PURDUE UNIVERSITY

Math PUrview

Newsletter of the
Department of Mathematics ◆ West Lafayette, Indiana Summer 2003

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Luis Caffarelli was a principal lecturer at the "Symposium on Analysis and PDEs" held at Purdue May 23-26, organized by Donatella Danielli. See page 11 for more on the conference and Danielli's activities.

Math PUrview is published annually for alumni and friends of the Purdue Mathematics Department. We welcome comments and suggestions for future newsletters (Sally Goeke, editor, goeke@math.purdue.edu).

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Purdue Hosts CAARMS9

The Purdue Mathematics Department hosted the 9th annual Conference for African-American Researchers in the Mathematical Sciences on June 24-27, 2003. Seventy-six mathematicians gathered to attend conference events that included invited technical talks, tutorials, and a graduate student poster session. James E. West of Johns Hopkins University was the banquet keynote speaker; his talk was entitled "Talking Drums, Microphones and African-Americans in Technology."

John Contreni, Interim Dean of the Graduate School, distributed awards to student poster presenters at the CAARMS banquet.

Invited speakers were Rodrigo Bañuelos (Purdue), Naiomi Cameron (Harvey Mudd), Garikai Campbell (Swarthmore), Richard Charles (Math Learning Institute), John Albert Ewell III (Northern Illinois U.), Nancy Glenn (U. South Carolina), A.B. Gumel (U. Manitoba), John Harkless (Howard U.), Raquel Hill (Georgia Tech), Trachette Jackson (U. Michigan), Tor A. Kwembe (Chicago State U.), Richard Tapia (Rice U.), and Rodney Wallace (IBM/George Washington U.)

James West, CAARMS banquet keynote speaker, with winners of the grad student poster competition.

The conference was organized by William A. Massey of Princeton University and Purdue faculty members Rodrigo Bañuelos, Johnny Brown, and Carl Cowen. The National Security Agency, the Institute for Mathematics and its Applications, and Purdue University provided financial support.

Additional information (e.g., abstracts of all talks and poster presentations, a history of CAARMS, previous conferences) is available on the conference website:

www.princeton.edu/~massey/CAARMS9

From the Department Head

Leonard Lipshitz

This past year—the first of my current term as department head—was unusually busy for the Mathematics Department. The entire faculty engaged in planning activities as the University continued to move towards developing a comprehensive strategic plan for the entire institution. In the spring, Dean Jeffrey Vitter conducted an external review of the department by bringing a team of seven prominent mathematicians to campus for two days. Headed by Salah Baouendi of UC San Diego, the committee, comprised of Douglas Arnold (U. Minnesota and the IMA), Robert Glassey (Indiana U.), Steven Kudla (U. Maryland), Thomas Kurtz (U. Wisconsin), Robert Lazarsfeld (U. Michigan), and Richard Tapia (Rice U.), meticulously examined our research and teaching programs, met one-on-one and in groups with faculty and students, and generated a report identifying our strengths and offering recommendations for improvements. This exercise was the perfect complement to our planning process; the committee's recommendations will provide a basis for our efforts to enhance our programs.

As part of the external review process, we prepared a comprehensive document describing all aspects of departmental activities. To the right is a list from the document, describing some of the interdisciplinary research in which our faculty currently are engaged. Various other events and activities of the past year are also featured in this newsletter. My thanks to Aaron Yip for his willingness to share his research and Purdue experiences with you—recently promoted to associate professor, Aaron began his academic life as a Purdue engineering major. Steve Bell, who writes about our REU students, was instrumental in our achieving the renewal of our NSF VIGRE award and obtaining additional GAANN support. We were privileged to host two research conferences earlier this summer. The entire department and Purdue community were deeply saddened by the sudden and unexpected loss last October of one of our respected colleagues, Professor Jean Rubin.

As is the case everywhere, we face many challenges brought on by tough economic times. The department has outgrown its space in the 35^{+}-year-old Mathematical Sciences Building, which was constructed with funding from the federal government during the mid-60's when, faced with Cold War competition from the former USSR, the support of mathematics research was a top priority in the U.S. (The world has certainly changed—a number of our faculty and doctoral students are natives of what is now Russia and Ukraine.) Despite current (and we hope temporary) budget restrictions and an increasingly crowded facility in need of some improvements, the Mathematics Department strives each semester to provide quality instruction to thousands of future engineers and scientists. At the same time, we offer highly respected undergraduate programs in mathematics and actuarial science and an excellent graduate program for the training of future researchers. And, we continue to do all of this while cultivating a high-caliber research environment that will attract outstanding researchers to our faculty.

We are grateful to all of our alumni for their support of our work—please stay in touch and let us know if there is something we can do for you. §

Recent Interdisciplinary Research of the Mathematics Faculty

Patricia Bauman and **Dan Phillips** were co-PIs on a DOE-funded project through the Midwest Superconductivity Consortium (MISCON). MISCON has evolved into MATCON (Materials Consortium), and Bauman and Phillips continue to participate. They are exploring possible avenues of joint research with faculty in Materials Engineering and Aeronautical Engineering at Purdue, and are members of the new Birck Nanotechnology Center.

Zhiqiang Cai is involved in collaborative work with Professor Starke at the University of Hanover, Germany on least-squares methods for elasticity, with Professor Kim at Changwon National University, Korea on singular function finite element methods, and with Drs. Lee and Tong at Lawrence Livermore National Lab on numerical methods for elasticity and incompressible flow. He, together with S. King in EAS and **John Cushman**, recently submitted a proposal to NSF entitled "Micro-polar continuum theory applied to convection in earth's mantle."

Carl Cowen spent the 2002-03 academic year at the Mathematical Biosciences Institute at Ohio State University. Next year he will embark on a joint project with Prof. Chris Sahley (Biology) to create a mathematical model to describe part of the sensory system of the medicinal leech, *Hirudo medicinalis*.

John Cushman's research is the physics of fluids in porous media, over time/space scales ranging from picoseconds/angstroms to years/miles. Problems of special interest are (i) species separation and phase change in micropores, (ii) dispersion in media with continuously evolving heterogeneity, (iii) swelling colloidal systems, (iv) reservoir-scale dispersion of environmental contaminants in natural geological media, (v) transconjugation of genes between microbes and their evolution in the environment, and (vi) developing theories for the evolution of earth's plates. Some past and present examples are available on Cushman's website (www.math.purdue/~jcushman).

Jim Douglas has for some years worked with Felipe Pereira and his associates, faculty and graduate students at Instituto Politécnico da Universidade do Estado de Rio de Janeiro, on modeling flows in porous media. The problems come from petroleum engineering and environmental engineering. Li-Ming Yeh (National Jiao-tong University, Hsinchu, R.O.C. Taiwan) has been involved in the petroleum engineering aspects of the research, and Anna Spagnuolo (Oakland University, Rochester, MI) and Chieh-Sen Huang (National Sun Yat Sen University, Kaohsiung, R.O.C. Taiwan) have been involved in the environmental engineering simulations. To a smaller extent, he has worked on a variety of wave problems arising in exploration geophysics with **Juan Santos** and Dongwoo Sheen (Seoul National University, Seoul, Korea).

Zhilan Feng is involved in a joint NSF-funded project with R. Swihart (Forestry), B. Craig (Statistics), and Y. DeWoody (Forestry) on modeling metapopulations in heterogeneous landscapes. Feng and **Fabio Milner** have a joint NSF-supported project with Dennis Minchella (Biology) on the modeling of the interaction between parasitic nematodes and their invertebrate and vertebrate hosts.

Andrei Gabrielov has been involved in NSF-funded collaboration with D. Turcotte (Geology, Cornell) on the application of dynamical systems to earthquake prediction, and in collaboration with V. Keilis-Borok (Earth and Space Sciences, UCLA) on understanding and prediction of critical transitions in complex systems, funded by the James S. McDonnell Foundation, The 21st Century Collaborative Activity Award for Studying Complex Systems.

(cont. on page 11)

QED may RIP
...and it happened at Purdue

by Steve Bell

Yes, it happened during our Research Experience for Undergraduates (REU) Program in the summer of 2002. This program is a centerpiece of the Math Department's "VIGRE Program," which has been funded by a multimillion dollar grant from the National Science Foundation awarded jointly to the Purdue Departments of Mathematics and Statistics. V.I.G.R.E. is short for *Vertical Integration of Research and Education in the Mathematical Sciences*, and it is NSF lingo for getting undergraduates, graduate students, postdocs, and faculty all lined up to do research together as one big happy family.

Nowhere are these goals being met more dramatically than in our Summer REU Program. Faculty, postdocs, and graduate students have banded together to give undergraduates from Purdue and across the country a very stimulating eight weeks of research and study. The experience culminates in a joint meeting with REU programs at Indiana University, Notre Dame University, Rose Hulman, and Wabash College, where the students report their research results. The following week, the Purdue REU's report their work at a special all day presentation.

Now back to the story about the demise of QED . . .

Mathematicians use the letters "QED" to punctuate the end of an argument, whether it be in print or the spoken word. The letters stand for the Latin *quod erat demonstrandum*, which translates, "which was to be proved." To us, it means "what was to be proved has been proved," and although we say the letters in a monotone voice, it is for us the equivalent of spiking the football in the end zone and doing an ebullient funky chicken dance. It is the *kachang*, the *BOOYA*, the high five of mathematicians. Every mathematician has had the dream where they stand in front of a jam-packed chalkboard and utter the words, "and this shows that all of the zeroes in the strip fall along the line real z equals one half," and, if we don't wake up with a shudder, followed by a deadpan "QED."

Faculty mentor David Goldberg makes a point after REU student Justin Mazur's talk at the Undergraduate Research Day Mini-conference, July 2002.

QED is so hardwired in my brain, that I was shocked, bewildered, and maybe even outraged to notice that undergraduates reporting on their research last summer seemed to be using the letters CRAH in place of the traditional QED. It was uttered at the right time with the right lack of intonation, but I could not fathom a guess as to what it stood for. Every time I heard it, I flinched and looked around the room at the faces of the undergraduates in the audience to see if they were reacting to it the way I was. They weren't. But one time I noticed that a student I knew quite well seemed to blush a little and look sheepishly away when I glared over my shoulder at him. After the lecture, I collared him and asked him what on earth it was all about. He told me that C.R.A.H. stands for "camera revolves around head." You see, all the students had gone together to see the movie, "A Beautiful Mind," that summer, and they noticed that every time Nobel Prize winning mathematician John Nash (played by Russell Crowe) made a breakthrough on his mathematical work, the camera slowly revolved around his head as his eyes bulged in an expression of sheer bliss. I liked it! And it conveyed better that feeling of "in your face and slap me five" that the end of a long and difficult proof deserves.

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From Engineering to Mathematics and Back to Engineering by Aaron Yip

Associate professor Aaron (Nung Kwan) Yip started his Purdue experience as an engineering undergraduate and returned a few years later as a member of the mathematics faculty.

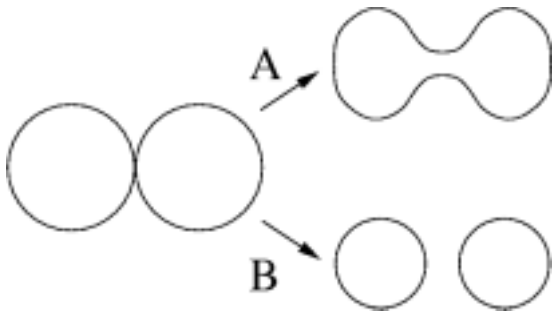
I still remember the day I first set foot in the United States on August 12, 1988. The immigration officer greeted me with a big "Welcome to the United States, Mr. Yip!" I was initially struck by the vast amount of space here, which was a great contrast to the highly dense structural landscape of Hong Kong. I arrived at Purdue as an undergraduate student majoring in electrical engineering. At that time, most young people in Hong Kong thought it was "cool" to be an engineer. A mathematician, on the other hand, was someone confined to working and thinking in an office, facing a blackboard all day long. So here I was at Purdue, following the popular line of thought among my peers at home by majoring in engineering. Mathematics, however, was always on my mind. The first math course I took was MA 271—multivariable calculus—taught by Professor David Drasin. I was soon convinced that mathematics could be exciting and useful, not just limited to working problems on a blackboard. After my first semester at Purdue I decided to switch my focus to mathematics, but I continued working on the EE degree so I could be more versatile later on "just in case." During later semesters, I squeezed math courses into my plan of study. "Problem of the Week" became my weekly homework problem. Though I am now a mathematician, I very much appreciate the rigorous engineering training I received at Purdue, which provided two crucial benefits: first, I realized that engineering problems can involve interesting and non-trivial mathematics; and second, I am not afraid of touching and using a computer.

A bubble inside a tetrahedral framework

As I was finishing up at Purdue, I applied to math graduate programs. The summer transition between Purdue and Princeton, where I earned a Ph.D. in mathematics, was like a tough semester—I tried to catch up on all the math courses I had missed. With so many holes in my mathematical background, I did not quite know what to do. The natural thing was to sample some graduate courses—I had already been warned that the graduate courses at Princeton are in fact research seminars. However, one course that caught my attention was "Geometric Measure Theory" (GMT). Every single word made some sense to me. During the first lecture, a professor enthusiastically presented in elementary terms many interesting open problems in the calculus of variations and geometry. Immediately after that lecture, still not having much of a clue what GMT was, I said to myself, "This is it. I want to be a student of THIS professor." That was only the first day of class! The professor was Frederic J. Almgren, Jr. For those trying to get a feeling of what GMT is, feel free to consult Federer's authoritative treatise [4] and Professor Almgren's work [1]. (The original manuscript of [1] is more than 1700 pages!) In my own words, I would describe GMT as a tool to study the properties of geometrical objects such as curves and surfaces that arise from minimization problems. Obvious examples include soap films and bubbles that attain shapes with minimum area under various constraints, such as enclosing prescribed volumes. A fun paper to read is [2]. Two other good references are [6] and [7].

Even though GMT was originally invented to study static minimization problems, it is also used frequently in the investigation of time-dependent problems. A good example is motion by mean curvature (MMC). A curve or surface is said to move by MMC if at every point, its normal velocity equals its mean curvature. Mean curvature can be viewed as the variational derivative of the area functional. Thus a surface evolving by MMC will decrease its area and presumably converge to a minimal or an area-minimizing surface. The mathematical study of MMC is very difficult as the underlying equation is highly nonlinear and singularities can occur. The first general mathematical result was made by Brakke [3]. Another interesting contribution was due to Gage and Hamilton [5]. (Incidentally, Hamilton has also worked on the Ricci flow, which is heavily used in the proof of the Poincare conjecture recently announced by Perelman.) For a more comprehensive view of mean curvature and various mathematical techniques in the study of MMC, I highly recommend [9]. MMC and its variants have also found wide applications in materials science and image processing.

My thesis problem was to incorporate stochastic noise into MMC and related motions. It is not immediately clear how this can be done due to the combined effects of the nonlinearity of the geometric motion and the possible singular spatial and temporal behaviors of noise. This is still largely an open but active research area. One interesting result on the effects of noise is the ability of noise to select "natural" solutions [8]. It is well known that MMC can have *multiple* solutions starting from the same initial data. One simple example is given by a pair of touching circles.



Multiple solutions for MMC can arise from the same initial data.

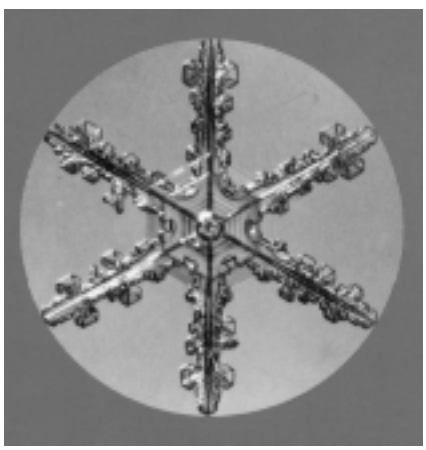
There are (at least) two ways this curve can evolve—A and B. Both are *stable* solutions. The deterministic motion cannot predict which one will arise. However, under the effect of a small amount of noise, it is proved that solution A will always occur. Mathematically, one considers the following stochastic motion law:

$$\upsilon_n = \kappa + \varepsilon \dot{W}(t)$$

where υ_n is normal velocity, κ is mean curvature, $\dot{W}(t)$ is white noise – the time derivative of Brownian motion, and ε is a small parameter. This motion law leads to a stochastic evolving curve $\Gamma^{\varepsilon}(t)$. Upon letting $\varepsilon \to 0$, it is proved that $\Gamma^{\varepsilon}(t)$ converges to solution A with probability one. This example clearly demonstrates the selection principle carried out by noise. It will be interesting to see if a similar statement holds in more general situations.

After spending three years as a post-doc at the Courant Institute and the University of Wisconsin, I was delighted to return to Purdue in 1999 as a faculty member. It was nice to return to a familiar place—MSEE, Potter Engineering Building, Math Science Building, "Problem of the Week"—and many of my teachers were still here. The Co-Rec is without a doubt THE BEST gymnasium among all the universities I have been to. But there were also some changes—the dormitory I lived in during my first and second years, Fowler House, had been converted to a day-care center. Very often I like to park my car far away from the Mathematics Department so that I can walk through the campus, just as I did as an undergraduate.

Teaching at Purdue is also a great experience. The first course I taught was MA 271 (what else?). Lecturing is like speaking to fellow students. Teaching courses that I had wanted to take as an undergraduate (but for which I had no time) is interesting. My engineering training in some ways determines which courses I teach. Mostly I teach courses of an interdisciplinary nature such as linear algebra and differential equations, which reach a wide audience. I hope to convey to students the idea that mathematics can actually be used both *inside* and *outside* of mathematics. I will let the students judge if my approach is successful.



A single ice crystal

I am also enjoying Purdue's strong interdisciplinary environment. I believe in the great existing and future potential for Purdue, especially in the Mathematics Department, to engage in further collaborative research. During my post-doc years, I was greatly intrigued by the wide range of applications of MMC, or more generally, curvature driven flows. My current research focuses on the mathematical analysis and modeling of phase boundaries in materials science. These boundaries, inevitably existing in real materials, separate regions with different materials or physical properties. They include the solid-liquid interface as in crystal growth and the solid-solid interface as in grain growth. Very often their motion is driven by the reduction of interfacial energy. This naturally leads to curvature driven evolutions. Some of my current projects include the descriptions of local minimizers of energy functionals related to phase transformations, motion of boundaries in heterogeneous environments, and the consideration of stochastic effects. These problems can touch upon interesting questions in areas such as analysis, probability, modeling, and simulation.

One of the central mathematical challenges of materials science is the bridging of scales—how information can be passed from small-scale microscopic processes to large-scale continuum descriptions. The length and time scales can easily cross over several orders

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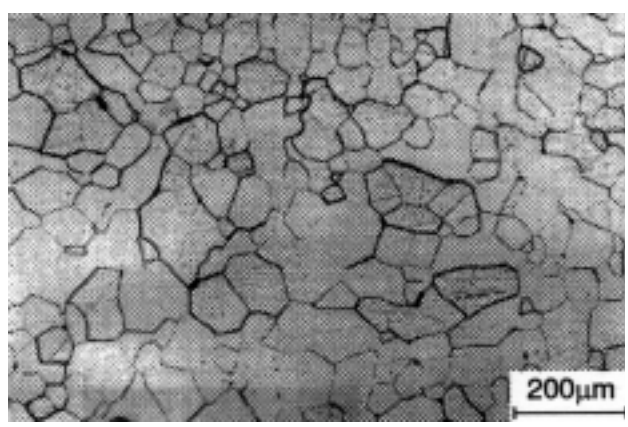

Microstructures of heavily deformed α-Fe after annealing

Faculty Milestones

Rodrigo Bañuelos has been elected to fellowship in the Institute of Mathematical Statistics. The citation letter reads: "Fellowship in the institute is a way of honoring the outstanding research contributions of our members, contributions of which help keep IMS in a leading role in the field of statistics and probability." The new fellows will be welcomed and presented with plaques in August at the IMS Annual Meeting during the Joint Statistical Meetings in San Francisco, California.

David Drasin is serving as Program Director in Analysis at the National Science Foundation in Washington, DC for the period 2002-04.

Jim McClure, Richard Penney, Eleftherios Zachmanoglou were among the Top Ten Teachers in the School of Science for 2002-03, an honor bestowed by junior and senior students in Science.

Recent faculty promotions in the department included **Zhiqiang Cai, Jin Ma,** and **Kenji Matuski** to full professor; **Aaron Yip** to associate professor; and tenure awarded to associate professor **Plamen Stefanov**.

Aaron Yip received a Purdue "Teaching for Tomorrow Award." Sponsored by the Classes of 1944 and 1945 and administered through the Provost's office, the award includes $500 in faculty development funds.

Joining our faculty in the fall will be associate professor **Jiu-Kang Yu**, formerly of U. Maryland, and assistant professor **Arshak Petrosyan**, who recently completed a three-year Bing instructorship at the University of Texas, Austin.

Mathematics Awards

Award-winning math students were recognized at the annual department awards program on April 29. Left to right: Eric Tkaczyk, Celine Gallo, Damir Dzhafarov, Alex Crane, Chris Manon, James Sherman, Ben Zwickl, Brandon Zerbe (seated), Jason Wake, Justin Mazur, Prof. Jim McClure.

Eugene V. Schenkman Memorial Award ($200)	Benjamin Zwickl
Glen E. Baxter Memorial Award ($400)	Christopher Connor Jared Huckstep
Michael Golomb Mathematics Award ($200)	Justin Mazur
Meyer Jerison Memorial Award ($200)	Damir Dzhafarov
Gerald R. MacLane Memorial Award ($300)	Yihuang Shen
Merrill E. Shanks Memorial Award ($100)	Alex Crane, Jason Wake
Senior Achievement Award ($100)	Celine Gallo, Christopher Manon, James Sherman, Eric Tkaczyk, Brandon Zerbe
Putnam Competition Award	Per-Anders Andersson, Damir Dzhafarov, Keith Henderson
Problem of the Week Certificates of Merit (spring 2003)	Per-Anders Andersson, Thomas Engelsman, Thukaram Katare, Yifan Liang, Neel Mehta, Ashish Rao, Amit Shirsat, Qi Xu

*An annual student math competition sponsored by the Mathematical Association of America was held at Butler University on March 29. Among the 39 teams registered, one of Purdue's teams (**Ryan Spalding**, **Sarah Shoup**, and **Jacob Foster**, above) placed fourth. Prof. Dominic Naughton supervised the team's weekly practice sessions.*

ecognition

Per-Anders (Jason) Andersson and Neel Mehta were recognized by Michael Golomb for solving "Problem of the Week." Professor Golomb administers the long-standing series of problems.

Since we began publishing problems on our web site, the problems and solutions pages have received over 175,000 hits from thousands of sites in over 50 countries. Solutions are submitted by a wide range of math enthusiasts, including Purdue students and staff, Indiana high school students, and individuals from around the world.

Actuarial Science students Vikas Shah, Jeanette Roell, and Juan Arroyo Yap received awards from program director Richard Penney.

Other Student Recognition

Goldwater Scholar: Damir Dzhafarov

School of Science Outstanding Seniors: Stephen Hoover, Haizhi Lin, Justin Mazur, Susan Overstreet

School of Science Outstanding Achievement Award: Nigel Thavasi

Phi Beta Kappa:
Alexander Crane
Jason Dietz
Jeffrey Felling
Molly Hamilton
Kimmely Hoge
Jared Huckstep
Sebastian Kleber
Jennifer Kowall
Haizhi Lin
Jennifer Mellott
Lori Phillips
Jeanette Roell
Nigel Thavasi
Wendy Thompson
Katrina Trumbo
Samuel Vaughn

Mathematics Scholarships

Alton D. and Juanita S. Andrews Memorial Scholarship ($500-1500)
Lance Alexander
Michael Huffman
Jennifer Susan Kowall
Bess Walker
Sheng-Kung Yi

Thomas Arai Scholarship ($400-500)
Lee Ballard
Bess Walker

Leonard D. and Anna W. Berkovitz Scholarship
Jeffrey Moser *($1000)*

Mark Hoppy Memorial Scholarship ($1000)
Jennifer Susan Kowall

Math Scholarships ($1000)
David Sapirstein
Bess Walker

Mathematics Faculty Scholarship ($100)
Lee Ballard

Mathematics Scholar ($2000)
Lee Ballard

Arthur Rosenthal Scholarship ($1000-5000)
Jason Anema
Jennifer Bacon
Kyle Riggs
Adam Whitehead

Helen Clark Wight Scholarship ($2000-2500)
Molly Hamilton
Jared Huckstep
Deborah Simon

Andris A. Zoltners Scholarship ($2000-3000)
Jeanette Roell
Seth Streitmatter

Actuarial Science Awards

Lincoln Scholarship
Sebastian Kleber
Jeanette Roell

Trustmark Scholarship
Vikas Shah

Towers-Perrin Scholarship
Juan Arroyo Yap

CIGNA Scholarship
Devin Gardner
David Weissenborn

CIGNA Exam Awards
Juan Arroyo Yap
Lauren Coleman
Kristoffer Ericson
Devin Gardner
Andrew Howard
Sebastian Kleber
Michael Knowles
Jennifer Kowall
Haizhi Lin
Kelly O'Brien
Jeanette Roell
Vikas Shah
Mary Weise
David Weissenborn
Justin Welliver
Zachary White
Casey Wright

When a Job Finds You

by Chris Lomont

A recent grad offers his insights into the job market and provides job hunting tips.

This year some graduating mathematics Ph.D. students had a hard time finding academic positions, and I was no exception. However, sometimes an unexpected job finds you, and this is how it happened to me. First of all, the bad news: of 82 academic applications, I got no offers or interest (until *after* I took the unexpected job!), but I applied from top ranked schools on down. Applying to a wider range of positions helped some people get academic jobs, so my first advice is to apply outside your ideal position, in case the ideal doesn't deliver!

Now—how to let employers find you. I always have a resume posted on the web, and over the seven years it took to complete a Ph.D., I had dozens of people call or e-mail me to see if I was interested in a job, usually something I didn't want or that would require quitting the Ph.D. program. However, a few of these random jobs turned out to be decent contract work. One reason this happened is that I had job experience before starting a Ph.D., but even if you don't, I would suggest keeping an updated resume on a website. You never know when employers or headhunters might wander across it and become interested in you.

For example: I did contract work for a friend in the refinancing industry when they were stuck on a mathematical problem. Over a weekend we found a way to save the company millions of dollars (they would not give me a percentage of any savings—I asked before I started!). As a result of immediately placing this experience on my resume, I got a few finance calls (none of which sounded fun—I am not a finance type of person). So put any work experience on your web resume, just to open doors and make contacts.

Early in March I got a call from a headhunter, and this time it was interesting. Since I had no academic jobs on the horizon, I followed up. The recruiter said he was searching for a person to do quantum computing research for a company called Cybernet (www.cybernet.com) in Ann Arbor, a research firm working on robotics and human-machine interaction. I was interested in quantum computing at one point and put it on a list of interests on my resume; his computer found me. So I was hired to develop quantum computer algorithms for image processing and image recognition with no previous professional quantum computing experience (who has much?!), as well as to assist on other projects ranging from hardware design, to algorithm design, to software design.

What is quantum computing? In classical computing, everything is well behaved and deterministic, just like classical physics, and a classical computer basically manipulates strings of 0's and 1's. Quantum computing has arisen over the past two decades as a way to utilize the bizarre behavior of quantum systems to do useful computational work. In particular, information is no longer 0's and 1's, but a mix of quantum states, with quantum superposition and entanglement becoming a new computational resource. The benefit is that quantum computing can solve some problems exponentially faster than classical computing, and I was hired to discover such algorithms. Since quantum computing is a blend of math, physics, and computer science, having interests in all of these areas made me a good fit for their position. I had not even applied!

The only problem with the Ann Arbor job is that I did not want to move far from Lafayette, since my wife is working on a Ph.D. at Purdue, and I decided early on I would not consider a distant position (unless it was *very* good). After negotiating with Cybernet, they agreed that my wife and I would come up during summers, and I could spend two thirds of my time in Lafayette during semesters. I was able to get them to agree to arbitrary (unpaid) vacation, as long as I do not abuse it, so I can go adventuring. After many years of long vacations, I did not want to get locked into a two weeks per year vacation common in industry. An added bonus is they want me to publish and to attend conferences, since my credentials help win contracts. The atmosphere of tinkering with inventions is also very appealing. So my advice here is to ask for what you want up front when negotiating job details; I push employers pretty hard since it is hard to change the deal after you accept a job.

Chris Lomont

Another thing I hear from math students is that they don't know enough programming to get into industry, but seeing both sides, I can state that learning programming is much easier than learning math. So don't be afraid to look into jobs with some programming component, because when you work eight hours a day you tend to learn pretty quickly. Companies will hire programmers when they want programmers; they hire you because you have math knowledge and skills that the programmer will not have.

So in short, when looking for a job, make it easy for employers to find you. Make contacts. Play with things that interest you, even if there is no immediate application, and list your interests on your resume. Don't be afraid to ask for things that are important to you; you might be surprised what employers will do in order to hire you and keep you happy. The job you accept may not be one for which you applied; but keep an open mind and you might find an even better job than you expected. Don't be afraid to step outside your current skills. In almost any post Ph.D. position you will need to be able to pick up skills (from short-order cook to postdoc to tenure track jobs).

I heard a recent graduate, Nate Brown, quote a friend: "Life is not fair, but it is asymptotically fair." And I believe it is. Congratulations to all the graduates, and I hope you all find jobs you enjoy! §

(cont. from page 3)

That group of students in our Research Experience for Undergraduates program were a thrill to behold in action. They had so much enthusiasm for mathematical research, and their enthusiasm was backed by significant accomplishments. As one of their faculty mentors, I started the summer with doubts that such an activity would be healthy for a budding mathematician. In my day, my undergraduate research experience was going home for the summer and doing the hard exercises in a famous textbook by Walter Rudin all by myself, and I thought that was the way it should be. That way, research could be done in time tested bite sized chunks. I was worried that my undergraduate, Seth Streitmatter, might spend the whole summer beating his head against a problem that was too hard for him and get so frustrated that he might decide that the graduate experience in mathematics was not for him.

But it didn't happen like that at all. Seth and I bounced ideas back and forth all summer, and we both ended up learning things and making discoveries that we are proud of. The end result is a body of results about "conformal mapping in finite terms" that we plan to write up together with one of my former Ph.D. students, Tom Tegtmeyer, who also got involved in the project. I might even be coerced into ending the paper with a nonchalant CRAH. §

Summer VIGRE Research Experience for Undergraduates Program 2002

Carolyn Abbott
(Tufts, mentor A. Richman)
"Modeling analytic maps of the ball with linear fractional maps"

Damir Dzhafarov
(Purdue, mentor E. Hall, J. Rubin)
"On relations between set-theoretical notions of finiteness"

Celine Gallo
(Purdue, mentor M. Dadarlat)
"A topic in geometric group theory"

Sarah Grove
(Youngstown State, mentor N.K. Yip)
"Where to park"

Ben Kalafut
(Tulane, mentor J. Cushman)
"Stable Levy motion with sticky boundaries"

Chris Manon and Justin Mazur
(Purdue, mentor C. Wilkerson)
"Groups acting on sets"

Chris Scheper
(Purdue, mentor C. Cowen)
"nth dimensional medians"

Seth Streitmatter
(Purdue, mentor S. Bell)
"Conformal mapping in finite terms"

Alumni Gifts are Important to Us!

As we continually work to improve the quality of our programs, one of our goals is to increase the amount of money available for departmental student activities and scholarships. The Jean Rubin Memorial Scholarship Fund was endowed by Jean to reward outstanding math students. For information on how to contribute to this and other Mathematics Department funds, see

www.math.purdue.edu/generalInfo/funds.php

We appreciate the support of those who currently help mathematics students, and we hope all of our alumni will consider designating the Mathematics Department as the recipient of future gifts.

Obituary

Jean E. Rubin

Professor Jean E. Rubin died on Oct. 25, 2002 in Lafayette. Born on Oct. 29, 1926 in New York City, she had lived in West Lafayette since joining the department in 1967. She received B.S. from Queen's College in New York City in 1948, an M.A. from Columbia in 1949, and a Ph.D. from Stanford in 1955. She taught at Oregon and Michigan State before coming to Purdue.

Jean was the author of more than 40 papers and 5 books in set theory and questions related to the axiom of choice. She supervised two Ph.D. students, Judith M. Harper and Nicholas Backscheider. She worked with a number of collaborators, including her husband, Herman, and her son Arthur. A long and successful collaboration with Paul Howard dates back at least 25 years. Her three books, two jointly authored with Herman and the third with Paul, have been standard references in the field. In recent years, Jean worked with several Purdue postdocs—Adrienne Stanley, Eric Hall, and Omar De la Cruz. She co-authored 13 papers in the last five years.

Jean created the undergraduate program in logic and set theory at Purdue, and she voluntarily taught large math lectures many times through the years. From 1981-98 she served as chair of the Elementary Service Committee. She was an REU mentor in summer 2002. Always an outstanding citizen of the department and a good friend to many, Jean is sorely missed.

(cont. from page 5)

of magnitude. Even with present (and very likely future) computing power, extracting useful information from purely atomic considerations remains a challenge. There will be many opportunities for mathematics to contribute.

I am still proving theorems because it is just fun. The process of putting one's line of thought into impeccable logical deduction is an art form in its own right. It is most apparent to me that mathematicians can participate broadly to overall scientific research. Isn't this how mathematics started, from the time of Archimedes and Euclid? So here I am in the Mathematics Department, trying to reach back and establish stronger links to engineering problems. We are all part of one family, aren't we?

For those who would like to know more about my personal view of mathematics and materials science, please do not hesitate to contact me. §

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Excellence in Teaching Awards

In keeping with its commitment to excellence, the Mathematics Department annually recognizes Graduate Teaching Assistants for their outstanding teaching. Six Purdue graduate students were selected in fall 2002 to receive "2002-03 Excellence in Teaching Awards." Vikram Buddhi, Louiza Fouli, Chris Mitchell, Baki Ozturk, Brent Strunk, and Oana Veliche each received cash prizes of $250 at an awards presentation in the Mathematics Department on November 26, 2002. Winners of the annual award are selected on the basis of student evaluations and the evaluations of their faculty teaching mentors.

Antônio Sá Barreto, Oana Veliche, Chris Mitchell, Louiza Fouli, Brent Strunk, Vikram Buddhi, Baki Ozturk, and Daniel Phillips. Sá Barreto and Phillips were the Graduate Committee co-chairs.

More Honors!

Oana Veliche has been awarded a 2003-04 Puskas Memorial Fellowship. The fellowship is designated for outstanding Purdue students who are citizens of Romania. Veliche began her degree program at Purdue in August 1997. She has been recognized by the Mathematics Department and the University for her excellence in teaching, and she was the recipient of the department's Keedy Scholarship. She has passed qualifiers, advanced topics, and is working with Professor L. Avramov on research in commutative algebra. She expects to complete her Ph.D. in 2004.

Graduate student **Mark Ward** is serving as one of two graduate student members of the Mathematical Association of America's Committee on Graduate Students. First formed in January 2002, the twelve-member committee considers and fosters activities, services, and membership for graduate students.

Five mathematics TAs were among graduate teaching assistants from across campus who were honored by the Provost's Office at the Celebration of Graduate Student Teaching banquet at the Purdue Union on April 17. **Vikram Buddhi, Louiza Fouli, Chris Mitchell,** and **Brent Strunk** each received an engraved plaque in recognition of their outstanding teaching contributions and dedication to Purdue students. **Anantha Sundararajan** was recognized for completing a Graduate Teacher Certificate through the Preparing Future Faculty Program, administered by the Center for Instructional Excellence.

2003 Distinguished Alumnus

Michael Hays

Michael Hays was among eight School of Science alumni honored at a banquet hosted by Dean Jeffery Vitter on April 25. The School recognizes distinguished alumni each year during Gala Week.

Dr. Hays is Senior Vice President at Massachusetts Mutual Life Insurance Company in Springfield, MA. He received two Purdue degrees in mathematics—a B.S. in 1964 and an M.S. in 1967—before attending the University of Colorado, where he earned a Ph.D. in 1973.

Dr. Hays began his career as an assistant professor of mathematics at Paine College in Augusta, Georgia. In 1975 he joined the Massachusetts Life Insurance Company. He was Chief Actuary of Retirement Services from 1986 to 1998, with responsibility for pricing, asset/liability management, reserving, risk management, and financial reporting. He was then Head of Portfolio Consulting at the MassMutual Investment Group, where he oversaw development of portfolio policy and strategy for all business units, oversaw investment risk management for the MassMutual general account, and assisted in the corporate asset and liability management process. He also served as the liaison between investment units and business units.

A Fellow of the Society of Actuaries and a member of the American Academy of Actuaries, Dr. Hays serves on our Actuarial Science Advisory Council. §

NSF CAREER Award

Donatella Danielli

Donatella Danielli is the recipient of a prestigious NSF award ($400,000 for five years) intended for faculty in the early stages of their careers: "CAREER: Analytic and Geometric Aspects of Partial Differential Equations." The award will support Danielli's work on a collection of problems motivated by the study of elliptic and parabolic free boundary problems, calculus of variations, and geometric measure theory. One of the main objectives of the proposed research is to prove regularity properties of the free boundary. Another area of interest is the optimal regularity of the solution and of the free boundary in the subelliptic obstacle problem. The necessary tools from harmonic analysis and partial differential equations (PDEs) for the study of these problems will be developed concurrently.

Danielli plans to integrate this research with several educational activities. She recently organized the first annual "Symposium on Analysis and PDEs," held at Purdue on May 23-26, 2003. The format consisted of two five-day minicourses aimed at graduate students and recent Ph.D.s, followed by a more specialized two-day conference. The principal lecturers were Luigi Ambrosio of Scuola Normale Superiore, Pisa, and Luis Caffarelli of the University of Texas at Austin. Invited speakers included Piotr Hajlasz (U. Warsaw), Francois Hamel (U. Aix-Marseille), Robert Hardt (Rice U.), Ki-Ahm Lee (Seoul National U.), Yanyan Li (Rutgers U.), Takis Souganidis (U. Texas, Austin), Jeremy Tyson (U. Illinois), and Jeff Viaclovsky (MIT). Additional support for the conference was provided by the Institute for Mathematics and its Applications (IMA) through its Participating Institution (PI) Program.

In addition, Danielli will supervise undergraduate research projects as part of Purdue's REU program. At the K-12 level, she hopes to hook receptive young minds through fun, hands-on mathematics workshops at the local science museum, as well as in the framework of Purdue's "Expanding Your Horizons" conferences, which are designed to encourage young girls to pursue science and mathematics based careers. To increase the representation of women in the scientific community, Danielli will also continue mentoring women in science. §

(Interdisciplinary Research, cont. from page 2)

Dan Gottlieb has been involved in a couple of interdisciplinary directions—one on the application of concepts from algebraic topology to physics (Berry's Phase) and (jointly with V. Onoonchin in Moscow) Maxwell's Equations), and the other on the application of topology to robotics.

Brad Lucier has worked on various applications of mathematics to image processing involving image compression applied to teleradiology and digital mammography, image noise removal, and reconstruction of positron emission tomography (PET) images of the brain. Currently, he is studying the application of anisotropic function spaces and wavelet decompositions to functional magnetic resonance imaging and dynamic positron emission tomography.

Jim McClure is part of a large grant proposal "Purdue University – Indianapolis Public Schools Middle School Math-Science Partnership" submitted to the NSF program EHR-MSP-target award.

Fabio Milner is involved in the modeling, analysis and simulation of tuberculosis dynamics involving drug-sensitive and drug-resistant strains of the bacillium.

Juan Santos has been involved for several years in joint research with J. M. Carcione, Head of the Department of Geophysics, Observatorio Geofísico Sperimentale, Trieste, Italy and his colleagues in developing pseudodifferential models for the numerical simulation of waves in poroviscoelastic saturated by single or multiphase fluids. Some of his former students, now professors in the Observatorio Astronomico, Universidad Nacional de La Plata, are also involved in this activity. He has recently started work in the area of nondestructive evaluation of frozen foods by ultrasonic methods, with Professor Osvaldo Campanella, in Agriculture and Biological Engineering at Purdue University, to combine numerical simulations with experimental work using ultrasonic measurements to test properties of frozen food and other materials.

Jie Shen is working with Long-qing Chen, Professor of Materials Sciences at Penn State University, on using phase-field models to simulate micro-structural evolution and on using the Landau-Lifshitz equation to simulate the evolution of magnetization in continuum ferromagnets. He is also working with Jimmy Feng, Associate Professor at the Levich Institute of City University of New York, on simulating the shear-induced deformation of an Oldroyd-B drop in a Newtonian matrix with matching viscosity.

Aaron Yip is interacting with the engineering community (especially Materials, Mechanical and Aerospace Engineering) on problems arising in Materials Science and Nanotechnology. (See story on page 4.)

Retirements

The Mathematics Department honored recent retirees **Leonard Berkovitz** and **Jim Douglas, Jr.** with a dinner at the University Inn and Conference Center on May 20.

Berkovitz joined the department in 1962 after working for the RAND Corporation for a number of years. He served as department head from 1975 to 1980 and as acting head in 1989-90. His research focuses on control problems, calculus of variations, and differential games. Berkovitz directed 13 doctoral students and served as editor for several journals.

Len and Anna Berkovitz visit with Joan Samuels (far left), who provided leis from Hawaii for the honored guests. Her husband, Steve Samuels, professor of statistics and mathematics, was honored along with Professors Berkovitz and Douglas.

Professors Nicola Garofalo and Jim Douglas

Douglas joined the Department of Mathematics in 1987 as distinguished professor and director of the Center for Applied Mathematics. He was formerly on the faculties of the University of Chicago and Rice University. Throughout his career, he supervised over 40 doctoral students. His expertise in the areas of numerical solutions of partial differential equations, simulation of flows in porous media, attenuated waves, and inverse and not-well-posed problems earned him an international reputation among those working in his field. Douglas plans to continue his many research collaborations.

CAARMS9

Above: CAARMS9 organizers Bill Massey of Princeton and our own Johnny Brown. Below: Rodrigo Bañuelos with Richard Tapia of Rice. See page one for more on CAARMS9.

Math PUrview

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