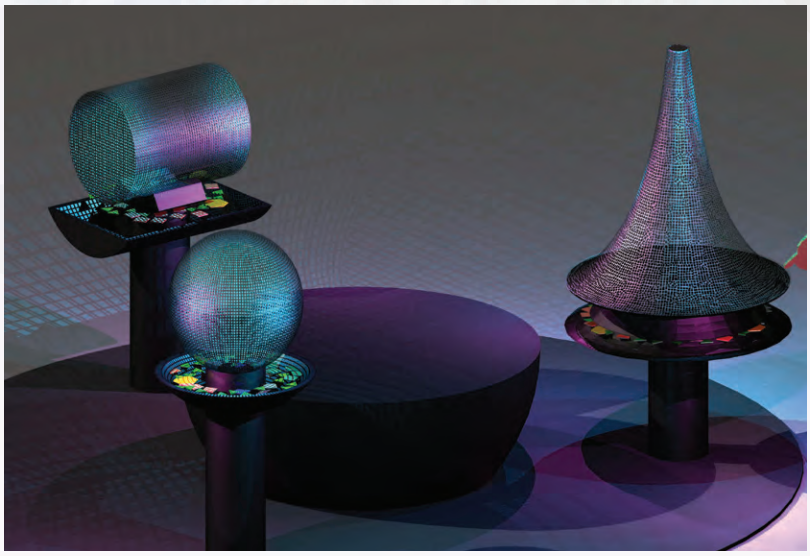
FALL 2011

THE Common Denominator

UCLA DEPARTMENT OF MATHEMATICS NEWSLETTER



A MoMath exhibit will let visitors play with tiling patterns on differently curved surfaces.

INSIDE

UCLA

Faculty Additions

World Leader in Algebra

Raphael Rouquier joins the Department as professor in the algebra group. In his work Raphael uses contemporary algebraic geometry, especially equivalences of derived categories, to solve problems in the representation theory of groups and algebras. Areas in which he has had major impact, or plays a leadership role,

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UCLA Math Alum Launches National Math Museum

How did a UCLA Math PhD and former University of Michigan professor turned hedge fund algorithm manager decide that his true calling was to create a national museum devoted entirely to mathematics? For Glen Whitney, executive director and founder of the Museum of Mathematics (**MoMath**), it was his desire to showcase the beauty and creative side of mathematics in a hands-on interactive environment that would spark young Americans to think about math differently and above all, make it fun. Scheduled to open in late 2012 in Manhattan, MoMath is all about the exploratory nature of math. Says Glen, "Most people don't really get a chance to know what mathematics is. They think that it's hard to solve, but we think if they do it, they'll actually get excited to get involved. We want to show that mathematics is an ongoing exploration, that it has beauty and people in it who are creative and excited about math."

Glen's time as a graduate student in the Department, where he received his PhD in mathematical logic in 1994 under Professor Emeritus Yiannis Moschovakis, was an influential period. Says Glen, "I've had this lifetime love affair with mathematics that started when I was a teenager, and UCLA was a key part of that whole trajectory. There's a great spirit to the Department – they're doing what they love and that just reinforced my old love of mathematics." Glen has a family history with UCLA. His mother obtained a master's in math from the Department, and his father graduated with a PhD in chemistry, both in the late '60s.

The Inspiration

Glen remembers visiting the classic IBM-Eames exhibition "**Mathematica: A World of Numbers and Beyond ...**" at the Chicago Museum of Science and Industry

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UCLA Math Alum Launches National Math Museum

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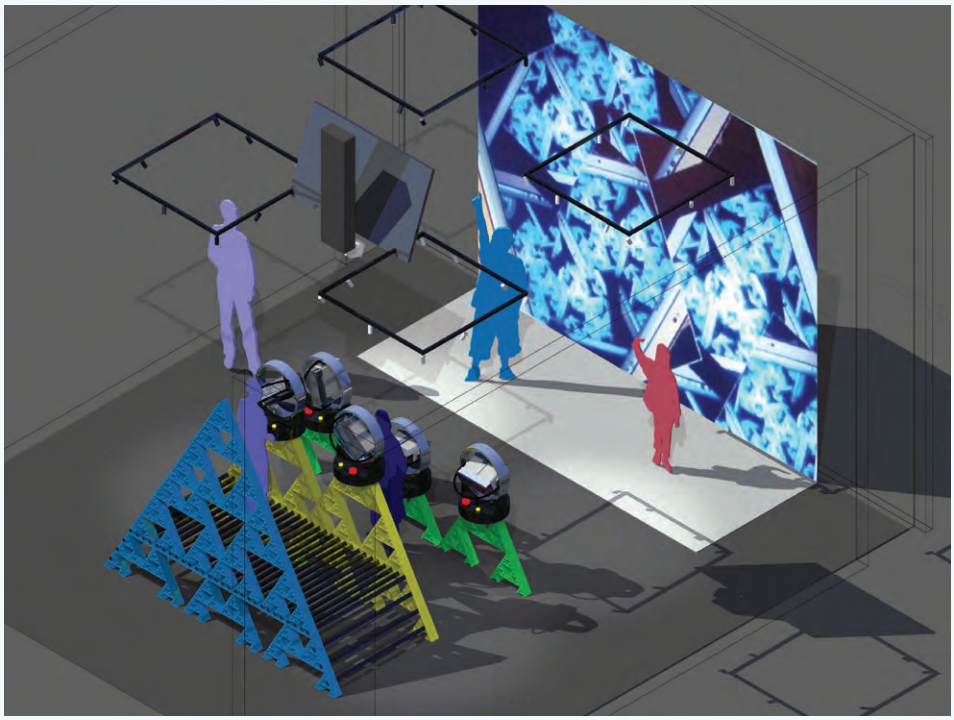
MoMath's traveling *Math Midway* exhibition features eye-popping interactive exhibits designed to let visitors experience and explore mathematical concepts. The *Ring of Fire* uses lasers for exploring two dimensional cross sections of three dimensional translucent solids, such as finding a hexagon within a cube. *Math Unleashed: Free the Tangled Terrier* uses a rope tied around two posts and leashed to a toy dog to challenge visitors to free the dog by removing one post. It demonstrates a series of geometric logic puzzles that lead to the mathematical concept of the winding number.

and at the Boston Museum of Science as a child and in college. UCLA Math Professor Emeritus Raymond Redheffer (1921 – 2005) collaborated with Charles and Ray Eames as the sole mathematical consultant for Mathematica, which debuted in 1961 at the former California Museum of Science and Industry and remained there until 1998. "It is an inspirational exhibit," remembers Glen, "really the first of its kind in a couple of ways – the first museum math exhibit that I know of, and a very early interactive exhibit, in that the visitor could make certain parts of the exhibit move to better display the mathematical phenomena being shown."

But it was his appreciation for a small math museum on Long Island – the Goudreau Museum – that was the direct inspiration for MoMath. In 2007, Glen was working at Renaissance Technologies in New York as the manager of the Research Infrastructure Group, devising trading strategies, and coaching a math club at his daughter's elementary school. The coaching experience awakened his passion for primary math education and led to the school team's participation in a math tournament. There Glen learned from a fellow parent that the Goudreau had closed. Says Glen, "That planted a seed. I thought maybe there was some way I could have helped out, but over the next several months I began to think it was actually an opportunity. I was looking for something where on a day-to-day basis I felt that I was having a positive impact on society."

Teaming up with fellow parent and math enthusiast Cindy Lawrence, now MoMath's Chief of Operations, Glen formed a working group in 2008 to explore the viability of creating a math museum with national ambitions. After producing a successful exhibition for the 2009 World Science Festival Street Fair in New York, the team – including mathematical sculptor and content designer George Hart, and design chief Tim Nissen – decided to take their show on the road, and the **Math Midway** traveling math carnival was born. Partnering with a strong network of hands-on science centers across the country, the Midway includes over 20 interactive math exhibits, and has served as the proof of concept for the museum. It continues to travel to multiple cities and made its West Coast debut at The Discovery Center for Science and Technology in Thousand Oaks, California, in June 2011.



An elegant feedback process adjusted by MoMath visitors generates an enormous range of beautiful fractals.

The Exhibits

The Midway's marquis exhibit, *Pedal on the Petals*, which will also be part of MoMath, invites visitors to ride a square-wheeled tricycle around a curved track to achieve a seemingly impossible smooth ride. The sunflower-shaped exhibit puts the mathematics on display in a fun, interactive way. The center is a seed pattern called a Fibonacci spiral arranged in a pattern based on the golden ratio that occurs in real sunflowers. The shape of the track, a catenary curve, allows the trike's square wheels to roll smoothly. In what Glen calls a "beautiful mathematical coincidence," the curves of the chains that surround the exhibit are also catenary.

The exhibits' fanciful names – including the *Roller Graphicoaster*, the *Ring of Fire*, and *Amazing Acrobats* – highlight the exploratory nature of mathematics that Glen aims to show the public. For the *Roller Graphicoaster,* the goal is to build a roller coaster that results in

the fastest ride from start to finish, using virtual and physical tracks. The mathematics goes back to an optimization problem posed by Galileo in the beginning of the 17th century and lets visitors play with mathematical curves. Department faculty members Christoph Thiele and Peter Petersen serve on MoMath's advisory council and contributed ideas for the 50+ new exhibits that will be featured in the museum's 20,000-square-foot leased location across from Madison Square Park in Manhattan. Says Glen, "We have an exhibit based on a surface of musical chords called the Musical Orbifold. Christoph's advice weighed significantly in our decision to include that exhibit from among the literally hundreds of concepts we considered, and Peter Petersen had numerous excellent suggestions that went into the design mix."

Glen hopes that MoMath will engage the American public in mathematics and inspire the nation's youth to pursue mathematics at higher levels the way that established interactive math museums have been embraced by and have flourished in other countries, including Germany, France and South Korea. With $22 million raised to date, including a $2 million gift from Google, MoMath is ready for the public to decide. Future plans include a larger, permanent space to house the burgeoning exhibits that his team continues to develop as well as an expansion to other cities. A West Coast location is at the top of the list. "Everybody thinks that math is for geeks and not something they want to go spend a Saturday afternoon doing," says Glen. "We believe that when they come through the doors of our institution, they will see the wonderland that mathematics can be, and they'll have a great time."

A smooth tricycle ride on square wheels

For more about the Museum of Mathematics, visit www.momath.org.

Faculty Additions

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include the theory of blocks of finite groups, complex reflection groups, braid groups, rational Cherednik algebras, Kac-Moody algebras, categorification (a hot new area where he is a founding father), q-Schur algebras, and Deligne-Lusztig varieties. His work is appreciated for the surprising ways in which it achieves concrete results with abstract methods, for its fertilizing quality for other researchers, and for its remarkable technical skill. His appointment is much appreciated by Department groups in allied fields such as number theory and topology. Raphael comes to UCLA from Magdalen College, Oxford, where he has held the distinguished Waynflete Professorship since 2007. He was educated in Paris at the École Normale Supérieure and at Université de Paris VII. He received his PhD in 1992 at age 22. From 1992 to 2005 he was a member of CNRS, France's premier research organization, where he rose to the rank of Directeur de Recherches. In 2005, he was made Professor of Representation Theory at University of Leeds in the UK. Raphael's prizes include the Elie Cartan Prize of the French Academy of Sciences (2009), the Adams Prize of the University of Cambridge (2009), and the (Senior) Whitehead Prize of the London Mathematical Society (2006). He spoke about his research at the International Congress of Mathematicians (ICM) in Madrid in 2006.

Rising Star in Applied Math

Marcus Roper brings his interests in the mathematics of cellular and organismic biology to the Department's applied mathematics group in the position of assistant professor. Marcus' strengths and passion for using math to solve problems in the fundamental biological sciences complement UCLA's applied math group, ranked number two in the country, and fit well with the university's ongoing initiative in biological sciences. His work combines mathematical precision and testing models against the actual physics through carefully designed experiments. A current focus of his work is the development of mathematical models and platforms for understanding how fungi and other microbes, including pathogens, move across landscapes. Marcus earned his PhD in applied math at Harvard University under the direction of Howard Stone and Michael Brenner. Prior to coming to UCLA, he was a Miller Institute Research Fellow at UC Berkeley and an Assistant Professor at the University of Warwick in the UK.

faculty news

Faculty News Highlights

Chandrashekhar "Shekhar" Khare received three distinguished honors this academic year. ■ The 2011 **Frank Nelson Cole Prize in Number Theory** by the American Mathematical Society (AMS), the most eminent price in number theory. Shekhar shares this award with collaborator Jean-Pierre Wintenberger. It was given for their remarkable proof of Serre's modularity conjecture, first proposed in 1973 by Fields Medalist Jean-Pierre Serre. In the mid-1980s, Gerhard Frey and Serre realized that the conjecture implies Fermat's Last Theorem, the landmark problem that was solved by Andrew Wiles in the 1990s. Wiles used ideas relating to Serre's conjecture to prove the theorem, but at that time the conjecture seemed out of reach. ■ **Infosys Prize 2010** in mathematical sciences. The prize recognizes outstanding contributions to scientific research that have impacted India across five categories. ■ 2010 **Humboldt Research Award**, which is granted across scientific disciplines and honors research having significant impact on the scholar's discipline. Shekhar will use this award to support his research at Heidelberg University in Germany.

Joseph Teran was among 94 recipients of the **Presidential Early Career Awards for Scientists and Engineers (PECASE)**, the highest honor bestowed by the U.S. government on science and engineering professionals in the early stages of their research careers. Sixteen federal departments and agencies join together annually to nominate the most outstanding scientists and engineers whose early accomplishments show the greatest promise for assuring America's preeminence in science and engineering. Joey was one of three UCLA scientists to receive the award. His research interests include computational biomechanics and virtual surgery. As a pioneer of virtual surgery, Joey uses mathematics to enable surgeons to practice on a three-dimensional "digital double" of a patient before performing an actual surgery. His applied math can also be used to design more durable bridges, freeways, cars and aircraft.

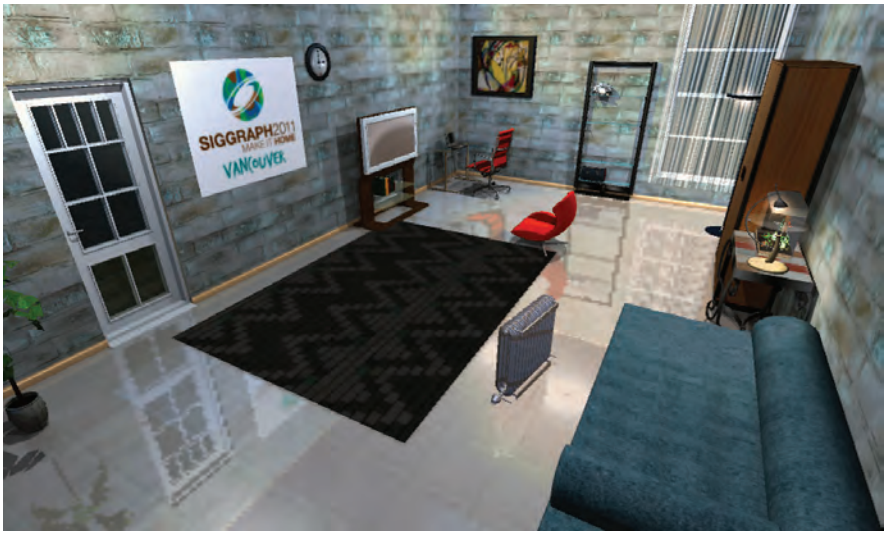
Stanley Osher and then PhD student Tom Goldstein were recognized for their 2009 paper, "The Split Bregman Method for L1-Regularized Problems" (SIAM J. Imaging Sci. 2[2]: 323-43, 2009). The paper was identified by **Thomson Reuters *Essential Science Indicators*℠** as a featured "New Hot Paper" in the field of computer science. The distinction was given to the research article as one of the most-cited papers in this discipline published during the past two years. The class of L1-regularized optimization problems has received much attention because of the introduction of compressed sensing, which allows images and signals to be reconstructed from small amounts of data.

Collaborative research in predictive policing by **Andrea Bertozzi**, **Martin Short** and others made the ***DISCOVER Magazine*** Top 100 Stories of 2010 and The ***New York Times Magazine*** 10th Annual Year in Ideas. Two different mathematical models were developed by UCLA mathematicians and statisticians in conjunction with anthropologists and criminologists. ■ Martin Short led collaborative research behind California's **Santa Cruz Police Department**'s implementation of a new program in predictive policing. In the same way that earthquake models predict aftershocks, the model predicts hotspots where future crimes, such as burglaries and car thefts, are likely to occur. In July, Santa Cruz experienced a 27 percent drop burglaries in one area compared to the same month a year ago. Cities nationwide, including Los Angeles, are considering adopting predictive policing as law enforcement agencies contend with budget cuts.

Grants

NSF awarded the Department's **California Research Training Program in Computational and Applied Mathematics**, ranking it at the top of 35 mathematical sciences workforce proposals and funding it at $2 million over five years. **Andrea Bertozzi** leads the program with fellow applied math faculty **Stanley Osher**, **Luminita Vese** and **Joseph Teran**. The summer research program trains California math undergraduates and master's students on topics ranging from crime modeling, to robotics and control to medical imaging. The program involves cross-disciplinary collaboration with UCLA and partnering California university faculty in medicine, anthropology, engineering, chemistry, and other fields. The new award also includes a training program for postdocs and junior faculty to learn how to involve pre-PhD students in publication-level research, and supports training of some PhD students in both research and mentoring.

NSF awarded the departments of mathematics at UCLA, UC Irvine and Caltech a five-year, $2 million **Research Training Group** (RTG) grant in **mathematical logic**. **Itay Neeman** directs the project with co-principal investigators Matthew Foreman (UC Irvine) and Alexander Kechris (Caltech). The Department will receive approximately half of the award. As part of the NSF initiative to enhance the mathematical sciences workforce in the 21st century, the grant will fund numerous programs, including summer schools for undergraduate and graduate students and fellowships, as well as enrichment programs for 7th through 12th graders and community college students.



The Mathematics of Interior Design

Former UCLA math postdoctoral scholar Sai-Kit Yeung (Kit) and UCLA computer graphics PhD student Lap-Fai (Craig) Yu are passionate gamers who were looking to improve the quality of their video gaming experience, specifically the realism of virtual indoor environments. Says Kit, "Game developers can model a whole city, like New York, but you can't go inside most of the buildings because it takes too much effort and cost to model the interiors." Now, with their Make It Home software, Kit and Craig have creatively solved the interior modeling problem by a stochastic optimization method, which allows a user to configure furniture and objects in a virtual room automatically, generating multiple functional arrangements for up to 30 objects in 20 seconds. For non-gamers, the applications in interior design are equally exciting. Unlike furniture retailer IKEA's online kitchen planner that allows shoppers to manually place items such as cupboards and sinks into their spaces to see how well they fit, Make It Home automatically generates optimal layouts for any given room in seconds, taking into account accessibility and visibility constraints like doors and windows. They also found that there was no significant difference in aesthetic preference by users between the synthesized results and layouts selected by human designers. The research team, including UCLA applied math professor **Stanley Osher**, UCLA computer science professor **Demetri Terzopoulos** and former UCLA math professor and Hong Kong University of Science and Technology President **Tony Chan**, also sees applications in film, theme park design, city planning and military troop organization. Kit, who will join the Singapore University of Technology and Design this fall as an assistant professor, plans to take the software to the next level using Stan Osher's level set method to allow even more complicated representation and arrangement of objects.

To see Make It Home's automatic furniture optimization in action, click here: http://www.math.ucla.edu/~saikit/projects/furniture/furniture.mov

UCLA Math at the Institut Henri Poincaré in Paris

Von Neumann algebras have emerged as playing a fundamental role in a number of mathematical areas, such as group theory, ergodic theory, non-commutative functional analysis, and descriptive set theory. Building on a long tradition in this field, UCLA Mathematics has assumed a leading role over the last decade through a constant flow of visiting researchers, exceptional graduate students and a series of influential conferences, held on a bi-annual basis. This culminated in a major international research program, "Von Neumann algebras and ergodic theory of group actions," held in spring 2011 at the **Institut Henri Poincaré** in Paris. The trimester, co-organized by Department chair **Sorin Popa**, whose work in the last 10 years revolutionized these subjects, had substantial participation of UCLA faculty, current and past postdocs and graduate students. It offered four graduate courses and 17 research level mini-courses, a third of which were given by UCLA faculty (**Yehuda Shalom**, **Dima Shlyakhtenko**, Sorin Popa) and former UCLA postdocs. Two major workshops, "II_1 factors, rigidity, symmetries and classification" and "Geometric and measured group theory," brought together over 50 prominent figures in these areas. The program saw fruitful cross-pollination between the areas of group theory, ergodic theory and von Neumann algebras, resulting in several new research directions and breakthroughs.

faculty news

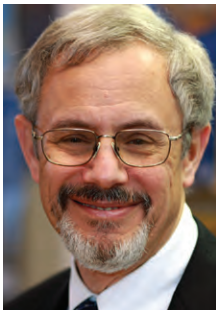
The After Math: UCLA Math Faculty Retirements

Paul H. Roberts

If you've ever held a compass, you know that the earth has a magnetic field. But where does the magnetic field come from? Scientists from Sir William Gilbert in the 1600s to Albert Einstein have contemplated this question. Modern investigations began with the proposal by Joseph Larmor in 1919 that the earth's magnetic field is generated by a dynamo; i.e., the rotation of the molten metal core in the earth's interior. Final success of this "geodynamo" theory was achieved by Professor Emeritus Paul Roberts and his collaborator Gary Glatzmaier through the first realistic computer simulation of the geodynamo in 1995. Moreover, their simulations were the first to include spontaneous magnetic field reversal in which the magnetic north moves to the south geographic pole, and gave the first coherent theory of this fascinating phenomenon. Paul started working on the geodynamo problem as a graduate student at Cambridge University, where he received his PhD in 1955. He came to UCLA in 1986 after a postdoctoral fellowship at the University of Chicago and a faculty position at the University of Newcastle upon Tyne. He has made important contributions to superfluids, sonoluminescence, magnetohydrodynamics and related fields over the last 25 years. In recognition of his research achievements, Paul received the Fleming Medal from the American Geophysical Union. He was also elected to the American Academy of Arts & Sciences and was named a Fellow of the Royal Society of London, the Royal Astronomical Society and the American Geophysical Union. Paul has been an inspiring presence in the Department, as well as in the Institute for Geophysics and Planetary Physics, for his research achievements, and his self-deprecating manner and wry sense of humor.

Thomas Liggett

Professor Emeritus Thomas Liggett arrived at UCLA 42 years ago, uncertain about his future as a research mathematician. Tom's initial doubts proved to be fleeting. His long and distinguished career has resulted in important contributions to the general area of analysis and probability theory. This includes helping to lead the development of a new field, interacting particle systems. His body of work and two influential books on the subject (*Interacting Particle Systems* and *Stochastic Interacting Systems*) are widely read and respected. In 2008, Tom was honored with prestigious membership to the National Academy of Sciences. Tom has been generous towards young researchers with his time, enthusiasm, and insights, supervising nine PhD students as well as numerous postdoctoral scholars and assistant adjunct professors over the years. Recently, he worked collaboratively with Pietro Caputo (Universita' di Roma Tre) and Thomas Richthammer (former UCLA adjunct professor now at Ludwig-Maximilans Universität München) on a particularly rewarding project. The team proved a conjecture originally posed to Tom around 1992 by David Aldous (UC Berkeley) concerning the spectral gap of two Markov chains, a conjecture that he had been thinking about on and off ever since. Their efforts culminated in success during a workshop held in honor of Tom's 65th birthday in Beijing in 2009. Tom has participated in all facets of life as a member of the Department, serving as vice chair and then chair over an eight-year period. He has also taught a wide range of courses from calculus through the graduate level. Fortunately, he won't disappear from Department life and teaching anytime soon. In spring 2012, he will bring his passion for mathematics to two undergraduate probability theory courses.



Mark Green

Professor Emeritus Mark Green has made decisive contributions to a remarkable number of fields in algebraic geometry and commutative algebra. After his influential work on holomorphic maps to algebraic varieties deriving from his thesis under Phillip Griffiths, Mark started research on algebraic geometry which he pursued upon joining the Department in 1974. He first produced a solution to a classical problem of algebraic curves first raised by Riemann. Mark then began to study the geometry of a projective curve and the commutative algebra of the equations defining the curve and formulated Green's conjecture, one of the most significant in the field. He has done important work in several other areas of algebraic geometry, e.g., deformation of cohomology groups and Hodge theory. Mark's research contributions have been widely recognized, most prominently by an ICM invitation in 1998 and election to the American Academy of Arts & Sciences in 2010. Equally impressive is Mark's service to UCLA. One of the most important developments for the Department is UCLA's NSF-funded Institute for Pure and Applied Mathematics (IPAM). It is impossible to overstate the impact of Mark's contributions to the enormous success of IPAM. Under his directorship, the institute positively and significantly influenced the path that research in mathematical science and its applications to technology have taken in the past decade. Mark has acquired a deep expertise in many of the applications from his hands on leadership and program attendance. This expertise and administrative skills, together with his research accomplishments, have led to his service on many important committees evaluating mathematics nationally and internationally. Mark was elected member of the AMS Board of Trustees in 2010 and served on the U.S. National Committee Delegates at the 2010 International Mathematical Union General Assembly.

math education

The Curtis Center

Teacher Continuing Education

Annual Mathematics and Teaching Conference

In March, over 250 secondary and university instructors attended the center's annual conference. The keynote address, "The Common Core: Where Are We Going and How Will We Know When We Get There?" was delivered by University of Arizona Distinguished Professor William McCallum who led the work team for the new Common Core math standards. The conference included 25 seminar talks and a reunion event for the UCLA Joint Math Education Program.

Mathematics Diagnostic Testing Project (MDTP)

MDTP continues to serve secondary mathematics teachers and their students in L.A. and Ventura counties. This past year, MDTP scored close to 100,000 diagnostic tests in 3,000 classrooms and returned detailed reports to help teachers learn more about the mathematical strengths and weaknesses of their students. MDTP also visited school sites, meeting with math departments and school administrators to help them make effective use of their MDTP results. This year MDTP is supporting a pilot project sponsored by the California Academic Partnership Program which will work with teachers to create formative assessment processes to improve performance in beginning algebra.

Math Content Program for Teachers (MCPT)

MCPT thanks Helen Chan for her dedicated service as program director and welcomes new director Michelle Sidwell and new program coordinator Julia Carafelli. In addition to offering content courses for K-12 teachers, the program now has preparation classes for the California Subject Exam for Teachers. An expanding professional development program will help teachers transition to the new Common Core math standards. A California Math Science Partnership grant with the Downey Unified School District has allowed 3rd through 8th grade teachers to take content courses and receive ongoing classroom support from UCLA.

Executive Office of the California Mathematics Project (CMP)

CMP led several task forces to provide resources for professional development leaders to strengthen teachers' knowledge of content in the Common Core state math standards. The resources can be found at http://caccssm.cmpso.org/. On March 22 – 24, 2012, CMP will sponsor the Mathematics Teacher Retention Symposium in Los Angeles. This national symposium will include keynote speakers Richard Ingersoll, Ed Silver, and Ellen Moir. Visit http://cmpstir.cmpso.org/mtrs-2012 for more information.

K – 12

Bill & Melinda Gates Foundation Projects

Curtis Center mathematics educators began a collaboration with UCLA's Center for Research on Evaluation, Standards, & Student Testing (CRESST) to develop an ontology of K-12 mathematics. The ontology will serve to drive a Web resource for K-12 mathematics education constituents. Center Executive Director Heather Dallas also began working with the University of Arizona's mathematics department to develop well-vetted tasks to illustrate the new national Common Core mathematics standards. Both projects are funded by the Bill & Melinda Gates Foundation.

UCLA Mathematics Festival 2011

In April, the Curtis Center and IPAM hosted the third annual mathematics festival sponsored by the Center for Talented Youth at Johns Hopkins University. Following the keynote talk, "Change of Perspective in Mathematics and Beyond" by Harvey Mudd math Professor Michael Orrison, 170 students and parents attended seminar breakout sessions led by university mathematicians, graduate students and high school teachers who use mathematical games, puzzles and physical models to deepen students' understanding.

Los Angeles Math Circle (LAMC)

In its fourth year, LAMC grew to six groups, spanning grades two through 12. Corporate program support from Boeing and Raytheon furthered LAMC's core mission of engaging local school children in innovative mathematical learning outside the classroom. With Boeing funding, the program introduced the Teacher Partnerships initiative to involve LAUSD teachers in weekly sessions. Two teachers from low-performing schools participated. Under the guidance of LAMC, five middle school students won prestigious Raytheon MathMovesU Scholarships for their presentations on the subject, How Math Puts Action into My Passion, including such passions as basketball, cryptography, tennis, origami and music. For her outstanding leadership, LAMC director Olga Radko received a MathMovesU Math Hero award with matching funds for the circle.

For more information about LAMC, visit http://www.curtiscenter.math.ucla.edu/k12.html.

2011 Summer Mathematics Institute for Young Scholars

The Curtis Center hosted its second successful summer institute for secondary students. Assistant Adjunct Professor David Weisbart led instruction and lecturer Stephen Kwok conducted twice-daily problem sessions. The program covered a range of topics in probability, linear algebra and special relativity. The seven students enrolled in the program attended invited talks in image processing, plasma physics, robotics and biomathematics.

IPAM

Public Lecture Series at IPAM

IPAM's 10th Anniversary Public Lectures

President of the Hong Kong University of Science and Technology and former UCLA mathematics professor **Tony Chan** spoke about IPAM's scientific impact in his lecture, "IPAM: Historical, UCLA, NSF and Global Perspectives." Electrical engineer and computer science professor **Claire Tomlin** (UC Berkeley, Stanford) relayed advances in air traffic control systems in her lecture, "Mathematics for Air Traffic Control and Other Hybrid Systems."

The Shape of Inner Space: String Theory and the Geometry of the Universe's Hidden Dimensions

Director of the Institute of Mathematical Sciences at the Chinese University of Hong Kong and Harvard Professor of Mathematics **Shing-Tung Yau** presented research from his new book on six-dimensional geometric spaces, dubbed "Calabi-Yau manifolds." These spaces, which Yau proved exist, may be more than a trillion times smaller than an electron and are at the center of string theory.

Save the Date

Principal Associate Director for the National Ignition Facility (NIF) and Photon Science Directorate **Ed Moses** will speak about the NIF, the world's largest laser, which has the goal of achieving nuclear fusion and energy gain in the laboratory. March 26, 2012, at 4:30pm.

To view IPAM's public lectures online, visit http://www.ipam.ucla.edu/videos.aspx.

IPAM Names New Associate Director

Professor Jinqiao Duan joined IPAM as an associate director this fall for a two-year term. Since 2000, Jinqiao has been part of the applied math group at the Illinois Institute of Technology. His research interests are broad, including stochastic dynamical systems, stochastic partial differential equations, and nonlinear dynamical systems, with an emphasis on modeling, analyzing, simulating and predicting complex phenomena in geosciences and biosciences.

IPAM presents its third annual newsletter. Download a copy at http://www.ipam.ucla.edu/newsletter.aspx.

Diversity Reigns at IPAM

Women in Mathematics Symposium. February 2011. The symposium provided a forum for women preparing for and embarking on mathematical careers. Over 50 graduate students and recent math PhDs from across the country joined 18 distinguished speakers and panelists representing academia, industry and government for invited talks and panel discussions on careers in government and industry, negotiation and self-promotion, interviewing skills, and grant writing.

17th Annual Conference for African American Researchers in Mathematics Sciences (CAARMS). June 2011. Princeton professor William Massey organized research talks, student poster presentations, a banquet, and tributes to African American mathematicians Ernest Wilkins, David Blackwell and Angela Grant, all who died in this past year.

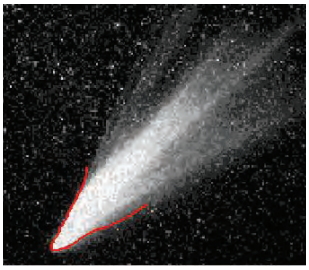
Modern Math Workshop at SACNAS national conference. October 2011. IPAM offered sessions for graduate students and recent PhDs, and undergraduate students to invigorate the research careers of minority mathematicians and mathematics faculty at minority-serving institutions. SACNAS is a society of scientists dedicated to advancing Hispanics/Chicanos and Native Americans in science.

Preventing Carmageddon: Traffic Flow Modeling

With the goal of addressing urgent societal problems, IPAM will introduce the first in a series of exploratory workshops in December, starting with one that targets arguably Los Angeles' most urgent concern – traffic congestion. "The Mathematics of Traffic Flow Modeling, Estimation and Control" will examine current traffic flow models and investigate emerging models that employ real-time traffic data to update drivers and in the future, provide sophisticated traffic management tools for transportation agencies. Unlike existing systems that use stationary cameras and underground sensors to measure traffic flow and velocity, new real-time data sources are larger and can be scaled up to include millions of drivers on a network. The Mobile Millennium research project, led by workshop organizer Alexandre Bayen (UC Berkeley), is a pilot traffic-monitoring system in the San Francisco Bay Area that uses GPS technology in drivers' cell phones to gather traffic information, process it, and relay it back in real time. Workshop co-organizer Benedetto Piccoli (Rutgers University-Camden) has been involved in traffic modeling for over 10 years, and conducts research for Octo Telematics in Italy. The company has enlisted over one million drivers in Europe, South America, South Asia and the U.S. to equip their vehicles with GPS tracking systems to reduce their insurance costs, aid in stolen vehicle recovery and provide real-time data for national traffic networks. The workshop will focus on developing new mathematical models based on fluid dynamics with stochastic approaches to create software for real-time traffic management to keep traffic moving. Says Benedetto, "The next step is to create transportation policy to control traffic using real-time information. When accidents occur, good forecasting could result in actions ranging from closing a highway to lowering the speed limit." Are we there yet?

For more information on the program, visit http://www.ipam.ucla.edu/programs/tra2011/.

graduate news



Detection of Comet Front

Applied Math Fellow Selected to Teach Undergrad Seminar in Imaging

The **Collegium of University Teaching Fellows** (CUTF) has selected PhD candidate **Hayden Schaeffer**'s undergraduate course proposal on image segmentation for a special winter 2012 seminar. Hayden was one of 16 UCLA students to be picked for the CUTF program, which gives some of the university's best graduate students the one-time opportunity to develop and teach a lower division seminar in their field of specialization. Hayden's special seminar, Boundaries, Edges, and Singularities: Exploring Mathematical Image Segmentation, focuses on segmentation, one of the most challenging problems computationally, yet one of the easiest to understand: how to partition an image into its basic objects. He will introduce students to the mathematical methods used in segmentation, which also have deep connections to fracture mechanics, optimal cutting, fluid mechanics, general relativity, and more. These models are used in multiple applications, including medical imaging (for location and diagnosis); satellite and aerial object detection and tracking (roads, buildings, cars or people, etc.); fingerprint and face recognition; astronomy; and plasma tracking. Under the direction of his PhD adviser **Luminita Vese**, Hayden hopes to present the power of applied mathematics to UCLA undergrads with limited math backgrounds. Says Hayden, "I'm inspired to teach students across disciplines about mathematical modeling with the emphasis on intuition rather than rigor. This is a great opportunity to do that and maybe get them interested in pursuing math."

Competitive Fellowships

2011 PhDs **Jacob Bedrossian**, **Nancy Rodriguez** and **Paul Smith** were named recipients of the **NSF Mathematical Sciences Postdoctoral Research Fellowship** (MSPRF). Jacob will use his fellowship at New York University Courant Institute of Mathematical Sciences; Nancy will conduct her research at Stanford University; and Paul will attend University of California, Berkeley.

PhDs Make Plans

The 2010 – 2011 PhD graduating class numbered 29 with most set to continue their research studies in postdoctoral positions or as tenure-track faculty at premier institutions, including UC Berkeley, Lawrence Berkeley National Laboratory, Mathematical Sciences Research Institute (MSRI), Statistical and Applied Mathematical Sciences Institute (SAMSI), Stanford University, New York University, and Georgia Institute of Technology. Careers in industry include placements at Intel Corporation, Disney, DreamWorks Animation, and Pacific Investment Management Company (PIMCO).

Second Annual Industry Night

UCLA Math, along with the departments of economics, statistics and UCLA Anderson School of Management's financial engineering program co-hosted a fall 2011 industry open house. The event gave companies the opportunity to showcase their business and research ventures to outstanding graduate students seeking positions in the private sector. Applied mathematics grad students joined professionals from Aspiriant, Bank of America, BlackRock, Bloomberg, Camden Asset Management, Econ One, Facebook, First Quadrant, Moody's, Morgan Stanley, OneWest Bank, Pacific Life, Palantir Technologies, PwC (LA), RAND, Research Affiliates, Southern California Gas Company, Telesis Capital, Union Bank, Warner Bros. Entertainment, Western Asset Management, and Wilshire Associates.

If you are interested in representing your company at next year's 2012 event, contact Maggie Albert, Mathematics Graduate Advisor at Maggie@math.ucla.edu or 310.825.4971.

Simons Postdoctoral Fellows in Mathematics

Last year, the Simons Foundation awarded UCLA Math two prestigious postdoctoral positions out of 68 in the fields of mathematics, theoretical physics and theoretical computer science.

Probabilist Oren Louidor *PhD Courant Institute, NYU*

Oren Louidor's research interests are based in the area where mathematics meets other sciences (physics, computer science, economics) and where tools from probability, analysis and combinatorics can be put to fruitful use. His publications include papers on polymer pinning, mixing of Markov chains, and interacting particle systems describing commodity flows. Oren has worked on problems concerning heat-kernel decay for random walks in random environments, large deviations for branching random walks and survival in the voter model on general graphs.

Combinatorialist Greta Panova *PhD Harvard University*

Greta Panova's research interests lie in enumerative and algebraic combinatorics, the interplay between the two, and various connections to other fields (representation theory, discrete probability, etc.) She is best known for her solutions of several open problems and conjectures in the field, involving various types of permutation statistics and enumeration of certain Young tableaux. Most recently, Greta has been working on reduced decompositions of permutations.

undergraduate news

Message from 2011 – 2013 Undergraduate Vice Chair Robert Brown

Like another Brown in California, I am returning to a position I held in the 1970s. Our state has changed greatly since that time, and our undergraduate program has also changed, growing from 166 graduates in 1978 to 276 graduates in five majors (plus our joint major in mathematics and economics) in 2011. The students of four decades ago, so bright and hardworking, have been followed by undergraduates who were admitted under a significantly more rigorous admissions process, and consequently represent an even more impressive group. But other things don't change. In the 1970s, we could have benefited from more resources and the current economic realities present an even greater challenge. Our majors have expanded and diversified to address the many professional opportunities for our students, but the size of our faculty has not changed. The goal of the undergraduate program is the same now as it was then: to support and inspire our students by offering them a first-rate mathematical education and helping them complete it in a timely manner. We endeavor to develop their abilities as mathematicians and problem-solvers for a modern workforce that increasingly demands complex thinking. When I consider the excellence of our students, the quality of our programs and the talent of our faculty, I am confident of our future.

2011 Alumni Career Panel: Math Launches Many Careers

At the Department's annual spring alumni career event for undergrads, UCLA Math alumni shared how their degrees launched a broad range of careers in data mining; technology, science and basic research funding using social networking; space radar engineering; economic, financial and strategic consulting; and health care management and finance. The 2011 panelists included John Donald (Yahoo! – Traffic Quality, Senior Data Analyst and Senior Manager of the Proactive Analysis and Monitoring Team), Dan D. Gutierrez (FundaGeek, CEO/Founder), Nick Marechal (The Aerospace Corporation, Senior Engineer), Marnie A. Moore (Analysis Group, Inc., Principal) and Don Phan (MSO Inc. of Southern California, Chief Financial Officer).

Marnie Moore, Analysis Group, Inc.

Don Phan, MSO Inc. of Southern California

If you are interested in participating on our 2012 alumni panel, contact Lisa Mohan at lisam@math.ucla.edu.

Commencement 2011

UCLA Math Alum and Professor Encourages 2011 Class to Make New Discoveries

For Rich Schwartz, the journey from a UCLA math undergraduate to Chancellor's Professor of Mathematics at Brown University started with great Department professors, including Mark Green and Ray Redheffer, and a daily dose of challenging math puzzles from his friends. In his commencement address, Rich lauded the "great things" about mathematics, including that it gives answers to fascinating questions everyone thinks about as kids: Do numbers go on forever? What is infinity like? As an artist, he praises math for combining fine-scale precision with large-scale beauty, and compares it to a digital piece of art. Says Rich, "Taken all together the effect produces a sense of wonder that something so organized and systematic produces something which can be so wild and astonishing." He also assured graduates that whether they pursue a career in math or something else, they have learned to think clearly and systemically about deep, subtle things. He showed that a seemingly unpractical problem – how to best place 4,096 points on some corners of a 23-dimensional cube – led to the creation of a powerful error-correcting code that the Voyager spacecrafts used when transmitting pictures of Jupiter back to Earth, underlining math's practical power as a great "underwriter of science and technology." For Rich, maybe the greatest thing about math remains the same: it presents compelling puzzles and deep mysteries and can inspire graduates to "make new discoveries about the world."

New Undergraduate Award for Actuarial Science

In recognition of the success of the actuarial science program and the founding support of UCLA alumna Patty Boyle and her family, the Department established a new annual award recognizing the outstanding graduating actuarial student to be presented at commencement. Since the program's inception in 1979, it has graduated over 1,000 students employed across more than 25 regional and national firms. Patty presented the award to the first recipient, past UCLA Bruin Actuarial Society President Binbin Xing, who graduated with double majors in math/applied science with a concentration in actuarial science, and business economics. Binbin also graduated with a minor in accounting. She joins Towers Watson as an actuarial consulting analyst this fall.

UCLA Putnam Mathematics Team Competes

The UCLA team ranked 32nd in the December 2010 William Lowell Putnam Mathematical Competition, which included 4,296 students from 546 colleges and universities in the U.S. and Canada. From UCLA, the top scorer was **Francisc Bozgan** with 56 points and a ranking of 128th nationwide. Other UCLA students in the top 1,000 were **Woo Young Park** (37 points), **Ryan Gochee** (29 points), **Cheng Mao** (29 points), **Sean Park** (20 points), and **Nicholas Strehlke** (20 points). Associate professor Ciprian Manolescu led the team.

First-Ever UCLA Bruin Day

In April, the Department welcomed prospective first-year students who were admitted for fall 2011 as part of the university's inaugural Bruin Day. Over 5,000 students and 10,000 of their family members had the opportunity to visit the Department's open house, which featured an information booth in the court of sciences, research talks, a Careers in Mathematics Panel, and an introduction to the major led by the academic advising office.

Publications from the Applied Math Research for Undergraduates (REU) Program

Research Projects: Robotics, bone growth models, fluid flows, multispectral pan-sharpening

M. Gonzalez, X. Huang, **Benjamin Irvine***, D. S. Hermina Martinez, C. H. Hsieh, Y. R. Huang, M. B. Short, and A. L. Bertozzi, "**A third generation mMicro-vehicle testbed for cooperative control and sensing strategies**," *Proceedings of the 8th International Conference on Informatics in Control, Automation and Robotics* (ICINCO), The Netherlands, 2011.

M.-G. Ascenzi, C. Blanco, **Ian Drayer***, **Hannah Kim***, **Ryan Wilson***, K. Retting, K. Lyons, and G. Mohler, "**Effect of localization, length and orientation of chondrocytic primary cilium on murine growth plate organization**," *Journal of Theoretical Biology*, 285 (2011) 147-155.

N. Murisic, J. Ho, V. Hu, P. Latterman, T. Koch, **Kanhui Lin***, M. Mata, and A. Bertozzi, "**Particle-laden viscous thin-film flows on an incline: experiments compared with an equilibrium theory based on shear-induced migration and particle settling**," *Physica D*, published online June 15, 2011, to appear in print in a special issue in honor of Steve Childress.

Sheida Rahmani*, Melissa Strait, **Daria Merkurjev***, Michael Moeller, and Todd Wittman, "**An adaptive IHS pan-sharpening method,**" *IEEE Trans. Geosci. Remote Sensing Letters*, vol. 7, no. 4, 2010.

** UCLA Math undergraduate and visiting student authors.*

Prizes

Departmental

Daus Prizes: Math-econ major **Nicole Abruzzo** earned departmental honors and is a departmental scholar in economics. She served as former co-president of the Undergraduate Mathematics Students Association. Nicole will join the Federal Reserve Board in Washington, D.C., as a research assistant in risk analysis. ■ Applied math and physics double major **Travis Meyer** earned departmental honors and participated in pure and applied math research programs. Travis will pursue his PhD in computational nanomaterials in engineering physics at UC San Diego. ■ **Anh-Trang Nguyen** is a departmental scholar in pure math who also earned departmental honors. Anh will pursue her PhD in pure math at UC Berkeley.

Sherwood Prizes: Pure math and physics double major **Anton Bobkov** earned departmental and college honors, as well as high scores in the Putnam Mathematical Competition in 2008 (30 points) and 2009 (19 points). Anton will pursue his PhD in mathematics at UCLA. ■ Pure math major and departmental scholar **Jeremy Brightbill** graduated *summa cum laude* with college and departmental honors. Jeremy will attend Cal State Northridge to earn his teaching credential in math, physics and chemistry to become a high school teacher.

Outstanding Actuarial Science Student Award: Binbin Xing graduated with double majors in mathematics/applied science with a concentration in actuarial science, and business economics, as well as a minor in accounting. Binbin was a past president of the UCLA Bruin Actuarial Society and joined Towers Watson in Los Angeles as an actuarial analyst in August.

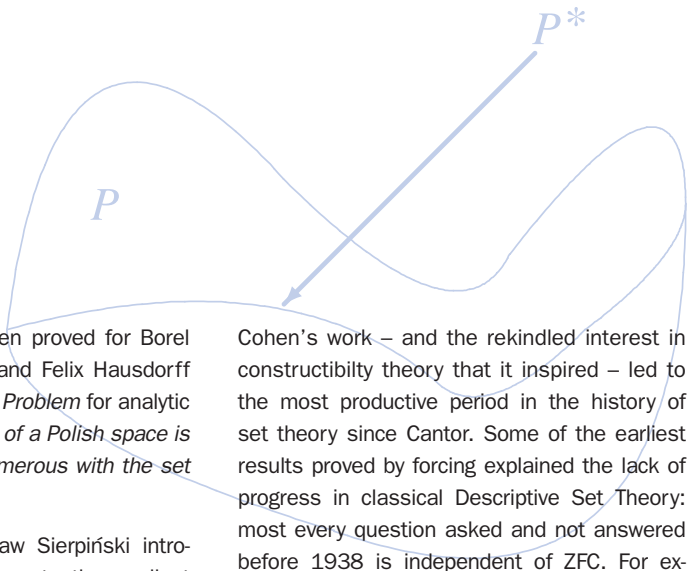
Basil Gordon Prize: Francisc Bozgan was the top scorer on the William Lowell Putnam Mathematics Competition (56 points, 128th overall).

College

Applied math grad **Anthony Ryan DeCino** was awarded a **Dean's Prize at UCLA's 2011 Science Poster Day**. Anthony's poster, "Learning About Collective Memory from Query Bursts," employed Bayesian statistics to develop an algorithm which can be used to compare models of various degrees of complexity to a specific data set. Anthony used this algorithm to analyze data from Google Trends to illustrate that the collective memory phenomenon resembles a power law decay.

focus on research

Descriptive Set Theory



by Alexander Kechris (Caltech), Donald A. Martin, Yiannis Moschovakis and Itay Neeman

This research overview is inspired by the untimely passing of UCLA Math professor and world-class logician Greg Hjorth, whose most seminal contributions were in Descriptive Set Theory. The theory is explored in an historical context, reaching its prominence at UCLA and Caltech since the mid-'60s.

The roots of Descriptive Set Theory go back to the work of Emil Borel, René Baire and especially Henri Lebesgue around the turn of the 20th century, when the young French analysts were trying to come to grips with the notion of *function as arbitrary correspondence* introduced by Dirichlet and Riemann. They mistrusted a concept so abstract and, in any case, most specific functions studied in mathematics are defined by *simple analytic expressions*, explicit formulas, infinite series and the like. Perhaps *definable functions* and sets are somehow "nicer" than arbitrary ones; and then the problem is to identify them and search for their characteristic properties.

Today the theory is developed for *Polish* (separable, completely metrizable topological) *spaces*, which is its natural domain and facilitates its numerous interactions with many areas of mathematics.

The classical period, 1905 – 1938. In a fundamental 1905 paper which marks the beginning of the field, Lebesgue introduced the *Borel measurable sets and functions* and established their basic properties, including their ramification into an uncountable *hierarchy* of $\aleph_1$ levels of increasing complexity. He also "proved" a famous false theorem: that the continuous image of an arbitrary Borel set is also Borel. The error was spotted in 1916 by Michail Suslin who dubbed the continuous images of Borel sets *analytic*, showed that *there exist non-Borel analytic sets*, and together with his teacher Nikolai Luzin established their basic regularity properties: *every analytic set is absolutely measurable, it has the property of Baire, and if uncountable, then it contains a non-empty, perfect subset*. This last result had already been proved for Borel sets by Pavel Alexandrov and Felix Hausdorff and settled the *Continuum Problem* for analytic sets: *every analytic subset of a Polish space is either countable or equinumerous with the set* $\mathbb{R}$ *of real numbers.*

In 1925, Lusin and Waclaw Sierpiński introduced the class of projective sets, the smallest extension of the Borel σ-field in a Polish space which is closed under complementation and continuous images. The projective sets also fall into a natural hierarchy of increasing complexity and they are most naturally characterized in logical terms: a subset A subset $A \subseteq M$ of a Polish space is projective exactly when it is definable in the natural formal language of M, and its complexity is determined by its "simplest definition" in that language.

The strongest results of the classical period were about the second level of the projective hierarchy, the class PCA of continuous images of complements of analytic sets, especially the Uniformization Theorem: *every set in* $M_1 \times M_2$ *which is PCA can be uniformized by a PCA set.* This has important foundational content, as it establishes a definable form of the *Axiom of Choice* for PCA sets. It was proved by Motohashi Kondo in 1938, refining earlier work of Pyotr Novikov.

Consistency and independence results, 1938 – . In the same, seminal year 1938, Kurt Gödel published his famous proof of the consistency of the Axiom of Choice AC and the *Generalized Continuum Hypothesis* GCH with ZF, the choiceless fragment of ZFC which is the standard Zermelo-Fraenkel theory of sets. Gödel's main tool was the class L of *constructible sets*, the smallest inner model of ZF. He proved (in ZF) that L *exists and satisfies* AC *and* GCH; and so AC cannot be disproved in ZF and the Continuum Hypothesis cannot be disproved in ZFC. Twenty five years later, in 1963, Paul Cohen introduced the forcing method of constructing models of set theory and used it to show a slew of independence results, most significantly that *the Continuum Hypothesis cannot be proved in* ZFC.

Cohen's work – and the rekindled interest in constructibilty theory that it inspired – led to the most productive period in the history of set theory since Cantor. Some of the earliest results proved by forcing explained the lack of progress in classical Descriptive Set Theory: most every question asked and not answered before 1938 is independent of ZFC. For example, ZFC *does not decide whether every PCA set is Lebesgue measurable* – the claim fails in L but holds in a famous forcing model of ZFC constructed by Robert Solovay, in which, in fact, every projective set is absolutely measurable.

In this, set theory stands apart from number theory or analysis, where one naturally expects that problems can be solved on the basis of standard mathematical assumptions. How do you attack a technical, rigorously formulated problem – like the Lebesgue measurability of projective sets – if you know at the get-go that it is independent of ZFC, which naturally encompasses all "standard mathematical assumptions?" It is why set theory is rife with foundational questions and has never been completely emancipated from logic.

Determinacy and large cardinals, 1968 – . Even before Cohen's work, the search was on for new axioms, plausible extensions of ZFC which settle some of the crucial open problems. Most promising were *large cardinal hypotheses*, and there were some spectacular successes with them in the mid-sixties: for example, *if there exists a measurable cardinal, then every PCA set is absolutely measurable* (Solovay) and every PCA complement can be uniformized by a projective set (Martin and Solovay). But it quickly became clear that measurable cardinals cannot answer important questions beyond the second level of the projective hierarchy.

A most unlikely, very different possibility arose in 1967 when David Blackwell used the (known) *determinacy of closed, infinite games of perfect information on* $\mathbb{N}$ to give a simple new proof of a classical result about analytic sets. What if we just assume that all projective games are determined? Projective deter-

minacy cannot be proved in ZFC, and it is by no means "obviously true"; but, as it turned out, it settles practically all problems about projective sets left open in the classical period. It implies, for example, that *all projective sets are absolutely measurable and satisfy the Continuum Hypothesis* (Jan Mycielski, Hugo Steinhaus) and that *they can be uniformized by projective sets* (Moschovakis). Moreover, the proofs require novel, game-theoretic arguments, some of them yielding new and illuminating proofs of classical results.

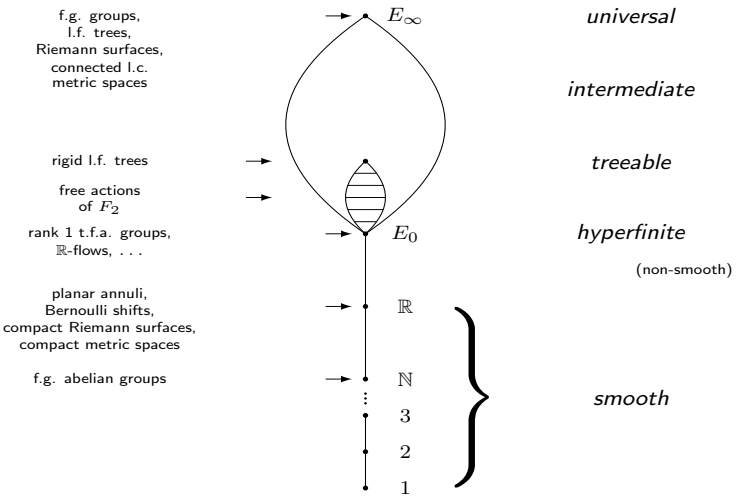
The study of determinacy and large cardinal hypotheses – and especially their interaction with Descriptive Set Theory – has been developed primarily by logicians in Los Angeles and their collaborators, most prominently Solovay, Kenneth Kunen, Leo Harrington and Hugh Woodin, and has solidified the reputation of the Los Angeles school of set theory, the so-called Cabal. It reached a high plateau in 1988, when Martin and Steel proved from suitable large cardinal hypotheses that *all projective games are determined*, and Woodin showed (from somewhat stronger hypotheses) that *in the smallest model L*(ℝ) *of all sets constructible from the real numbers, every game on* ℕ *is determined.* The three of them were honored for this work in 1988 by the prestigious Karp Prize, which is awarded every five years by the Association for Symbolic Logic.

Considerably before that, in 1975, Martin had shown in ZFC that *every Borel game on* ℕ *is determined*. This is the strongest determinacy result that can be proved in classical, axiomatic set theory, and it was pivotal in justifying extending ZFC by determinacy hypotheses.

Closely and intricately related to these developments is the rich and evolving theory of canonical (L-like) *inner models for large cardinal hypotheses*. For example, results of Neeman on ultrafilters in *L*(ℝ) under determinacy are proved using inner models, and there are no known descriptive set theoretic proofs of them. Similarly, there are results of Hjorth (extended by Sargsyan) on bounds for the lengths of prewellorderings in various projective classes that again hold under determinacy and are purely descriptive set theoretic, but are proved using inner models.

Borel and analytic equivalence relations, 1990 – . In many areas of mathematics, one often wants to classify mathematical objects up to some notion of equivalence by invariants, which is often Borel or analytic on a suitable Polish space. This motivated the study of equivalence relations on Polish spaces using methods from descriptive set theory, a research program which started in the late 1980s and has already yielded some of the most substantial interactions of set theory with fields outside logic, including dynamical systems, ergodic theory and topological dynamics, operator algebras, topological groups and representation theory.

Picture of $\leq_B$ on countable equivalence relations



Set Theory and Dynamical Systems

The key concept is that of *Borel reducibility*: given equivalence relations E, F on respective Polish spaces X, Y, we say that E is Borel reducible to F if there is a Borel map f : X → Y such that $x\,E\,y \Leftrightarrow f(x)\,F\,f(y)$. Borel reducibility imposes a partial (pre-) ordering among equivalence relations on Polish spaces and provides a hierarchy of complexity for problems of classification by invariants.

Simplest in this hierarchy are the *concretely classifiable* (or smooth) equivalence relations, i.e., those that can be reduced to the equality relation on a Polish space, and so they are Borel and admit complete invariants that are "concrete," like reals or sequences of numbers. For example, the famous Ornstein Isomorphism Theorem classifies Bernoulli shifts up to isomorphism by their entropy. In 1990 Harrington, Kechris and Louveau proved the so-called *Generalized Glimm-Effros Dichotomy* that identifies the precise obstruction to concrete classifiability: *a Borel equivalence relation E is not concretely classifiable if and only if the tail equivalence relation on infinite binary sequences is Borel reducible to* E.

Natural examples of analytic equivalence relations which need not be Borel come from the theory of dynamical systems: for example, the orbit equivalence relation of a Polish group acting in a Borel way on a Polish space is analytic. This part of the theory comes into contact with many aspects of ergodic theory and topological dynamics. A very nice example of this interplay is a result of Hjorth that relates the dynamic complexity of a continuous action with the complexity of possible invariants of the associated orbit equivalence relation. An equivalence relation is *classifiable by countable structures* if it admits complete invariants (computable in a Borel way) that are isomorphism classes of countable structures, like groups, graphs, etc. Hjorth's theorem essentially says that the precise obstruction to have such classifiability is the presence of a dynamic phenomenon called *turbulence*.

For their contributions to this area, Hjorth and Kechris were awarded the Karp Prize in 2003.

Descriptive Set Theory is equally concerned with foundational questions and with interactions of logic with other fields, sometimes bringing out surprising connections between these two. It flourishes where there is a tradition of research in logic and broad coverage of mathematics of all kinds, which makes UCLA an ideal home for it.

events

Math Under the Stars

The AMS Einstein Public Lecture in Mathematics: The Cosmic Distance Ladder

On an Indian summer evening in October 2010, Professor **Terry Tao** gave the fifth American Mathematical Society-sponsored Einstein Public Lecture in Mathematics. The lectures began in 2005 to celebrate the 100th anniversary of Einstein's annus mirabilis. The Department and the UCLA Division of Physical Sciences hosted the event at UCLA's Schoenberg Auditorium, which attracted an overflow crowd of 1,000 mathematicians, alumni, supporters and university colleagues. Terry addressed how we know the distances from the earth to the sun and moon, from the sun to the other planets, and from the sun to other stars and distant galaxies. Although we cannot measure these distances directly, there are many indirect methods of measurement, combined with basic mathematics, which can give convincing and accurate results without the need for advanced technology; the ancient Greeks could compute the distances from the earth to the sun and moon with moderate accuracy. These methods rely on climbing a "cosmic distance ladder," using measurements of nearby distances to deduce estimates on distances slightly farther away. Terry discussed several of the rungs in this ladder.

A free video of Terry's lecture is available on UCLA on YouTube (link: http://www.youtube.com/watch?v=7ne0GArfeMs) or UCLA on iTunes U, Categories: Mathematics (link: http://www.math.ucla.edu/itunes)

2010 – 2011 Distinguished Lecture Series

Horng-Tzer Yau of Harvard University spoke on the recent progress made by many mathematicians, including Yau, on the universality phenomenon in random matrix theory, and in the theory of random Schrodinger operators. This phenomenon asserts, roughly speaking, that the asymptotic behavior of a random system (and in particular, the fine-scale behavior of the spectrum) is largely independent of the choice of model used to describe the system. While there is extensive numerical evidence for this phenomenon, it was only recently that rigorous justification of this phenomenon for a large class of random matrix models (such as Wigner random matrices) was available, using methods from statistical physics, complex analysis, and high-dimensional geometry.

Michael Harris of the Institut de Mathématiques de Jussieu lectured on the implications of the Fundamental Lemma and related results; this lemma is a key component of the Langlands program which was very recently established by Ngo in his Fields Medal-winning work. In particular, Harris described how the Fundamental Lemma could be used to construct Galois representations that can be used to make progress on important problems in number theory, such as the Sato-Tate conjecture and the main conjectures in Iwasawa theory.

Pierre Colmez of the Université Pierre et Marie Curie spoke on his recent breakthrough of the p-adic Langlands program formulated by Breuil and Emerton in the early 2000s, which predicts a natural correspondence between Galois representations of degree n and p-adic automorphic representations of GL(n). Colmez constructed the prescribed p-adic automorphic representations of GL(2) out of degree 2 Galois representations, basically finishing the proof in the case of degree 2. One of the key ingredients in Colmez's proof is the solution in 2009 of the modulo p Langland program (Serre's mod p modularity conjecture) by Khare-Wintenberger.

Ehud Hrushovski of Hebrew University spoke on the amazing new connections he discovered between the structure of large finite structures (e.g., finite subsets of a group) and model theory (and specifically, stable group theory) and how tools in the latter can be used to obtain deep new results in the former, for instance leading to new proofs of Gromov's theorem on groups of polynomial growth and on the structure of finite approximate groups.

Summer Salon: 2011 Research in Undergraduate Applied Math

In August, alumni and supporters joined the Department and **Dean Joseph Rudnick of the Division of Physical Sciences** for a summer presentation of undergraduate applied math research. Director of Applied Mathematics and program leader **Andrea Bertozzi** presented an overview of the Department's applied math Research Experience for Undergraduates (REU), which allows students to participate in faculty-led research that tackles real world problems. Students presented research findings on crime modeling, slurry flow experiments, population models, atomic force microscopy and robotics.

Fifth Annual UCLA Alumni Day

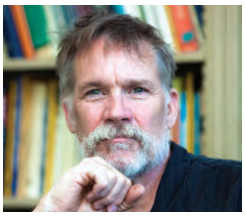
At the Department's Info Fair, UCLA Assistant Adjunct Professor Martin Short (right) presented his ground breaking research on crime modeling. Pictured here, he is flanked by Los Angeles Math Circle student leader Jeff Hicks and Curtis Center program coordinator Lucy Madatovian. Lucy presented information about the center's math teacher preparation program and Jeff shared math puzzles with alumni families.

Special Alumni Guest Lectures: The Money Game

In his November 2010 guest lecture, "The Money Game," UCLA Math alum Alan Gillette, PhD '06, examined how money systems operate as games with quantitative rules for which there are distinct roles for players involved. In his follow-up lecture, "The Money Game Part 2," in April 2011, he explored how money systems compete. Alan is President of Heaviside Wealth Management.

Research Conferences

October 9 – 10, 2010: The Department hosted the 2010 **American Mathematical Society Fall Western Section Meeting**, featuring an invited address by Stanley Osher on "New Algorithms in Information Science," and including Field Medalist Terry Tao's AMS Einstein Public Lecture. The AMS holds eight sectional meetings annually in the spring and in the fall in four regional sections of the U.S. For a full program, visit http://www.ams.org/meetings/sectional/2170_progfull.html.



November 11 – 12, 2010: The Department hosted the two-day conference, **Motives and Modular Forms** to celebrate Professor **Don Blasius**' 60th birthday and his mathematical contributions. Themes included modular forms, motives, Galois representations, and L-functions.

March 22 – 25, 2011: The Department's algebraic geometry and topology groups hosted the international conference, **K-Theory and Motives** on the occasion of the 60th birthday of Andrei Suslin (Northwestern University). Featured mathematics from Andrei's work included K-theory, motives and the theory of algebraic cycles, and quadratic forms.

2011 Special Awards Ceremony

Faculty and students at the Department's Special Awards Ceremony

Robert Sorgenfrey Distinguished Teaching Awards

Graduate student awardees are (from left) Konstantinos (Duncan) Palamourdas, Anush Tserunyan, Jacob Bedrossian and Ryo Takei (not shown).

Postdoctoral awardees are Steven Butler and Mario Micheli; Christian Haesemeyer and Ciprian Manolescu are faculty awardees.

Dissertation Year Fellowships and Beckenbach Awards

were presented to Patrick Allen, Clinton Givens, Hao Huang, Tye Lidman, Christopher McKinlay, Justin Palumbo, James Sizemore, Laura Smith and Alden Waters.

Graduate Vice Chair Itay Neeman with Beckenbach awardee Alden Waters.

William Chen and Yajing Liu received the **Horn-Moez Prize for Excellence in First-Year Graduate Studies**. Zaher Hani was awarded the **Heaviside Wealth Management Award for Outstanding Graduate Student Research Presentation**.

in memoriam

Lowell J. Paige

Professor of Mathematics, Emeritus

1919 – 2010

Professor Emeritus Lowell J. Paige died on his birthday in Carmichael, California, on December 10, 2010. He was 91. Lowell served as a lieutenant in the U.S. Naval Reserve during World War II from 1942 to 1946. He received his PhD in mathematics in 1947 at the University of Wisconsin-Madison under the supervision of Richard Hubert Bruck. His research interest was abstract algebra. In 1947 Lowell joined the Department, where he served as chair from 1964 to 1968. At that time, the Mathematical Sciences Building was being built. He added the 5th floor Department Reading Room to the building plans and rescued the book collection from the old Institute for Numerical Analysis. Lowell launched his university leadership career with his election as vice-chairman of the Academic Senate in 1966, then served as chairman in 1968. He served as the dean of the Division of Physical Sciences in the College of Letters and Science from 1968 to 1973. Lowell was appointed by President Richard Nixon to be assistant director of the National Science Foundation in 1973, a position he held for two years before returning to the University of California in 1975 to become special assistant for governmental relations to the president of the UC. Lowell retired from UCLA in 1983. From 1983 to 1987, he was Gov. George Deukmejian's assistant adviser for higher education. In 1987 he was appointed to a six-year term on the California Postsecondary Education Commission. Lowell published *Elements of Linear Algebra* in 1961 and a second edition in 1974 with J. Dean Swift. He is survived by his wife Betty, sons Michael and Steve, and niece Judy Monaco.

Herbert B. Enderton

Professor of Mathematics, Emeritus

1936 – 2010

Adjunct Professor Emeritus Herbert B. Enderton died at his home in Santa Monica on October 22, 2010, after battling leukemia for nearly a year. Herb received his PhD in mathematics in 1962 at Harvard University under the supervision of Hilary Putnam. He had a postdoctoral appointment at MIT and was an assistant professor at UC Berkeley. In 1968 he came to UCLA, where he took on two half-time positions, one in the Department and the other as an editor of the reviews section of the *Journal of Symbolic Logic*; in 1980 he was made the coordinating editor of the reviews section, a position he retained until 2002. The majority of Herb's published research was on recursion theoretic hierarchies of sets of integers, characterized by him as "little steps for little feet." Herb's first book, *A Mathematical Introduction to Logic*, was published in 1972 and is the most popular logic text at the advanced undergraduate/beginning graduate level; it is still used (especially by computer scientists) as the standard reference to logic. His 1977 *Elements of Set Theory* has also been very successful. A new undergraduate text, *Computability Theory: an Introduction to Recursion Theory*, was completed after he became ill and was published in 2011. Herb retired from the Department in 2003, but he continued to teach regularly until 2009. He also continued to organize the UCLA Logic Colloquium, as he had done for decades. Herb was an active participant in the life of the logic group, and he will be sorely missed. He is survived by his wife Catherine, his sons Eric and Herbert ("Bert"), and his granddaughter Evelyn.

Greg Hjorth

Professor of Mathematics

1963 – 2011

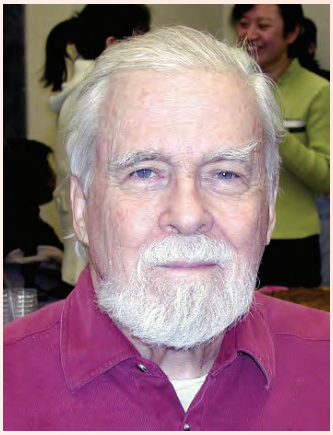
Professor Greg Hjorth died of a heart attack in his birth city of Melbourne, Australia, on January 13, 2011. He was 47. Greg was recognized as a young chess whiz in his primary school years. He quickly advanced to tournament chess, becoming joint Commonwealth Champion in 1983 and earning his International Master title in 1984. He played Garry Kasparov, among other accomplished chess rivals, but took his own later advice that "if you're not in the top 100 by 21, get out." Greg's passion for chess played over to mathematical logic, a field in which he achieved great heights with high academic honors and wide recognition. He received his PhD in mathematics in 1993 at UC Berkeley under the supervision of Hugh Woodin. Greg's brilliant thesis earned the first Sacks Prize in 1994, awarded by the Associa-

tion for Symbolic Logic for his research in descriptive set theory and its surprising consequences concerning the relationship between projective sets and large cardinals. Greg joined the Department in 1995. Over his 16 years at UCLA, he made a series of stunning and far-reaching contributions, in particular to ergodic theory and orbit equivalence of group actions. His work has been widely recognized with a Sloan Foundation Fellowship, an invited lecture at the International Congress of Mathematicians, the ASL Karp Prize (joint with Alexander Kechris) – and last year, an invitation to deliver one of the major lecture series in logic, the Alfred Tarski Lectures at UC Berkeley. Greg supervised eight PhD students at UCLA, including Inessa Epstein, who also received the prestigious Sacks prize. Greg will be richly remembered by fellow colleagues as a brilliant mathematician in constant pursuit of solutions to intractable problems, and as a committed and caring teacher. He is survived by his parents Noela and Robert, and his sister Larissa.

Barrett O'Neill

Professor of Mathematics, Emeritus

1924 – 2011



Professor Emeritus Barrett O'Neill died on June 16, 2011, at age 87. Barrett joined the Department in 1951, directly from MIT, where he received his PhD under the direction of Witold Hurewicz. Barrett retired in 1991, but he continued his work with a major book on relativity, *The Geometry of Kerr Black Holes*, published in 1995. He began his mathematical life as an algebraic topologist: his dissertation was on fixed point theory and he made further contributions to that subject, developing a generalization of the Lefschetz Fixed Point Theorem to multi-valued (set-valued) mappings. Early on Barrett turned primarily to Riemannian geometry and to semi-Riemannian geometry, the geometry of non-degenerate quadratic forms on the tangent spaces that are not positive definite. He had a long and distinguished career, exerting a notable influence on his fields with over 1,000 citations of his work in the Science Citation Index. Barrett wrote three books, each of great distinction. An undergraduate text book on differential geometry, *Elementary Differential Geometry*, was notable for its systematic use of differential forms and also for the elegance of its illustrations at a time before computer graphics. *Semi-Riemannian Geometry* was one of the first books to treat indefinite metric geometry systematically on an equal footing and in modern notation with the more usual positive definite Riemannian geometry. His last book *The Geometry of Kerr Black Holes* is a masterpiece of exposition and mathematical insight, managing to get to deep matters while being accessible to readers with only limited background in differential geometry. Barrett advised eight PhD students, several of whom became distinguished geometers (Patrick Eberlein, Alfred Gray). He was an encouraging, intellectually stimulating and cheerful presence in the Department and extraordinarily kind and helpful to his younger colleagues. He possessed a fine dry sense of humor. Barrett is survived by his wife Hope, their three children Eric, Evelyn, and Jean, and two grandchildren.

Jonathan Rogawski

Professor of Mathematics

1955 – 2011

Professor Jonathan Rogawski died on September 27, 2011, after a long battle with cancer. He was 56. Jon was a key figure in the dynamic field of automorphic forms. After receiving his PhD from Princeton University in 1980, Jon held positions at Yale, University of Chicago, and the Institute for Advanced Study before coming to UCLA in 1986. His thesis advisor was Robert P. Langlands, author of the visionary Langlands Program which asserts the existence of deep connections between the fields of infinite dimensional representation theory, algebraic geometry, number theory and automorphic forms. Jon's early papers established him as a gifted researcher at the center of a youthful, growing field. Jon's best known research work is his 1990 monograph A*utomorphic Representations of Unitary Groups in Three Variables*. The monograph brought him broad fame in the subject and provided a partial template for later research, still ongoing, into the general multivariable cases. Another 1993 paper became, over a decade later, the model for the remarkable, prize-winning collaborative program of research called the Book Project led by M. Harris. In other papers Jon made basic progress in our understanding of the connections of theta functions, a classical subject, with the new theories. In the late 1990s, Jon began a calculus text, completing the massive project in 2007. His W. H. Freeman text *Calculus*, now in its second edition, is used at all levels and is one of the best-selling calculus books in the country. Jon was a kind and deeply religious man, who had a penetrating, broadly curious mind. He was a wonderful colleague and friend who took joy in work, in others and in life. He will be richly remembered. Jon is survived by his wife Julie, his three daughters Rivkah, Dvora and Hannah, and son Akiva. His mother Elise and brother Michael also survive him.

giving

Why We Give: Alumni Couple Prove that Math Conquers All

Roy Glickman
BA, UCLA Math 1969
JD, UCLA School of Law 1972
Real estate and business attorney

Judy Glickman
BA, UCLA Math 1970
CRMS, Graduate School of Education 1971
Mathematics teacher, 7th – 12th grades

Roy and Judy Glickman in 1968

In 1967, her freshman year at UCLA, Judy summed up fellow math major Roy at a Dykstra Hall dorm dance and theorized they would make a good match. After careful analysis of Roy's schedule, she calculated a few chance encounters, and two years later, her original conjecture was solved when they became officially engaged outside Boelter Hall. Today Roy and Judy share a beautiful partnership that encompasses over 40 years and a special relationship with the Department through their $50,000 gift to support mathematics education.

We had been longtime donors to UCLA when we realized that we would like to target our support towards mathematics. We were both math majors and really feel that we got a lot out of our math education. This background gave us great training in how to think and solve problems to return good results. Math gave me a critical foundation for logical thinking in my law career. Judy's love of mathematics flourished into a 21-year career as a well-respected 7-12 math educator and administrator. We want to give back to the discipline that means so much to us.

Equally important to us is that we fundamentally believe that math education is vital for young people today. You read a lot about how kids are turned off to studying math. So many of the decisions informed citizens have to make involve mathematical thoughts, calculations, and estimates. So much public policy is based on numbers and projections and budgets, and we can't afford not to pay attention. If we can all learn how to think more like mathematicians, solve problems and calculate the unknowns, then we can make educated decisions that are required to make our society prosper. How can we do it without a good math background?

We discovered the Department's commitment to instilling early appreciation for mathematics through its math education center, the Curtis Center for Mathematics and Teaching. The Los Angeles Math Circle appealed to us specifically because it brings math alive for K-12 students who show special aptitude and gives them an extra boost to encourage them to go forward and challenge them. That's why this program so resonated with us. We also know that our targeted gift is being used wisely and that we can see the results. We feel personally involved in the program and thrilled to support its successes. We are also very aware that the university faces long-term funding challenges and that our support is more important than ever. We're very happy that we've found the math circle. It's a down-to-earth, building block program that has real world impact.

Join Roy and Judy by making a donation to support our innovative undergraduate and graduate programs, as well as our K-12 math education center.

Support America's Problem Solvers

Help build minds and create global, analytic, problem-solving leaders in mathematics research, education and industry. Support us online at www.math.ucla.edu or use the enclosed envelope.

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Dear Friends, Colleagues, Students and Alumni:

I am very pleased to present our annual fall edition of *The Common Denominator*. This past year has seen the Department expanding its prominence on all fronts. On the research side, our top ranked groups in algebra and applied math have attracted Raphael Rouquier and Marcus Roper, two exceptional mathematicians who elevate and complement our pure and applied math faculty team. On the mathematics education field, UCLA Math alumnus Glen Whitney is leading efforts to radically transform how the public views mathematics with the launch of MoMath, the national museum of mathematics that will open in Manhattan in 2012. We feature the story behind MoMath, including an historical look back at the Department's connection to the first 1960s interactive public math exhibition Mathematica and its influence on MoMath.

Further demonstrating our successful efforts to promote high level mathematical research and bring math to the community, the Department hosted the 2010 American Mathematical Society (AMS) Fall Western Section Meeting, which attracted a record number of research mathematicians for special sessions and plenary talks, culminating with Terry Tao's AMS Einstein Public Lecture in Mathematics. Terry's highly accessible and beautiful lecture, "The Cosmic Distance Ladder" attracted nearly 1,000 math enthusiasts, making it the Department's largest public event.

Our research mathematicians continue to be recognized for their breakthrough work with the awarding of high honors. For his proof of the Serre's modularity conjecture, Chandrashekhar Khare received the Cole Prize, the biggest prize in number theory. Applied mathematician Joseph Teran was awarded a Presidential Early Career Award for Scientists and Engineers for his pioneering work in computational biomechanics and virtual surgery. Major NSF training grant awards in logic and applied math further strengthened these top ranked research groups and will support graduate, undergraduate and postdoctoral student programs.

Over this past year, the Department had three notable retirements, including Paul Roberts, Tom Liggett and Mark Green to whom we pay tribute.

Finally, I want to thank Jim Ralston for acting as chair while I led a spring program in group theory, ergodic theory and von Neumann algebras at the Institut Henri Poincaré in Paris. This hugely successful program included multiple Department faculty and a host of past and present graduate students.

As you further explore the many happenings and achievements in the Department, we hope that you are inspired to continue to support our efforts to make mathematics transformative to the research community and to the world at large. Your partnership will make all the difference as we go forward.

Sincerely,

Sorin Popa

UCLA Department of Mathematics

Fall 2011 Newsletter

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