

# Department of Mathematics and Statistics *Newsletter*

University of Massachusetts Amherst College of Natural Sciences and Mathematics Spring 2008 Volume 23



## DEPARTMENT HEAD'S MESSAGE *by Eduardo Cattani*

Dear Alumni and Friends of the Department of Mathematics and Statistics:

It is always a pleasure to write this introduction to our annual department newsletter since it gives me the opportunity to highlight the work and accomplishments of our faculty and students and to present to you some of the remarkable graduate and undergraduate students who have passed through this department. This year we are featuring **Chris Byrnes, M.S. '73, Ph.D. '75**, who is The Edward H. and Florence G. Skinner Professor of Systems Sciences and Mathematics at Washington University in St. Louis, and **Thomas Kalmbach '88** from the Hartford Life Insurance Companies.

I would like to start this message by congratulating our colleague **Panos Kevrekidis**, who received a Humboldt Research Fellowship from the Alexander von Humboldt Foundation. Panos is spending this spring semester visiting the University of Heidelberg. Congratulations are also due to **Tom Braden**, who received tenure and was promoted to Associate Professor, and **Nate Whitaker**, who was promoted to Full Professor. Both of these promotions were effective on

*continued on page 2*

### INSIDE THIS ISSUE:

Markov Chains in  
Modern Statistics

Applied Math Master's  
Degree Program

Awards

Department News

Challenge Problem

Donors

## PROFILES

### Chris Byrnes '75: Subtle Connections Between Mathematics and Engineering

Chris Byrnes's career had its beginnings in chance.

As a graduate student at UMass Amherst, Byrnes began attending seminars in systems science in the Computer Science Department at the prompting of Ernie Manes. He had the good fortune to hear a talk by Rudolf Kalman, a Hungarian electrical engineer famous for inventing a mathematical technique used to extract a signal from a series of incomplete and noisy measurements. At this talk, Kalman proposed a research problem. "Essentially, he was studying a class of control systems with parameters," Byrnes explains. "The basic problem was to find a way to tune the parameters nicely so that the family of systems took on a mathematically simple form."



Later on Byrnes heard a talk by David Mumford, who at the time was one of the most famous algebraic geometers in the world and who was at UMass Amherst lecturing on a subject called geometric invariant theory. Byrnes made a connection that opened the floodgates. "I saw right away that Kalman's problem

*continued on page 6*



### Thomas Kalmbach '88: Mathematics and Actuarial Science

For Tom Kalmbach, mathematics came as the answer to a long quest.

"I came to UMass Amherst in 1982 and didn't know what to study. First I tried electrical engineering, then mechanical, but it didn't grab me. But then I found math, and that was it."

Certainly it was, for today Kalmbach is a highly successful actuary. He is Vice-President for Individual Life Product Financial Management at Hartford Life. He leads a team of actuaries in the R & D sector of the company, where his responsibilities include analyzing new products from a financial perspective as well as working with top-level peers in other divisions. "The company wants to build a product and sell it. Our team analyzes whether the product will work from a financial standpoint. Other teams handle underwriting, marketing, and sales."

Besides teaching him the skills in the nuts and bolts of actuarial science that he applies in his job every day, Kalmbach says that a degree in mathematics prepared him in other ways as well. "Being able to think mathematically helps you to plan projects, to take a

*continued on page 6*

**Department Head's Message** *continued from page 1*

September 1, 2007. Those of you who have had a chance to interact with either Tom or Nate know how dedicated they are to their work and how much they deserve this recognition of their research, teaching, and service to the department and the profession.

For the second year in a row a graduate student in our department has received the Distinguished Teaching Award. **Shabnam Beheshti** was one of only two TAs in the university to receive this prestigious award this year and joins a distinguished list of former winners from our department, including Jennie D'Ambroise, last year's winner. Shabnam completed her dissertation under the direction of **Emeritus Professor Floyd Williams** and, after a one-year visit at the Tata Institute of Fundamental Research in Mumbai, India, she will take on a post-doctoral position at Rutgers University. Shabnam was honored at a luncheon hosted by the Graduate School.

This spring will mark the retirement of a long-time member of the department, Professor **John Fogarty**. John received his Ph.D. in 1966 from Harvard University, where he worked with David Mumford, one of the most distinguished American mathematicians. After several years at the University of Pennsylvania, he joined our faculty as an Associate Professor in 1971 and became Professor of Mathematics in 1980. John is well-known, nationally and internationally, for his work on invariant theory. His 1969 *Lecture Notes on Invariant Theory* are among the classics in the subject, and he collaborated with Mumford to produce a revised edition of Mumford's book, *Geometric Invariant Theory*. A third edition of this book appeared in 1994 and continues to be an obligatory reference in the subject. John is a superb painter and sculptor, and he will, no doubt, also find many building projects to keep him busy. We wish him and his wife, Charlotte, the best for the coming years.

This past January we welcomed a new senior statistician, Professor **Michael Lavine**, who joined us from Duke University, where he was a faculty member for 20 years. Michael has made fundamental applications in both pure and applied statistics and, as you can tell from the article he wrote for this newsletter, he is also a gifted expositor. We look forward to Michael's contributions in the years to come!

We had a very busy and successful hiring season this year. Three new Assistant Professors will be joining our faculty: **Daeyoung Kim**, who will receive his Ph.D. in statistics from Penn State University; **Alexei Oblomkov**, a 2005 Ph.D. from MIT who is currently a Postdoctoral Instructor at Princeton University; and **Hong-Kun Zhang**, who received her Ph.D. in 2005 from the University of Alabama at Birmingham and is currently a Visiting Assistant Professor at Northwestern University. They will be profiled in next year's newsletter.

The Visiting Assistant Professors (VAPs) are a very important part of our research and instructional programs. Typically they are new PhD's in mathematics and statistics who spend three years in our department teaching and doing research while being mentored by a senior faculty member. Of the ten VAPs who were with us this year, seven have departed or will do so at the end of the academic year. **Ana Maria Castravet** took a tenure-track position at the University of Arizona, and **Hadi Susanto** left this past January to go to the University of Nottingham. **Roman Fedorov**, **Evgeny Materov**, **Ralf Schiffler**, **Georgios Tripodis**, and **Dan Yasaki** will be leaving this summer. We are very grateful for their contributions in all aspects of departmental life and wish them great success in their career. Five outstanding new VAPs will join us this September: **Michael Broshi** (Chicago), **Peter Dalakov** (UPenn), **Yakov Savelyev** (Stony Brook), **Giancarlo Urzua** (Michigan), and **Yao Wang** (Virginia).

*continued on page 4*

## MARKOV CHAINS IN MODERN STATISTICS

by Michael Lavine

The last twenty years or so have seen an explosive increase in the use of Markov chains in the field of statistics. Most of that increase has been through the use of Markov chains as computational devices, which in turn has led to a growing body of research on the convergence and mixing rates of Markov chains. The next several paragraphs sketch some of the developments.

### MARKOV CHAINS

A Markov chain is a sequence of random variables  $X_1, X_2, \dots$ , indexed by time. The *Markov property* is that for each positive integer  $t$ , the distribution of  $X_t$ , given the chain's history  $X_1, X_2, \dots, X_{t-1}$ , depends only on  $X_{t-1}$  and not on any history prior to  $X_{t-1}$ . Statisticians write this as  $[X_t | X_1, \dots, X_{t-1}] = [X_t | X_{t-1}]$ , where the notation  $[A | B]$  means the conditional distribution of  $A$  given  $B$ . Markov chains are extremely useful for modeling many physical systems. Usually in such models the rules governing how the system moves from one state to the next do not change over time. Hence the Markov chain is governed by a *transition kernel*  $\bar{P}(z|y) = \Pr[X_t = z | X_{t-1} = y]$ , where  $\bar{P}$  is independent of  $t$ . Often when  $\bar{P}$  is independent of  $t$ , the chain converges to a steady state called the *stationary distribution*. If  $x_1, x_2, \dots, x_n$  are the possible values of  $X$ , then the stationary distribution  $\pi$  and the transition kernel  $r$  are related by the formula

$$\pi(x) = \sum_{i=1}^n \rho(x|x_i) \pi(x_i).$$

Here are some examples of how Markov chains are used to model physical systems.

1. Ecologists use Markov chains to model population dynamics, where  $X_t$  might be a vector of the number of 1-year olds, 2-year olds, etc. in a population at time  $t$  and where the transition kernel describes the processes of growing older, having children, leaving the population, etc. The stationary distribution  $\pi$  describes how many 1-year olds, 2-year olds, etc. there would be in a stable population.
2. Financial analysts use Markov chains to model financial markets, usually assuming that the state of the market tomorrow depends on the state of the market today and on what happens in the world today and tomorrow, but does not depend on any older history. A Markov chain for this system might not have a stationary distribution; this could indicate, for example, that the Dow-Jones average keeps increasing over time.
3. Weather forecasters assume that the next hour's weather is governed by the laws of physics and by the state of the atmosphere now, but not by any previous history. The stationary distribution is the long-term climate.

Since the early 20th century, the field of statistics has been dominated by so-called *classical* or *frequentist* thought, as opposed to *Bayesian* thought, which we now explain. A typical scientific investigation has the purpose of determining some quantity in nature such as  $X$ , the global average temperature in the year 2100, or  $Y$ , the rate at which sugar maples are leaving the continental U.S. and migrating to Canada. In the Bayesian paradigm, the role of the statistician is to use all the available evidence to construct a probability distribution for  $X$  or  $Y$ , one that reflects the state of our knowledge. The distribution should put most of its mass on values of  $X$  and  $Y$  that are well supported by the evidence and little mass on values that are not well supported.

Almost always, the statistician works with some background knowledge and a data set that has been recently compiled. And again almost always, the statistician constructs the distribution of  $X$  or  $Y$  in stages. First, she constructs a distribution to reflect the state of background knowledge; then she updates it with the recent data. The mathematical tool is Bayes' Theorem, which states the following:

$$\pi(x|\text{data}) = \pi(x) p(\text{data}|x) / \int \pi(x) p(\text{data}|x) dx.$$

In this formula  $X$  is the unknown quantity,  $\pi(x)$  is the probability density of  $X=x$  as determined by background knowledge,  $p(\text{data}|x)$  is the conditional density of the recent data given  $X=x$ , and  $\pi(x|\text{data})$  is the conditional density of  $X=x$  given both the background knowledge and the recent data. The conditional density  $\pi(x|\text{data})$  is interpreted as representing our current state of knowledge about  $X$ . The terminology is that  $\pi(x)$  is the *prior* distribution and  $\pi(x|\text{data})$  is the *posterior* distribution of  $X$ . Often  $X$  is multidimensional; when we are interested in a single coordinate of  $X$ , we must integrate  $\pi(x|\text{data})$  with respect to the other coordinates.

Unfortunately, however appealing the Bayesian paradigm is philosophically, it is analytically intractable except in the most trivial examples. The necessary integrals are not available in closed form and are usually not even amenable to numerical methods of integration. At least that was the case until the mid to late 1980s when computers became better and statisticians discovered better computational algorithms. The primary algorithms are the Metropolis algorithm, which is based on Markov chains, and variants of that algorithm. Interestingly, the Metropolis algorithm was well known to physicists and applied mathematicians for many years before statisticians recognized its potential. The key idea is that instead of directly evaluating integrals related to

*continued on page 5*

**Department Head's Message continued from page 2**

We are delighted by the appointment of **Dr. Robert C. Holub** as the new Chancellor of the Amherst campus. Dr. Holub has been the chief academic officer at the University of Tennessee Knoxville for the past two years. Before that, he served at the University of California Berkeley for 27 years, rising to the rank of full professor and serving in several administrative posts. We welcome his appointment and look forward to his leadership.

Last year the College of Natural Sciences and Mathematics launched a set of Excellence Initiatives addressing issues of national and global importance in the areas of renewable energy, clean water, nanomaterials, biomedicine, education, and innovation. Thanks to the support of the Provost's office, the College has been able to fund a large number of seed grants to facilitate the preparation of grant proposals in these areas of excellence to public and private agencies. In particular, Professors **John Buonaccorsi**, **Michael Lavine**, **Bruce Turkington**, and **Nate Whitaker** have been researching funding opportunities for our programs in applied mathematics and in statistics.

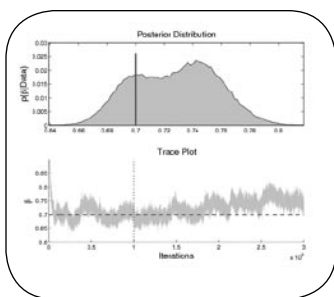
Thanks to the efforts of **Weimin Chen**, this past year the department instituted a new Distinguished Lecture Series. We were fortunate to have four outstanding lectures in addition to our traditional Connecticut Valley Colloquium Lecture. They were given by Professors **Charles Doering** (Michigan), **Karen Uhlenbeck** (U. of Texas), **Mikhail Kapranov** (Yale), **Barry Mazur** (Harvard), who was the CVC lecturer, and **Dennis Sullivan** (Stony Brook).

The Research Experience for Undergraduates (REU) is a program that allows undergraduate students to work on research projects during the summer. Students receive a stipend and work closely with a faculty mentor. Often, students work in groups and hold meetings and seminars where they share their projects and help each other in the true spirit of scientific collaboration. This coming summer, eleven mathematics and statistics majors will participate in the REU program. Two of these students will be supported by the **Sheila R. Flynn Research Scholarship Fund**, while others will be supported by the Department Gift Fund and by supplements to the NSF grants of individual researchers.

Programs such as the Distinguished Lecture Series and the REU are made possible, in part, by your very generous gifts to the department. Indeed, I am extremely pleased to report that the total amount of gifts has increased by over 30% in each of the past two years. I am very grateful to all of you for your thoughtfulness. There were, however, a number of especially generous contributors whom I would like to thank individually: **Joan and Edgar Barksdale** for establishing an Undergraduate Scholarship Fund to support students planning to major in science, preferably mathematics (their very generous gift is described elsewhere in the newsletter); **Robert and Veronica Piziak** for their contribution to the M. K. Bennett Fund; **Roy Perdue** for his continuing support of the Henry Jacob Mathematics Competition; **Olga Beaver** for her generous donation; **Steven and Geni Monahan** for their very thoughtful and appreciative gift on behalf of their daughter **Elizabeth**, who is graduating this year; and **Peter and Anne Costa** for the donation that made it possible to institute an Annual Applied Mathematics Lecture in memory of Professor Mel Berger. Mel was Peter's dissertation director and a very influential figure in the development of applied mathematics in our department. I am delighted to announce that the first lecture in this series is tentatively scheduled to take place this coming October and that **Christopher Byrnes** has agreed to deliver the inaugural lecture.

Finally, a farewell. This is my last newsletter as Department Head as my term comes to an end in August 2008. The Head Search Committee, chaired by **Andrea Nahmod**, is busy identifying candidates and doing some gentle arm-twisting. I want to thank the faculty, students, and staff for their support and for their passion for teaching and learning. It is through their efforts that the University of Massachusetts Amherst is becoming the great institution that we all want it to be.





300,000 iterations of a computer simulation of a Markov chain for a random variable named  $\beta$ . The bottom panel shows the values of  $\beta$ , plotted against  $t$ . The top panel shows the values of  $\beta$  collected into a histogram.

### Markov Chains *continued from page 3*

$\pi(x|\text{data})$ , the statistician can draw a random sample from  $\pi(x|\text{data})$  and use the sample to estimate integrals. In the Metropolis and other Markov-chain algorithms, the sample is drawn via the following three steps:

- 1) construct a Markov chain that has  $\pi(x|\text{data})$  as its stationary distribution,
- 2) simulate the Markov chain on a computer,
- 3) take the simulated values as the random sample.

One of the early papers along these lines was coauthored by a UMass Amherst mathematician, Donald Geman, in the paper “Stochastic Relaxation, Gibbs Distributions, and the Bayesian Restoration of Images” by S. Geman and D. Geman, *IEEE Trans. Pattern Anal. Mach. Intell.* 6: 721–741 (1984).

Although statistics makes use of sophisticated mathematical tools, the thinking in statistics is backwards from the usual thinking in mathematics. Mathematicians often prove theorems such as the following: “If the properties of the chain’s transition kernel are ..., then the chain’s stationary distribution will be ....” However, statisticians reason differently, saying “I want the stationary distribution to be ...; therefore I need the transition kernel to be ....” As it turns out, devising a transition kernel to yield the right stationary distribution is easy. What’s difficult, at least in many problems, is finding a transition kernel under which the chain mixes well and approaches its stationary distribution rapidly.

As this discussion shows, the last twenty years or so has seen a large growth not only in the use of Markov chains to carry out statistical applications, but also in research on the mixing and convergence rates of the types of Markov chains that statisticians use. Furthermore, statisticians’ newly found ability to evaluate integrals has led to an explosive growth in Bayesian statistics — in both theoretical and applied studies — as opposed to classical or frequentist statistics. No statistics program is now complete without courses in Bayesian statistics. And no study of Bayesian statistics is complete without Markov-chain algorithms for evaluating posterior distributions.

For further reading, an introduction to an easy Markov-chain algorithm is given in “Explaining the Gibbs Sampler” by G. Casella and E. George, *The American Statistician*, 46: 167–174 (1992). Two textbooks on the subject are *Monte Carlo Statistical Methods* by C. Robert and G. Casella (1999) and *Monte Carlo Strategies in Scientific Computing* by J. Liu (2004), both published by Springer.

### RESEARCH PROJECTS BY UNDERGRADUATES by Peter Norman

Each summer a group of mathematics majors undertakes research projects during the summer. The students work in groups of one, two, or three with an individual faculty member trying to understand an unsolved problem. During the summer of 2007 more students were able to participate than ever before. Having the students do their own research has a number of worthwhile consequences. First, the students soon become experts in their own problem areas and can see the beauty of the mathematics with which they are working. Second, instead of working on questions assigned by faculty members, the students quickly begin to ask their own questions. Third, doing their own research enables the students to understand the relevance of course work.

The projects undertaken during the summer of 2007 covered a broad range of mathematics.

- Weimin Chen asked his student, Shaohan Hu, to develop algorithms locating fixed points of transformations. The theory behind this is the Brouwer fixed point theorem,

a qualitative result in topology. Shaohan’s work led to a senior thesis.

- Kerry Dullea and Swetha Valluri worked with Markos Katsoulakis to develop a Monte Carlo method for studying Markov processes.
- Working with Paul Gunnells, Jacob Mitchell studied non-Euclidean polyhedral complexes.
- Nate Whitaker had his student, Jinin Ha, study systems of stochastic differential equations that describe the growth of blood vessels towards a tumor.
- Dan Yasaki had Adrian Bruno try to understand an abstract ring associated with a tree, which is a special kind of graph. The goal was to understand Catalan numbers, which are of interest to number theorists.

Support for the students came largely from donations by alumni to the department. Additional support also came from the National Science Foundation as supplemental grants to faculty research grants. Faculty involved in these undergraduate research projects are not compensated beyond the pleasure of working with bright, hardworking students.

**Chris Byrnes** *continued from page 1*

was really best understood in the language of Mumford's talk." With these mathematical tools, Byrnes easily found the answer to Kalman's problem. The geometry underlying the problem meant that there was no way to tune the parameters nicely!

Today Byrnes continues to apply sophisticated and subtle techniques from pure mathematics to problems in engineering and control theory. He takes a unique geometric approach that combines tools ranging from algebraic topology — the study of the structures underlying spaces that do not change under stretching and bending — to differential geometry — the study of the properties of spaces associated to notions of length and area. But don't think that this means his work isn't practical. In fact, he is co-inventor on four US patents, has had his results applied in the stabilization of telecommunications satellites, and has even seen some results of his group flight-tested by Boeing.

Byrnes's Ph.D. advisor at UMass Amherst was Marshall Stone, and today he fondly remembers Stone's style. "I found him to be very approachable and generous with his time. We met every Tuesday and Thursday for three to four hours at a time. The ground rules were that I could ask a question about any topic in mathematics at all except my thesis problem. Anything else was

fair game." He also remembers valuable mentoring from Eduardo Cattani, John Fogarty, Aroldo Kaplan, and Hans Fischer.

Throughout his high-profile career Byrnes has earned many honors and awards in engineering and mathematics. He is a fellow of the IEEE and also of the Japan Society for the Promotion of Science. He is a foreign member of the Royal Swedish Academy of Engineering Sciences, and he won the SIAM Reid Prize in Mathematics. He has also received awards from journals for the quality of his papers, such as the George S. Axelby Outstanding Paper Award (twice) for the best paper in the *IEEE Transactions on Automatic Control* and the IFAC Automatica Best Paper Award. Recently he won the 2008 Hendrik Bode Prize from the IEEE, which recognizes distinguished contributions to control systems science or engineering.

Byrnes was born and raised in New York City. He received his B.S. in mathematics from Manhattan College and his M.S. and Ph.D. from UMass Amherst. After positions at Utah, Harvard, and Arizona State, he moved to Washington University, where he is currently the Edward H. and Florence G. Skinner Professor of Systems Science and Mathematics. He lives in St. Louis, Missouri with his wife Renee; together they have six children.

**Thomas Kalmbach** *continued from page 1*

business problem and think it through. Mathematics helps you to find the key points of a problem."

When asked what it's like to be an actuary, Kalmbach answers immediately, "I love it. It's a great career." He attributes his high job satisfaction, which is typical for actuaries, to a variety of factors. "The work is technically fascinating, we have great professional societies, and there's a lot of support within insurance companies to help you along your career path. The actuarial profession opens a lot of doors."

Kalmbach's favorite professors at UMass Amherst were Don Catlin and Mike Gauger. Together they were responsible for all his math courses for about eight semesters.

"Professor Catlin taught me calculus in a video classroom. We were part of a small 'studio audience' because the lecture was broadcast so that people could attend remotely. That was pretty new at the time." According to Kalmbach, Catlin was very focused on the class and always gave very practical, applied examples. "He also was a skilled gambler and enjoyed making it a part of class."

With Gauger he studied actuarial science, and he still remembers how exciting Gauger made it. "His examples were great. He loved to use a red corvette that somehow always got involved in a life-contingent event."

Tom Kalmbach was born and raised in Springfield, Massachusetts. Today he lives in Southwick, Connecticut with his wife and two daughters. He is a member of the Society of Actuaries and a Fellow of the American Academy of Actuaries.

### **NEW CHALLENGE PROBLEM** *by Haskell Cohen*

A special case of this problem was in the Math Competition Test given in the spring.

Let  $P(x)$  be a real polynomial with distinct real zeros  $a, b, c$ , where  $a < b < c$ . Let  $d$  be the critical value satisfying  $a < d < b$  whose existence is guaranteed by Rolle's theorem. Prove that  $d$  is nearer to  $a$  than it is to  $b$ .

As usual, send your solutions to  
Professor Emeritus Haskell Cohen, Problem Editor  
Department of Mathematics and Statistics  
University of Massachusetts Amherst  
Amherst, MA 01003-9305  
or send email to [haskell@math.umass.edu](mailto:haskell@math.umass.edu)

## KEVREKIDIS AWARDED HUMBOLDT RESEARCH FELLOWSHIP



Associate Professor of Mathematics and Statistics Panayotis G. Kevrekidis has been awarded a Humboldt Research Fellowship to spend up to a year in Germany. Kevrekidis is presently using the fellowship to visit the University of Heidelberg for six months during the spring and summer of 2008, where he is collaborating with colleagues at the Institutes of Physics and Physical Chemistry and at the Kirchoff Institute for Physics.

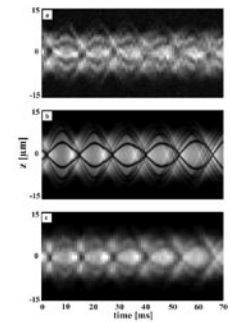
The Alexander von Humboldt Foundation is a non-profit foundation established in 1953 by the Federal Republic of Germany for the promotion of international research cooperation. It promotes academic contacts by enabling highly qualified scholars not resident in Germany to spend extended periods of time doing research in Germany.

Using a multidisciplinary approach combining mathematical analysis, fundamental physical principles, and powerful computational resources, Kevrekidis' research focuses on Bose-Einstein condensation in gases, which form a new type of matter that exists only at extremely cold temperatures, in fact, the coldest temperatures in our universe (of the order of a  $10^{-9}$  Kelvin, i.e., very close to absolute zero). The experimentally used atomic vapors of rubidium, sodium, lithium and other alkali atoms are at the forefront of physics because their atoms behave like bosonic particles that have extremely peculiar properties near absolute zero. In particular, these particles sustain a quantum phase transition at a critical temperature, below which they all condense in the ground state of the system, forming a giant matter wave. This affords physicists and mathematicians the opportunity to observe quantum effects at a scale visible, with magnification, to the human eye. Moreover the interparticle interaction produces an effective nonlinearity in the system, bringing it to the exciting interface where atomic physics, optical physics, wave phenomena and nonlinear mathematics meet. Bose-Einstein condensates have potential relevance to such technologies as superconductivity, quantum computation, and atom lasers.

Kevrekidis and his collaborators have just completed a ground-breaking study, revealing for the first time the presence in these condensates of oscillations and interactions among so-called dark solitons. Dark solitons are the prototypical nonlinear wave structure that emerges as a density hole in the wavefunction describing the probability of finding the atoms in a particular location. In their work, Kevrekidis and collaborators have been able to systematically generate such structures, observe their oscillation in magnetic traps confining the atoms, and monitor their collisions. These experimental observations have been corroborated not only by 3-dimensional and 1-dimensional numerical simulations, but also by an analytical description of these solitary waves as effective particles; this description monitors their positions by means of simple nonlinear ordinary differential equations.

A prototypical example of the remarkable agreement between experiments and the numerical simulation of the underlying nonlinear models is given in Figure 1. George Theocharis, a postdoctoral fellow in the Department of Mathematics and Statistics Department at UMass Amherst is also involved in this work.

"The most exciting thing about my research," said Kevrekidis, "is how mathematical descriptions such as nonlinear partial differential equations give us a great tool to understand a wide range of physical phenomena stemming from physics, chemistry, and biology. Being able to relate theory and numerical computation, which is what I do, with experiments, which is what many of my collaborators do, makes it a really very rewarding experience. It is extremely gratifying when we are able to put our strengths together in order to understand even small pieces of how nature works."



(a) Comparison of experimental results, (b) numerical results from the solutions of a 3-D nonlinear partial-differential-equation model, and (c) a reduction of (b) accounting for spatial and temporal resolution of the experiment. The figure shows the spatial and temporal evolution of the particle density;  $z$  is measured in microns and time in milliseconds. The white regions indicate high-condensate particle density, while the black ones indicate low-particle density. Clearly observable are the oscillating and interacting density holes within the condensate representing dark-soliton excitations.

## APPLIED MATH MASTER'S DEGREE PROGRAM: BOSE-EINSTEIN CONDENSATION AND CELLULAR AUTOMATA

by *Nathaniel Whitaker*

The Master's Degree Program in Applied Mathematics prepares students to work in an industrial setting after graduation. While the students take courses both outside of the department and inside the department, the most important part of the program is the year-long group project or projects. This year, students in the program worked on two projects. In the first project they looked at models of blood vessel growth towards a cancerous tumor. In the second project they looked at methods of data compression.

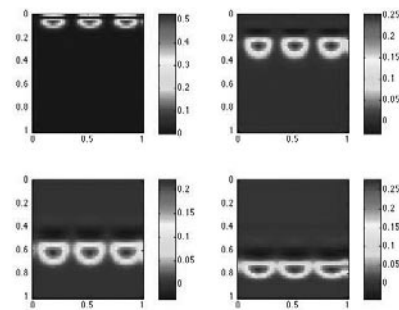
The students involved in these projects were Catherine Dillard, Abhinav Guliani, Cathy Ho, Evangelia Panagakou, Yan-nan Shen, Zekun Shi, Nadiah Wahi, Patrice Williams, Caitlin Worth, and Elena Zaurova. The projects were directed by Nathaniel Whitaker.

A critical question for a patient diagnosed with cancer is whether the disease is local or has spread to other locations. Cancer cells penetrate into lymphatic and blood vessels, circulate through the bloodstream, and then invade and grow in normal tissues elsewhere. This mechanism of spreading is called metastasis. Its ability to spread to other tissues and organs makes cancer a life-threatening disease. Hence, there is naturally a great interest in understanding what makes metastasis possible for a malignant tumor. One of the key findings of cancer researchers studying the conditions necessary for metastasis is the fact that the growth of new blood vessels is critical in this respect.

The process of the formation of new blood vessels is called angiogenesis or neovascularization. Such a process is beneficial in a number of situations, such as the formation of the placenta during embryogenesis or the repair of mammalian tissue following injury. Pathological neovascularization of the same type also occurs in the eye, in ulcers, and potentially in the myocardium. Tumor angiogenesis is the proliferation and migration of endothelial cells that form a capillary sprout network that vascularizes the tumor. This network supplies nutrients and oxygen to the tumor and removes waste products.

Tumor-induced angiogenesis is initiated by the secretion, from the tumor, of chemicals collectively known as Tumor Angiogenic Factors (TAFs). The TAFs create a chemical concentration gradient that chemotactically attracts the endothelial cells towards the tumor. The walls of blood vessels are formed by vascular endothelial cells that normally rarely divide.

For our applied math students the true culmination of the project was the use of the analytical and numerical methods developed in an attempt to match an experiment setup in Dr. Rong Shao's laboratory for the study of breast cancer at Baystate Medical Center in Springfield. The students derived a system of partial differential equations describing the proliferation of the endothelial cells to form new blood vessels based on their interaction with TAFs. The students solved the partial differential equations in 1 dimension and 2 dimensions, obtaining good qualitative agreement with the in vitro experiments in Dr Shao's laboratory. In the figure below, four snapshots of the density of endothelial cells moving towards the tumor are given at various times. Each picture shows three clusters of cells at a fixed time. The clusters are moving from the top of the picture towards the bottom, where the tumor is located. The densities represented in each picture are given by the color bar to the right.



In the second group project, the applied math student studied data compression. In computer science and information theory, data compression is the process of encoding information using fewer bits than in the uncoded representation. A popular instance of compression is the ZIP file format. As with any communication, compressed data communication is useful only when the sender and receiver understand the coding scheme. Compression is useful because it reduces the amount of space required for storage of the original data. On the other hand, compressed data must be decompressed in order to be used, and the additional processing could be harmful to some applications. For example, a compressed video may require expensive hardware for the video to be decompressed fast enough to be viewed while it is being decompressed.

The choice of data-compression schemes requires consideration of tradeoffs including the level of compression, the amount of distortion introduced, and the resources needed



to compress and uncompress the data. Lossless compression usually exploits the statistical redundancy in the data, allowing it to be stored in a more efficient way. By contrast, lossy compression allows some loss of data. Lossy compression is guided by how people see the data in question. For example, the human eye is more sensitive to luminance than variations in color; JPEG compression works by rounding off some of the less important data. In general, lossy compression provides a way to obtain the best fidelity for a given amount of compression. Sometimes unnoticeable compression is desired, and in other cases fidelity is sacrificed in order to reduce the amount of data as much as possible. Lossless compression schemes are reversible whereas lossy schemes accept some loss of data in order to achieve higher compression.

The students undertook several tasks involving data compression. In their first task, they used the Fourier transform to compress images. The Fourier transform is used to interpolate pixel data representing the image, and then the higher frequency terms are discarded, thus reducing storage requirements but at the same time preserving the quality of the image as perceived by the human eye. In the figure below, three images are shown. The original is on the left, followed by the image in the center representing 12% of the storage required in the original image. These two images are indistinguishable. The image on the right required only 1% of the storage as the original image. However, this image would be unacceptable in most uses.



These ideas were also applied in the students' investigation of compressing sound using the wavelet transform. The true highlight of this work came when the group tackled the much larger problem of compressing a video. Given the massive size of video files and the fact that a movie is just a series of images, they took what they had learned from image compression and exploited the fact that in successive frames of a video there is often little change. The students developed general software that can be applied to any movie.

These projects on blood vessel growth towards a cancerous tumor and on methods of data compression were presented in a colloquium in the Department of Mathematics and Statistics in April.

## BARKSDALE SCHOLARSHIP FUND ESTABLISHED

Joan Barksdale, an alumna of the Department of Mathematics and Statistics, together with her husband Ed Barksdale, have announced the establishment of a scholarship fund to benefit students in the College of Natural Sciences and Mathematics.



The fund will provide scholarship support to five first-year undergraduate students planning to major in some area of the natural sciences, with preference for students majoring in mathematics. In addition, preference will be given to students expressing an interest in teaching after graduation, especially in teaching mathematics.

"Giving an opportunity to someone who is diligent and gifted is a privilege for us," says Joan. "We've been blessed financially, and we want to help others achieve their goals and dreams."

According to Eduardo Cattani, Department Head of Mathematics and Statistics, the award will have a profound impact on the department. "We are very grateful for the continuing generosity of the Barksdales. In particular, we are delighted that they have chosen to target students who might otherwise have had no chance to attend the University of Massachusetts Amherst. Mathematical talent is everywhere, and we look forward to the opportunity of working with the Barksdale scholars."

Joan put herself through UMass Amherst through a combination of work and academic awards. "I received scholarship aid to attend UMass Amherst, and I also waited tables at the Faculty Club." The Barksdales have high regard for education and the way it can change lives. "Ed and I believe that education is the way to get ahead."

When asked about her association with mathematics, Joan explains that she went into mathematics for practical reasons. "There were a lot of career opportunities in mathematics and a lot of recruitment of math majors on campus. The research labs at IBM and Bell Labs were just getting started."

She also remembers how faculty influenced her decision. "I had a wonderful calculus professor who sparked my interest in math and who encouraged me to be a math major. At first I was going to major in history, but even my history advisor thought I should switch to math!"

After graduating from UMass Amherst in 1966 with a B.S. degree in Mathematics, Joan taught mathematics at the college level, both at Monmouth College in New Jersey and at Golden Gate University in San Francisco. She also worked as a special education teacher at Darien High School in Darien, Connecticut.

In addition to her teaching experience, Joan has worked for many not-for-profit organizations in various capacities, such as being Vice President of the Board of Directors for the Norwalk Community College in Norwalk, Connecticut, and Chairman of the Darien United Way. Beginning this summer, she will serve on the Advisory Council of the College of Natural Science and Mathematics.

Joan Barksdale lives in Darien with her husband Ed. Together they have three grown children who live in far-flung places from Maine to Japan and who have continued the family tradition of philanthropy.

## KRAININ AWARDED GOLDWATER SCHOLARSHIP

Michael Krainin, a junior Computer Science and Mathematics major from Sharon, MA, has won a prestigious Goldwater Scholarship. He is one of only 321 students in the nation to win the award for the 2008–2009 academic year.



Goldwater Scholars are selected on the basis of academic merit and are students who intend to pursue careers in science, mathematics, or engineering. This year 1,035 students were nominated for the award from colleges and universities nationwide. The scholarship covers the cost of tuition, fees, books, and room and board up to \$7,500 a year.

A Commonwealth College honors student, Krainin is currently on exchange at Uppsala University in Sweden, where he is taking courses in algorithmic problem-solving, machine learning, elementary particle physics, and basic Swedish. He was the first-place winner in last year's Henry Jacob Mathematics Competition (see page 14).

Goldwater Scholars have gone on to be awarded 70 Rhodes Scholarships, 94 Marshall Awards, and numerous other prestigious fellowships. The 20-year-old scholarship program honors the late U.S. Senator Barry M. Goldwater.

## WILLIAM LOWELL PUTNAM COMPETITION 2007 *by Jenia Tevelev*

The Putnam Exam is widely regarded as the most prestigious mathematical competition for undergraduate students in the U.S. and Canada. Along with the International Mathematical Olympiads, it is probably the most difficult mathematics test in the world. The six-hour intellectual marathon is held on the first Saturday in December. In order to prepare students for this ordeal, most mathematics departments, including the Department of Mathematics and Statistics at UMass Amherst, offer advanced, weekly problem-solving workshops. The precursor to the modern Putnam Exam was the mathematical contest held in 1933 between Harvard University and the United States Military Academy, which the latter institution won. The Putnam Exam in its present form has been administered annually by the Mathematical Association of America since 1938.

Solving problems on the Putnam Exam requires good problem-solving skills and some ingenuity rather than a lot of knowledge. In 2007, the only problem that was inaccessible to most freshmen was the following group-theoretic problem A5. Suppose that a finite group  $G$  has exactly  $n$  elements of order  $p$ , where  $p$  is a prime. Prove that either  $n = 0$  or  $p$  divides  $n+1$ . This problem was solved by just 14 participants. It is interesting philosophically because if  $n = 0$ , then of course  $p$  does not divide  $n+1$ . Expert mathematicians will undoubtedly recall similar statements about so-called torsors.

The solution of this problem resembles a trick pulled by Baron Münchhausen, who escaped from a swamp by pulling himself up by his own hair. Here are the main ideas. Take an element in  $G$  of order  $p$  and consider the subgroup  $H$  of order  $p$  that it generates. Then  $H$  acts on the set of elements of order  $p$  by conjugation. Because all orbits have size  $p$  or 1, it suffices to prove that  $p$  divides  $k+1$ , where  $k$  is the number of elements of order  $p$  that commute with  $H$ . In this way we reduce the problem to the same question for the centralizer of  $H$  in  $G$ . Doing this for any element of order  $p$  and arguing by induction on the size of  $G$ , we further reduce the problem to the case in which all elements of order  $p$  commute with each other. But if one adds the identity element, then these elements form a subgroup isomorphic to  $(\mathbb{Z}/p\mathbb{Z})^m$ , where  $m$  is a positive integer, and its size  $p^m$  is indeed divisible by  $p$ .

A total of 3753 students from 516 colleges and universities participated in the Putnam Exam in 2007. The UMass Amherst team did very well and finished with a rank of 43. The members of this “Dream Team” were Ilya Scheidwasser, Alex Levin, Alden Wheeler, and Jordan Morris. In the individual competition, the best result was achieved by Ilya, who got 22 points and a rank of 367, with Alex coming a very close second. We congratulate our students on this achievement.

## IN MEMORIAM: STEVE ALLEN

**Professor Emeritus Steve Allen died on October 29, 2007 at the age of 92. He received his B.A. from Amherst College in 1937 and saw active duty during World War II. Steve received his M.A. in Mathematics from Harvard in 1946, and his Ph.D. in Mathematics from the University of Pittsburgh in 1963. He joined our department in 1948 as an Instructor in Mathematics and remained here until his retirement in December 1980. Steve was an Associate Head of the Department from 1964 to 1970 and an Assistant Dean of the College of Arts and Sciences from 1970 to 1975. He leaves his wife Gretchen of 64 years, two sons, two grandchildren, and two great-grandchildren.**

*Professor Emeritus Joseph Horowitz wrote the following remembrance of Professor Emeritus Morris Skibinsky, who died in October 2007. The two were colleagues for a quarter of a century.*

### Remembrance of Morris Skibinsky

When I came to UMass Amherst in fall 1969, there were three statisticians in the department. One was an old-line applied statistician, Gale Oakland, who died a few years ago; the second was a junior faculty member who has long since left the department. The third was Morris.

I was scheduled to teach what are now Stat 111 and Stat 515, but I had never taken a course in elementary probability theory or statistics, so I contacted Morris by letter — no email in those days — for advice on textbooks and what to cover. Fortunately, he suggested the book by Mood and Graybill for Stat 515 and pointed me in the right direction regarding course content. I learned a lot about statistics that year, from the book and from Morris, and in later years from other colleagues in statistics.

Although Morris was primarily interested in mathematical statistics, it is interesting that his first paper, published in *J. Parapsychology* in 1950, while he was a graduate student at the University of North Carolina, was on testing for ESP (yes, “that” ESP). He had spent some time working at the Duke University Parapsychology Laboratory, now the Rhine Research Center. When we discussed his work at Duke, I don’t recall his taking a position on parapsychology, but he did question the interpretation of the results of some of the experiments performed at the lab.

Morris’s dissertation was written under the supervision of W.

#### HELEN CULLEN

**Professor Emeritus Helen F. Cullen died on August 25, 2007 at the age of 88. She attended Boston Latin School and graduated from Radcliffe College, receiving her Ph.D. from the University of Michigan. She taught for many years in the Department of Mathematics and Statistics at UMass Amherst, where she published the book, *Introduction to General Topology*. Helen leaves a brother, a nephew, a niece, and a great nephew.**

#### MORRIS SKIBINSKY

**Professor Emeritus Morris Skibinsky received his Ph.D. in 1954 from the University of North Carolina. From 1954 to 1961 he was at Purdue University as an Assistant Professor of Statistics and later as an Associate Professor of Statistics. After holding visiting positions at the University of California Berkeley and the University of Minnesota, he joined Brookhaven National Laboratory in 1963. He joined our department in 1968 as a Professor of Statistics and remained until his retirement in August 1994. Morris died in October 2007 after a brief illness.**

Hoeffding, whose inequality is well known to dabblers in probability theory. Some of the dissertation results appeared in *Ann. Math. Stat.* 31: 332-351, 1956. Morris’s papers through 1967, all appearing in *Ann. Math. Stat.* except for two technical reports, deal with the theory of estimation and testing, broadly conceived. After 1967 his work turned to moment spaces, which is the mathematical setting for the study of properties of probability distributions, usually on the unit interval, that can be ascertained from their first few moments. This work occupied him until his retirement in 1994 and beyond. He also wrote two papers on estimation theory with our former colleague, Andrew Rukhin (*Ann. Inst. Stat. Math.* 1989 and *J. Theor. Prob.* 1991).

In my opinion Morris’s most interesting work on moments is his three papers (*Ann. Stat.* 1976, *Sankhya* 1977, and *Ann. Inst. Stat. Math.* 1980). The 1976 *Annals* paper is entitled “Sharp Upper Bounds for the Probability on an Interval When the First Three Moments Are Known,” and the other two are on related subjects. On the other hand, my guess concerning his own favorite paper would be “Principal Representations and Canonical Moment Sequences for Distributions On an Interval,” *J. Math. Anal. Appl.* 120: 95-118, 1986, a detailed study of the geometry of moment spaces.

It is fair to say that Morris’s work was narrowly focused, but very deep, an opinion corroborated by our new faculty member, Michael Lavine. Morris was extremely interested in establishing the foundations of his subject, and that carried over into his teaching as well as his research. He had a fascinating collection of devious examples that showed how the major theorems of mathematical statistics failed if any of the technical conditions in the hypotheses were not met. He also began writing, but did not finish, an elementary statistics textbook that started out with a detailed exposition of the basic ideas of probability and included interesting and unusual examples that showed how tricky it is to use mathematics to model reality. The problems that he submitted for qualifying exams were generally nontrivial, and they demonstrated the depth and delicacy of the subject.

After the tragic loss of a daughter, which was of course profoundly traumatic for the family, Morris was sustained in part by his lifelong interest in the arts, and in later years he could be seen on Amherst Community TV reciting poetry that he had memorized. More recently he also wrote poetry that I found very moving.

Aside from his academic work, Morris regularly did hard physical labor around his house, which included moving heavy boulders. Several times the two of us would have a laugh when we met, both hobbling around the department with our backs “out.” According to his wife, Phyllis, Morris remained active and in apparent good health until about a month before his death, when he was diagnosed with pancreatic cancer.

I will long remember this shy, modest, intelligent man.

## SOLUTION TO LAST YEAR'S CHALLENGE PROBLEM

Last year's challenge problem was the following:

Suppose that  $r$  and  $s$  are roots of the equation  $x^2 + ax + b = 0$ . Find polynomials  $P(a,b)$  and  $Q(a,b)$  such that  $r^2$  and  $s^2$  are roots of the equation  $x^2 + P(a,b)x + Q(a,b) = 0$ .

This was a rather easy problem (which we need every once in a while), and many of you found it so. We received solutions from Rich Coco '75, Niall Emmart '92, Mark Leeper '72, Myrtle D. Simas '57, Earl A Smith '61, Christopher Thomas '94, and Ronald S. Tiberio '68.

The solution starts by noting that if  $r$  and  $s$  are roots of  $x^2 + ax + b = 0$ , then  $r + s = -a$  and  $rs = b$ . Similarly,  $P(a,b)$  must equal  $-(r^2 + s^2)$ , and  $Q(a,b)$  must equal  $r^2s^2$ . Since  $rs = b$ , it follows that  $r^2s^2 = b^2 = Q(a,b)$  and that  $r^2 + s^2 = (r + s)^2 - 2rs = a^2 - 2b = -P(a,b)$ . Therefore  $P(a,b) = 2b - a^2$  and  $Q(a,b) = b^2$ .

## NEW FACE IN THE DEPARTMENT: MICHAEL LAVINE

We are delighted to welcome Professor Michael Lavine to the University of Massachusetts Amherst. Professor Lavine's appointment as a tenured Professor of Statistics represents the culmination of a national search for a senior statistician. It also fulfills one of the major recommendations of the panel who reviewed the department as part of the Academic Quality Assessment and Development study, which took place during spring 2005.

Michael received his Ph.D. in statistics in 1987 from the University of Minnesota, one of the leading graduate programs in the country. That same year he joined the prestigious Institute of Statistics and Decision Sciences of Duke University, where he became a full Professor in 2001. Professor Lavine has also held visiting positions at Cornell University and Carnegie-Mellon University.

Professor Lavine has established a remarkable record of theoretical and applied research. His early work focused on Bayesian non-parametric statistics. His innovative work in this area is considered to be of fundamental importance, and indeed its impact continues to grow. In more recent years, Michael has turned his attention increasingly toward the applied side of statistics research, becoming involved with large projects in the fields of ecology, oceanography and neurobiology, among others. His applied work has led to the creation of new statistical methodology adapted to the needs of these evolving fields.



Michael has been an editor of some of the major journals in statistics: *Biometrics*, *Environmental and Ecology Statistics*, *Journal of the American Statistical Association*, and *Journal of Statistical Planning and Inference*. In addition he has been an editor of *Ecology and Ecological Monographs* and the executive editor of *Chance*, the statistical magazine tailored to graduate and undergraduate students.

Michael is deeply committed to expanding our graduate and undergraduate programs in statistics and to interdisciplinary collaborations. He is already working in several projects involving colleagues at UMass Amherst and at the Five Colleges. His energy, leadership, and spirit of collaboration are already being felt in every aspect of departmental life!

## SHABNAM BEHESHTI RECEIVES DISTINGUISHED TEACHING AWARD

For more than 30 years the Provost's Office has conferred an award recognizing excellence in teaching. This year Shabnam Beheshti has been awarded the Distinguished Teaching Award, one of the University's most competitive and prestigious honors. Chosen from more than 100 nominees, she is one of two graduate students and four faculty members to receive this campus-wide award. In addition to a stipend and an engraving in the Campus Center, Ms. Beheshti will be recognized for her achievement at both the undergraduate and graduate commencement ceremonies.



During her time at UMass Amherst Ms. Beheshti has taught a variety of undergraduate courses, but her favorite has been the Math 131-132 calculus sequence. "I love teaching the freshmen who know they want to do something involving science and engineering," she said, "but who still have a clean slate when it comes to mathematics. For them, everything is still fresh so they bounce back from setbacks quickly."

When asked about her most successful teaching technique, Ms. Beheshti instantly responds: humor. "Smiling during lectures is highly underrated, but if your face says you're enjoying both the material and the students' company, then it has a huge payback in their desire to attend and to follow," she maintained. Another factor that she attributes to her success in the classroom is the sharing of both breakthroughs and roadblocks in her own research with her students. "They really seem to appreciate hearing that I too battle mathematical demons, and it serves as a reminder that success does not come without a lot of hard work."

Ms. Beheshti completed her dissertation, "Solutions of the Dilaton Field Equations with Applications to the Soliton-Black Hole Correspondence in Generalized JT Gravity," under the supervision of Emeritus Professor Floyd Williams. Her results will be published in *Recent Trends in Mathematical Physics* (Nova Sci. Pub.) and the *International Journal of Pure and Applied Mathematics* later this year. She has accepted a research fellowship at the Tata Institute of Fundamental Research in Mumbai, India followed by a postdoctoral position at Rutgers University.



## GRADUATE PROGRAM NOTES *by Siman Wong*

Our former student **Sasanka Are** is now working at JP Morgan-Chase in New York City. He received a Ph.D. degree in December 2007.

**Shabnam Beheshti** won the University Distinguished Teaching Award. She received a Research and Travel Grant to attend the SMS-NATO Summer School Advanced Study Institute on Hamiltonian Dynamical Systems in Centre de Recherches Mathématiques in Montreal, Canada. She was also a speaker at the AMS sectional meeting at NYU-Courant, and she will attend the 5th International Conference of Applied Mathematics and Computing in Bulgaria as well as the MSRI Summer School, "A Window into Zeta and Modular Physics." Together with Professor Emeritus Floyd Williams, Shabnam co-authored a paper that was published in *Journal of Physics A*, and her thesis will be published as a chapter in *Recent Developments in Mathematical Physics*. Starting in fall 2008, she will spend a year at the Tata Institute of Fundamental Research in Mumbai, India as a Research Fellow, followed by a postdoctoral position at Rutgers University.

**Diego Belfiore** and **Jason McGibbon** will attend this year's Topology Festival at Cornell University.

**Patrick Boland** attended John Millson's 62nd Birthday Conference in College Park, MD. He plans to attend the Graduate Student Combinatorics Conference at University of California Davis and the BIRS 5-day workshop on Locally Symmetric Spaces in Banff, Alberta.

**John Cullinan** is currently a Visiting Assistant Professor at Bard College and has accepted a tenure track position there starting in fall 2008. John received a Ph.D. in May 2005.

**Jennie D'Ambroise** published a paper in the *International Journal of Pure and Applied Mathematics* entitled "A Schrödinger Formulation of Bianchi I Scalar Field Cosmology".

**Michael Diehl** is an Assistant Professor of Mathematics at Endicott College.

In October 2007 **Molly Fenn** gave a talk at the International Workshop on B-stable Ideals and Nilpotent Orbits in Rome, Italy. Next year she will be a Teaching Assistant Professor at North Carolina State University in Raleigh.

Together with ten other co-authors, **Elena Giorgi** is the first author of a paper that was recently accepted for publication by the *Proceedings of the National Academy of Sciences*. Last October she gave a presentation at the third annual retreat for the Center for HIV/AIDS Vaccine in Durham, North Carolina, and she will give a presentation at the 15th HIV Dynamics

and Evolution Meeting in Santa Fe, New Mexico. She also submitted an abstract to the Gordon Theoretical Biology and Biomathematics Conference to be held next June in Lucca, Italy, and it has been accepted.

**Laura Hall-Seelig** attended the AGCT-11 Conference on Arithmetic, Geometry, Cryptography, and Coding Theory held at Luminy, France in November 2007. She attended along with faculty member Professor Farshid Hajir, our former student **John Cullinan**, and Kristian Brander, who visited our program as an exchange student from Denmark during fall 2005.

**Kody Law** attended the 2007 Onassis Foundation Science Lecture Series in Physics in Greece, and the Advanced Winter School on the Mathematical Foundations of Control and Quantum Information Theory in Spain. Together with faculty member Professor Panayotis Kevrekidis, he is also the coauthor of two papers that have been published in *Physics Letters A* and in *Optics Letters* and of one paper that has been accepted for publication in *Physical Letters A*.

This year **Brett Milburn** is visiting the Institute for Advanced Study. Next fall he will be a visiting assistant professor at University of Texas at Austin.

Our former student **Dimitrios Tsagkarogiannis** is currently a postdoctoral fellow at the Max-Planck Institute in Leipzig, Germany and is a recipient of an FP7 People Marie-Curie Award for 2008-10 from the European Commission. He received a Ph.D. degree in August 2005.

Together with Professor V.V. Lozin of Rutgers University, **Jordan Volz** is the coauthor of a paper that was recently accepted for publication by *International Journal of Foundations of Computer Science*.

The following students are expected to receive a Ph.D. degree this year: **Shabnam Beheshti**, **Michael Diehl**, **Molly Fenn**, and **Brett Milburn**.

In September 2007 **Aleams Barra** and **Michael Diehl** received an M.S. degree in mathematics while **Jiaying Zhang** received an M.S. degree in statistics. In February 2008 **Nathan Fidalgo** received an M.S. degree in mathematics, and **Yanika Paliwal** and **Lei Ye** received an M.S. degree in statistics. The following students are expected to receive an M.S. degree this year: **Garrett Cahill** and **Allison Tanguay** in mathematics; **Catherine Dillard**, **Evangelia Panagakou**, **Zekun Shi**, **Patrice Williams**, and **Elena Zaurova** in applied mathematics; and **Philip Carter**, **Lili Cheng**, **Tyler Lemieux**, **Ting Lu**, and **Tianji Shi** in statistics.

## OUTSTANDING UNDERGRADUATES HONORED

This spring the Mathematics and Statistics department hosted a banquet to honor achievements of our top undergraduates. Participants in the Capstone course (see below) and in undergraduate research projects (see page 5) were recognized along with the winners of the M. K. Bennett Geometry Award and the Henry Jacob Mathematics Competition. We were also delighted to host alumni Jim Francis '86 and Roy Perdue '73 and Dean George Langford of the College of Natural Sciences and Mathematics.



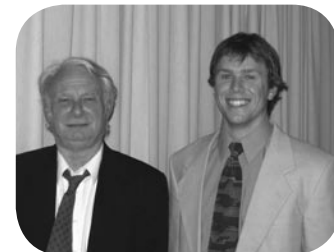
Paul Gunnells, Adriano Bruno, Alex Levin, Jacob Mitchell, Farshid Hajir



Banquet

### M. K. Bennett Geometry Award

The M. K. Bennett Geometry award was founded by a group of alumni led by Robert and Veronica Piziak to honor the memory of Prof. Mary Katherine Bennett. In 1966 Professor Bennett earned the first Ph.D. from the department under the direction of Professor David Foulis. After teaching at Dartmouth College, she returned to UMass Amherst for the rest of her career, where she encouraged interest in geometry and high school teaching among undergraduates. Each year the award is presented to the students with the strongest performance in Math 461, Geometry. This year's winners were Justin Reischutz and Olivia Simpson.



Peter Norman, Justin Reischutz

### Henry Jacob Mathematics Competition

The Henry Jacob Mathematics Competition honors the memory of Professor Henry Jacob, who encouraged interest in mathematics among undergraduates through an annual mathematics contest. This year's first prize was awarded to Andrew Hall, a mathematics and physics double-major. The \$1500 cash award was presented to Hall by the sponsor of the competition, Roy Perdue '73 (Solutions by Computer). Second prize (\$750) went to Kai Xiao, also a mathematics major, while third prize (\$250) went to Kim Kyungyoon, a computer science major. Yi Ding won an honorable mention award of \$100.

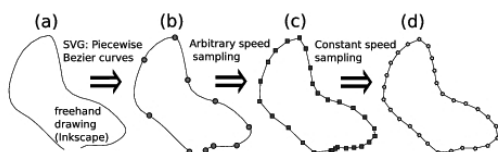


Haskell Cohen, Eleanor Killam, Dean George Langford, Kai Xiao, Roy Perdue, Andrew Hall, Eduardo Cattani

## FAST FOURIER TRANSFORMS IN APPLIED SCIENCE *by Hans Johnston and Richard S. Ellis*

**Bart Parkis, Nat Trask,  
Maksim Kuksin, Rick Stewart**

Fast summation methods were the main topic in this year's Capstone Course, Math 499, which prepares advanced undergraduate math majors to do independent research culminating in an honors thesis. These transforms make it possible to do efficient simulations of large-scale problems in a wide variety of areas including celestial mechanics, plasma physics, fluid dynamics, and molecular dynamics.



The thesis topics being investigated by students taking the course this year include applications of the Fast Fourier transform to algorithms in mathematical finance, number theory, and pattern recognition. In carrying out the last of these applications, one of the students, Bart Parkis, implemented a pattern-recognition algorithm involving Fourier descriptors of parametrized curves. This algorithm allowed Bart to develop a program that identifies simple plane curves. It begins by inputting a hand-drawn shape or curve. After parameterizing and discretizing the input, Bart's program uses the fast Fourier transform to extract geometric invariants and symmetries in the form of Fourier descriptors. These descriptors are then compared statistically to a database of pre-stored shapes in order to classify the original curve. This is a simple example of an important class of applications that includes the recognition of handwriting by computers and the identification of geographic structures by satellites. The accompanying graph, which is taken from Bart's senior thesis, illustrates how his algorithm parametrizes and discretizes a simple plane curve.

# THE FOLLOWING ALUMNI AND FRIENDS HAVE MADE CONTRIBUTIONS

to the Department of Mathematics and Statistics over the past year. We greatly appreciate your generosity. It is through this generosity that we are able to improve and enrich the educational experience of our students.

**Giving to the Department of Mathematics and Statistics supports initiatives in an array of areas, including the following:**

- A gift of \$100 or less helps support the Math Club, the Awards Dinner, and other student functions.
- A gift of \$100 – \$500 provides funding for awards for outstanding undergraduate majors and graduate students to help honor their achievements.
- A gift of \$500 – \$1000 helps support student travel to conferences and workshops, and could sponsor a prize in the mathematics competition.
- For \$1000 – \$3000 your gift could provide funds to support increasing classroom technology such as tablet PCs and projectors. You could fund a seminar series or a distinguished lecture.
- For \$3,000 – \$5000 your gift could fund the summer research of REU (Research Experience for Undergraduates) students. You could provide summer support for graduate students so that they could concentrate on their dissertation research, or provide support for junior faculty.

To make a gift to the department, please use the enclosed gift envelope or visit our gift page on the department's website: [www.math.umass.edu/Donate/donate.html](http://www.math.umass.edu/Donate/donate.html). The website [www.umass.edu/development/](http://www.umass.edu/development/) offers more information about donating to the campus and the opportunity to make your gift online.

## INDIVIDUAL DONORS (\$1000+)

Jennifer and Tucuoing Lien  
Geni and Steven Monahan  
Roy Perdue

## INDIVIDUAL DONORS (\$250-\$1000)

Carmen Acuna  
John and Patricia Baillieul  
Douglas Brothers  
Ida Cole  
Carol and William Cox  
Jonathan Fienup  
Dawn and Stephen Forde  
Louise and Robert Fredette  
Kenneth Johnson  
Robert Jones  
Richard and Sarah Jordan  
Alvin Kho  
M. Loncoln  
Darlene and John Nelson  
M. Plaisted  
Barry Randall  
Laura Ritter  
Gerard Sarnie  
Andreana and James Shanley  
Bernard Shapiro  
Scott Simenas  
Jonathan Skinner  
Kevin Smith  
Archie Strong

## INDIVIDUAL DONORS

Geraldine Amprimo  
Samuel Antiles  
Robert Babeau  
Amy Bacon  
Linda Bailey  
Richard Bates  
Donna Bedinelli  
Laurie Benoit  
Richard Berger  
Todd Blessinger  
Anne Boucher  
John Brady

Gail Brittain  
Nancy and William Burch  
Richard Burns  
Ronald Burt  
Elizabeth Carmen  
Ann Celino  
Ronald Charbonneau  
Frances Chervarley  
Karen Chiklakis  
Susan Chlebus  
Ann Condon  
Nancy Connolly  
Marjorie Cook  
D. Coparanis  
C. Corrigan  
Christopher D'Amour  
Leona and Leonard Dalton  
Roxanne Dardenne  
Lawrence DeBlasiis  
Paul Desmarais  
Robert Dines  
Susan Director  
Elizabeth Doane  
Patricia Doherty  
Joseph Dorval  
Carol Ducharme  
Debra and Francis Duches  
Susan and Wayne Duckworth  
Constance Duffy  
Patricia Fisher  
Keith Foiuntain  
Kenneth Frail  
Mary Ann Godbout  
William Goddhue  
Andrew Gori  
Arthur Groves  
Douglas and Rose Mary Haddad  
Jonathan Hale  
Helen Harris  
Donald Hastings  
Stephen Hinthorne  
Mary and Samuel Holland  
Daniel Horvitz  
Carolyn Hoyt  
Timothy Ingalls

Pauline Jacek  
Gretchen Jacob  
Gerald Janowitz  
Patricia Jones  
Anthony Julianelle  
Joh Keller  
Richard Kennedy  
Kathleen Kennedy  
John Ketler  
Mizan Khan  
Robert Knowles  
William Koch  
Deborah Krau  
Elizabeth Kumm  
Elizabeth and Stephen Kurina  
Vicki Kuziak  
Richard LaBlanc  
Marilyn Lacerte  
Alexandria Lamartine  
Denis Lankowski  
Evelyn and Mark Leeper  
Alan Leff  
Barbara and Donald Lieb  
Patti and Robin Lock  
Susan Luca  
Douglas Malloy  
Eduardo Marchena  
R. Marcus  
Brad Marcus  
Edwin Marden  
Christine Martell  
Clifford and Lois Martin  
Gerald May  
Robert McCarthy  
Regina McEvoy  
Ruth McGlothlin  
Daryl Miller  
Forrest Miller  
George Morin  
Abdelhamid and Deborah Morsi  
Steven Murray  
Gary Noseworthy  
Joseph Oliveira  
Thaddeus Osetek  
Donna Pacheco

Katherine Porter  
Kevin Prestana  
Stuart Rachlin  
Daniel and Laura Rasmussen  
Douglas Robinson  
Claire and Steven Robinson  
Deborah and Norman Roth  
David Ryan  
Joyce Shelden  
Ann Sieben  
Betty and Robert Sinkiewicz  
Walter Sizer  
Matthew Snow  
Benjamin Stein  
F. Stenross  
Charles Stevens  
David Stillman  
Sally Stuckey  
Robert Sturtevant  
Mary Sweet  
Richard Tabor  
Timothy Tracy  
Thomas Uryniak  
Kate Van Der Kloot  
Richard Venditti  
Hong Wang  
Barbara Weissbrod  
William Welsh  
Judith White  
Jeffrey and Tobi Whitney  
Gerald Wickham  
Michael Wilson  
James Wilson  
Terry Wojtkunski  
Charles and Sharon Wolbach  
Joan Wuensch  
Johnette Yoshida

## CORPORATE DONORS

General Electric  
Intel Coporation  
National Grange Mutual  
Refrac Systems  
Sun Life Assurance  
Verizon Foundation

*The newsletter is published annually by the Department of Mathematics and Statistics for its alumni and friends.*

## **YOU ARE IMPORTANT TO US!**

We want to hear about how your experience with our Department affected your life. There are also many opportunities for alumni and friends to become involved with the Department, from giving to the Department to giving a presentation to our students about your career and how the Department is important to you. Please contact us, share your news with us, and let us know what you're doing! Send any correspondence to:

**Prof, Eduardo Cattani, Department Head  
Department of Mathematics and Statistics  
Lederle Graduate Research Tower  
710 North Pleasant Street  
University of Massachusetts Amherst  
Amherst, MA 01003-9305**

**Telephone: (413) 545-0510  
Fax: (413) 545-1801  
dept@math.umass.edu**

*The newsletter was compiled and edited by Eduardo Cattani, Richard S. Ellis, and Paul Gunnells. The newsletter was designed by Kamilla Talbot (kt@kamillatalbot.com)*



THE COLLEGE of  
NATURAL SCIENCES & MATHEMATICS

# UMassAmherst

**Department of Mathematics and Statistics  
Lederle Graduate Research Tower  
710 North Pleasant Street  
University of Massachusetts Amherst  
Amherst, MA 01003-9305**

**Non-Profit Org.  
U.S. Postage  
PAID  
Permit No. 2  
Amherst, MA 01002**