ocean forms an acoustic waveguide, which is coupled to an energy adsorbing seabed.

My current research is on what I term Medical Mathematics. I am currently working on osteoporosis and bone rigidity. We are also interested in cell biology as it pertains to bone formation. In the future I wish to also move in the direction to cardiology, in particular blood flow in the arteries.

• You once wrote a letter to Albert Einstein and he replied to you. What was the subject of this correspondence?

As a young graduate student of 20, I wrote to Albert Einstein about the Heisenberg Uncertainty Principle. He answered me and sent a paper of his.

• Tell us about a memorable moment you experienced in the classroom?

Occasionally one has a bright student who seems to understand. When this happens it is a great joy for me.

• You have been in academia for more than 30 years. What are your other hobbies outside of mathematics?

I suppose the primary hobby is photography. At one time I wanted to be an artist. Some of my cousins on my mother's side became professional artists. I might go back to oil painting myself. I had painted up to the time of graduate school, but found it too time consuming while pursuing a career as a mathematician. I also enjoy sailing in the summer and playing the cello in the cooler part of the year.

• Any advice for students and younger mathematicians who would like to follow your steps?

My advice to the young is to work hard, but what is more important is to have good ideas in the first place.

• You are also well known in Asia and Europe. How did these connections get started?

My connection with Asia came about when Lin Wei wrote to me and asked to come to work with me. At that time I was Director of the Applied Math Institute (the predecessor of the Wave Center). The Institute was directly under the provost not the chair or dean. This caused friction, because we got the dean's share of the overhead. I directed the Institute from 1975–1986. We had a budget and I was able to invite Lin Wei for a year.

We wrote three papers together and when he went back to China he arranged for me to visit Sun Yat-Sen, Fudan and Beijing Universities. The Chinese were very interested in my work on "generalized hyperanalytic function theory" and they translated my first book, *Function Theoretic Methods for PDEs,* into Chinese. It sold 7,500 copies, three times what it had sold in the West. From that time on I was very well known in China.

With regard to Germany and Europe. I had just developed the generalized analytic function theory when I first visited Germany and Holland. It seems my work killed two Ph.D. theses after I gave my lectures. For some reason this way to attack problems was very hot at that time.

• Tell us about a decisive moment during your career or a memorable meeting with a famous fellow mathematician?

A memorable meeting with a mathematician might be the meeting with Gaetano Fichera at U. Maryland. We got on famously after I remarked that as he was an Italian mathematician he must love geometry. It turned out he as I did also. Some people found him to be difficult at times but I always got along very well as I did also with Alexander Weinstein and Carlo Pucci. Through Fichera I met Ladyschenskya, Mazya and Oleinik. I visited Gaetano numerous times in Rome. We were very good friends until he died.

I also knew Max Schiffer, Stefan Bergman and Ilya Vekua quite well. I had edited Vekua's notes he gave at Maryland. From the following correspondence came a long friendship.

• You are still actively working with some of your former Ph.D. students. How do you keep these collaborations going on?

I still work with Jim Buchanan, Steve Xu, Ming Fang, Yvonne Ou, Alex Panchenko and Ana Vasilic. The collaboration lasts as long as the ex-Ph.D. is still interested in research. So far I am still active and will continue to remain so for some time.

• You directed the Applied Math Institute at UD from 1975 to 1986? What was the purpose of this institute and what kind of research was conducted there?

The Applied Math Institute had many members from other departments; however, the only department that shared overhead with us was the math Department. David Colton and I had an AFOSR grant together and so did Ralph Kleinman with George Hsiao and Tom Angell. I had a DOE grant with Alan Jeffrey, who was an Adjunct Prof. from Newcastle. Fadil Santosa was also a member as was Marcel Neuts.

We had the old brick house that now serves for Academic Services at 5 West Main Street.

All types of applied mathematics were carried on at the Institute from moving boundary problems, inverse problems, fluid dynamics to elasticity.

New Hires

Evangelia Kalligiannaki joined the department as a Post-Doctoral Researcher. She received her Ph.D. in 2007 from University of Crete, Greece.

Before joining the University of Delaware, she was a Post-Doctoral Researcher in the Joint Institute for Computational Sciences, a joint institute of the University of Tennesse (UT) and the Oak Ridge National Laboratory. She also held a post-doctoral research position in the Institute of Applied & Computational Mathematics, Foundation for Research & Technology-Hellas (F.O.R.T.H.), Creece.

Evangelia's research interests involve analysis, development and implementation of new algorithms for stochastic simulations with Monte Carlo methods, as well as analysis of coarse-graining schemes for polymeric systems. Her doctoral research was based on quantum mechanical theory tools, such us Wigner transformation, semiclassical asymptotics, applied to high frequency wave propagation.

Idris Mercer received his Ph.D. under Peter Borwein at Simon Fraser University in greater Vancouver, and comes to Delaware via Toronto where he held temporary positions at York University and also worked for a private tutoring company for university students. His favorite subject to teach is calculus, and his research interests are problems that lie on the boundary between combinatorics, probability, and classical analysis.

Idris is especially interested in applying analytic and probabilistic methods to combinatorial enumeration, discrete probability, or number theory. Recent interests include binary sequences and their autocorrelation properties, and random polynomials and their behavior on or near the unit circle.

Idris's interests outside of mathematics include jogging, trivia, crosswords, and hoppy beer.

Miao-Jung Yvonne Ou joins the department as an Assistant Professor. She received her Ph.D. in Applied Mathematics from the University of Delaware in 2001.

Dr. Ou's main research interest is on the interface of applied analysis and physical sciences. Her current work focuses on the mathematics for finely structured composites, which is sponsored by the Mathematical Biology program of National Science Foundation. The aim is to develop an algorithm that can recover information on the micro-architecture of composites by using informations of how effective properties such as effective Young's moduli change with temperatures or frequencies. Interestingly, the algorithm is based on a theorem in several complex variables. Dr. Ou is also interested in fast algorithms for definite and indefinite Helmholtz equations. They are related to physics of wave propagation, potential scattering in quantum mechanics and electronic structure computations. During her time at Oak Ridge National Laboratory, she was a member of the team that developed multiwavelet solvers for these problems. Her main contribution there was providing the mathematical pieces that enable the implementation of arbitrary Dirichlet/Neumann conditions in the package MADNESS, which stands for Multiresolution Adaptive Numerical Environment for Scientific Simulation. Currently, she is also working on developing a fast boundary element method solver which can compute the effective properties of cancellous bones directly from the μ-CT scans.

Chetan Pahlajani received his Ph.D. in Mathematics in October 2007 from the University of Illinois at Urbana-Champaign under the direction of Richard Sowers. Following that, he was a Visiting Assistant Professor of Mathematics at the University of California Santa Barbara.

His main research interests lie in Probability Theory and Mathematical Biology. He has recently worked on some model reduction problems in stochastic chemical kinetics, motivated by questions in gene regulatory networks. He is currently working on a problem involving modeling and analysis of reaction kinetics in caveolae-pockets on membranes of cells that speed up various important reactions. In addition to this, he has lately developed an interest in some questions in stochastic control that arise in problems of robot navigation in the presence of noise.

Over the 2010–2011 academic year, he has taught Calculus III and Differential Equations and Linear Algebra II.

Francisco-Javier Sayas joins us as a tenure track associate professor. He received his Ph.D. in 1994 from the University of Saragossa (Zaragoza) in Spain, under the unconventional supervision by mail of Michel Crouzeix from the Université de Rennes in France. In 1997 he got a tenure position at the Department of Applied Mathematics in Saragossa. Starting in 2007 he enjoyed a three-year visiting appointment at the University of Minnesota.

Francisco's interests deal with many branches of numerical analysis and computational mathematics, with a focus on scattering problems and coupled fluid systems. Much of his interests are related to making the most of different methods in physical systems that require different treatment in separate parts of the space. The Boundary Element Method has been a recurrent source of problems in his academic life, although Mixed Finite Elements, Discontinuous Galerkin Methods and Classical Finite Methods make frequent appearances in his papers. Francisco has supervised five doctoral students, four in Saragossa and one at the University of Concepción in Chile.

His personal interests include playing the piano, concert-going around the world and keeping track of his ever increasing collection of recordings of British composers.

UNIVERSITY OF DELAWARE

Department of Math Sciences
University of Delaware
Ewing Hall
Newark, DE 19716

Many Thanks for Your **Support!**

Thank you to all the alumni, parents, and friends who have made generous contributions to the Department of Mathematical Sciences.

Mathematical Sciences drives break-through research and technological advances firmly rooted in mathematical knowledge. From the Internet and DNA testing to the creation of the skyscraper and space travel, mathematics plays a crucial role. Your gift to our department will support over 40 full-time faculty, over 60 graduate students, and more than 200 undergraduate majors that are changing the world. By supporting the Department of Mathematical Sciences, you will be providing valuable resources to our students such as research opportunities, scholarships, and much more.

The easiest way to make a gift is to visit **www.udel.edu/makeagift**. Our online form allows you to give via check or credit card. Please be sure to note "Department of Mathematical Sciences" in the "other" designation box. To mail in a check, please indicate "Department of Mathematical Sciences" in the check's memo section and mail it to:

University of Delaware
Office of Annual Giving
011 Hullihen Hall
Newark, DE 19716

For additional information on how to make a gift, please visit **www.math.udel.edu/resources/alumni/giving.html**, or call the Development Office toll free at 866-535-4504 during normal business hours or email **annualgiving@udel.edu**.

Thank you again for supporting the Department of Mathematical Sciences!

Donor Support

Mathematical Sciences Alumni Donors to the University of Delaware in Fiscal Year 2010 and Other Friends contributing to the Department of Mathematical Sciences.

Dr. John F. Ahner
Ms. Sandra Amory
Dr. Karen L Balasaygun
Dr. David J. Barsky
Dr. Robert Bowers
Ms. Melinda Bush
Mr. Peter Daunais
Ms. Helen T. Donches
Ms. Margaret M. Donches
Ms. Margaret M. Donlan
Dr. David A. Edwards
Dr. Thomas E. Favinger
Mr. & Mrs. Jonathan L. French
Mr. and Mrs. Carl F. Geiszler
Dr. William J. Geppert, Jr.
Mrs. Rochelle Goren
Ms. Emily K. Gustafson
Ms. Deborah L. Heiser
Mr. and Mrs. Lawrence Jones III
Dr. and Mrs. Kirk E. Jordan
Mr. and Mrs. Harry Kutch
Dr. & Mrs. William G. Lese, Jr.
Dr. Liangping Ma
Mr. Peter A. McHugh
Dr. Authur Milholland
Mr. & Mrs. Carl O. Miller
Mr. Ashish J. Modhera
The Pfizer Foundation, Inc.
Dr. John F. Polk, Jr.
Dr. Kathryn F. Porter
Mr. Richard L. Postles
Mrs. Jo Anne Pratt
Dr. and Mrs. Thomas K. Pratt
Mrs. Francine Quintano
Dr. Scott E. Rimbey
Dr. & Mrs. Anthony Seraphin
Mr. Richard L. Showers
Mrs. Evelyn Strawbridge
Dr. & Mrs. Raymond R. Strocko
Dr. Dennis E. Sweitzer
Mr. Peter M. Ucciferro
Mr. and Mrs. Thomas Vozzo
Dr. G. Andrew Webber
Dr. Joan Weiss
Mr. Kenneth R. Welsh
Dr. & Mrs. Dahong Yu