THE UNIVERSITY OF ARIZONA
COLLEGE OF SCIENCE
Mathematics

IN THIS ISSUE

...some of nature's mathematical patterns.

MATHEMATICS

Fall 2014
Volume IX, Single Issue

View from the Chair

BY KENNETH MCLAUGHLIN

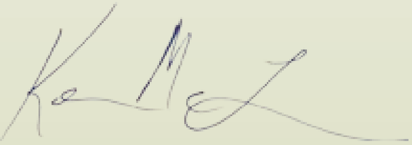
Four months ago, I would not have known what to write in this opening sentence, welcoming you to the Newsletter for the Department of Mathematics. But now, I'm already in the middle of the second sentence! There! That one is finished too! Woo hoo!

Heads of Departments are not so much grown as they are plucked and I'm no exception. But since starting the job of head, my pride in being a member of this great department has ballooned exponentially. There is more excellence going on than we can fit in this newsletter. But a snapshot is possible, so please read on! You will learn that our annual Daniel Bartlett Memorial Lecture, on patterns and randomness, takes place on March 2 (more details on the opposite page), and read about the research of two of our faculty—Andrew Gillette and Janek Wehr. You will learn about the upcoming Arizona Winter School in Arithmetic Algebraic Geometry, find out how our graduate students talk math with Tucson's Mayor Rothschild, and how the Arizona Mathematics Roadshow made it all the way to Beijing!

On a somber note, however, we are saddened by the very recent and unexpected passing of one of our dear colleagues, Professor Moshe Shaked, and also by the passing of long time lecturer Dr. John Leonard earlier this year.

Looking ahead, we have a number of exciting initiatives keeping us creatively busy. Two of these, in particular, could especially benefit from your input. First, our people are developing our own brand of on-line courses, at levels spanning the entire range of our offerings. In this front, we are working to grow in areas that particularly benefit the state of Arizona. Second, we are planning a new fellowship program to diversify the professional development activities of all our students, undergraduate and graduate. To find out more about these programs or how you may support them, please contact me. I wish you all an excellent start of 2015!

Kenneth McLaughlin
Professor and Head
Department of Mathematics
The University of Arizona



Ken McLaughlin *has been a troublemaker on the University of Arizona campus since the age of five. He received his PhD from New York University's Courant Institute in 1994. He has held professorships at the University of North Carolina at Chapel Hill and the University of Arizona, and he was a Professor Títular at the Federal Universidade de Brasília, Brasília, Brazil. He has held visiting research positions at the Université de Bourgogne, Dijon, France, the Mathematical Sciences Research Institute, Berkeley, CA, the Pontificial Universidade Católica de Rio de Janeiro, Brazil, the Katholieke Unversiteit, Leuven, Belgium, The Ecole Normale Superieur, Paris, France, and the Université de Paris VII. His research is in the analysis of partial differential equations, in the theory of approximation, and in the theory of random matrices. His priorities are: (1) family; (2) teaching; (3) research; (4) play. But he's never made it past item (3) in this list.*

Contact him at: **mcl@math.arizona.edu**

Corrections: In our short bio closing Bill McCallum's article "Illustrating Mathematics" (Fall 2013 Newsletter, Volume XIII, Issue 2) we said he was a Regents Professor. In fact, he is a Distinguished Professor. Also, in the "In Memoriam" article on David Lomen, we said he joined our department in 1996. In fact, he joined our department in 1966.

GOING GREEN

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NOTE: we can only start sending you the newsletter electronically if you sign up by providing your name and email address above. Otherwise, you will continue to receive a paper copy of our newsletter.

February 6

AZ Mathematics Road Show Math and Science Night

A hands-on tour of our award-winning portable museum of mathematics

Andrada Polytechnic High School

K-12 friendly

March 14, 15

Pi Day 2015 – The Science of the Number Pi

Interactive explorations of the ubiquitous number Pi, on Pi year: 3.14.15

Science City, at the Tucson Festival of Books
The University of Arizona

K-12 friendly

March 30

The Daniel Bartlett Memorial Lecture

Patterns and Disorder: How random can random be?

Bryna Kra, S.R. Roland Professor and former Head of Mathematics, Northwestern University

Richard A. Harvill Building, Room 150
1103 East 2nd Street, The University of Arizona

March/April

Dynamic Dimensions – A Visual and Hands-on Exhibit

A guided public tour through topics in geometry and topology

Flandrau Science Center, The University of Arizona

April 17

AZ Mathematics Road Show Math and Science Night

A hands-on tour of our award-winning portable museum of mathematics

Luz-Guerrero Early College High School

K-12 friendly

SPECIALIST EVENTS IN SPRING 2015

January 31

Mathematics Education Appreciation Day (MEAD) K-12 Teacher Conference

Keynote: Cathy Seeley, Past President of the National Council of Teachers of Mathematics (NCTM)

Over 400 school teachers and educators come together for a day of scholarly sessions on K-12 mathematics, policy, teaching, and learning

Center for Recruitment and Retention of Mathematics Teachers,
The University of Arizona

March 14-18

Arizona Winter School 2015

Arithmetic and Higher-Dimensional Varieties

Doctoral arithmetic geometry students from around the world attend distinguished mathematicians' lectures and work collaborative on related research projects

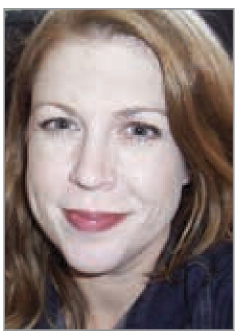
Southwest Center for Arithmetic Geometry,
The University of Arizona

For more information on these and other upcoming events, please subscribe to: **math.arizona.edu/outreach/newsletter/subscribe/ or visit math.arizona.edu**

Becoming a Teacher Leader of Mathematics:
The Arizona Master Teachers of Mathematics (AZ-MTM) Program

BY REBECCA MCGRAW

> *We often assess students only for what they have learned from our content and not for their connected thoughts and constructed ideas. In teaching critical thinking disciplines it seems important that teachers see the value in what students bring and construct. In professional development with teachers I would like to encourage more teachers to take up the lens of action research and interview students regularly to assess their progress. This process may also create more of a bridge from research to our instructional practices in the classroom.*
>
> — AZ-MTM Elementary Teacher Leader



Funded by a grant from the National Science Foundation[1], the AZ-MTM program prepares elementary school teachers to serve as mathematics leaders in their school districts and across Arizona. Each teacher takes courses at UA and receives leadership training from the AZ K-12 Center (azk12.org), the Pima Regional Support Center (pimaregionalsupport.org), and Systems Thinking in Schools (watersfoundation.org). The program supports fourteen grades 2-7 teachers from four local unified school districts – Tucson, Sunnyside, Marana, and Flowing Wells. Taken together, these districts serve over 85,000 students.

AZ-MTM teachers are currently in their fourth year of the program. Each teacher has received 18 credit hours of instruction in number, algebra, geometry, measurement, data analysis, and probability. During fall 2014, the teachers attended a weekly class led by Dr. Marta Civil, a professor in the Department of Mathematics who is internationally known for her work with elementary school students and parents, especially English language learners. Dr. Civil describes the class as "a study group with a focus on teachers development as leaders. In the course teachers explore three topics—professional development in mathematics education; mathematics and English language learners; and mathematics teaching and learning from an international perspective." In addition to classes during the school year, AZ-MTM teachers attend weeklong leadership institutes in the summer and receive training in systems thinking and professional coaching techniques. As the introductory quote suggests, the systems thinking approach to teaching and learning emphasizes the interdependence and connectedness of knowledge pieces within and between disciplines, including mathematics.

K-12 teachers at the MEAD keynote address luncheon.

At this stage in the AZ-MTM program, all the teachers are engaged in leadership work of one kind or another – coaching other teachers within their schools, conducting mathematics workshops for teachers in their districts, giving presentations to district leaders, and sharing their knowledge at local, state, and national conferences. In January 2014, for example, five teachers, Sarah Clarkson, Tabetha Finchum, Margaret Hackett, Jennifer Hendrickson, and Deborah Parslow, gave four presentations at the annual Mathematics Educator Appreciation Day (MEAD) conference, an event organized by the UA Center for Recruitment and Retention of Mathematics Teachers (CRR) that brings together over 400 teachers each January. The teachers shared strategies for differentiating instruction,

AZ-MTM teachers at work.

Cover Photography: *Sand Ripples* by Joceline Lega
Producer and Editor: Guadalupe Lozano
Designer: Roma Krebs, AHSC BioCommunications

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Teachers Sarah Clarkson (left) and Karie Lattimore (right) use mathematical models to describe experimental data.

supporting English-language learners, and engaging all students in mathematical reasoning and critical thinking. Two AZ-MTM teachers, Margaret Hackett and Paul Seidler, have also begun providing Pima County teachers with professional development focusing on the recently adopted State standards for K-12 mathematics.

In the AZ-MTM program, leadership and scholarship go hand in hand. Three AZ-MTM teachers, Kathy Eichhorst, Christy Erickson, and April Knippen, have received National Board Certification, an advanced teaching credential awarded to teachers who demonstrate strong content knowledge and classrooms skills that enhance student achievement. Tabetha Finchum, another AZ-MTM teacher, was recently recognized with the 2014 Rodel Exemplary Teacher award for her outstanding results teaching mathematics in high-poverty schools. In her article "Becoming a Leader: Finding my Voice," published recently in *Teaching Children Mathematics*, Finchum wrote:

> *AZ-MTM gave me the opportunity to learn new mathematics at an adult level and develop a new depth of understanding about mathematics content. This stronger mathematics understanding, paired with educational research on pedagogy and ample time breaking down the Common Core State Standards for Mathematics, boosted my confidence in understanding multiple strategies for solving mathematics problems and taught me the importance of children being able to do the same. (Finchum, 2014, p.102)*

Finchum has begun implementing workshops for teachers in her school district focusing on problem-based mathematics instruction, and has instituted an "open-door" policy in which other teachers and administrators are invited to drop in and observe her teaching.

With less than one year of grant funding remaining, AZ-MTM project leaders are looking forward to continuing their work with program teachers, and to growing the network of mathematics teacher leaders in the Tucson area and beyond. ▲

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[1]This material is based on work supported by the National Science Foundation (NSF) under Grant No. DUE-1035330. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of NSF.
Current PI – Dr. Rebecca McGraw, previous PI – Dr. Mathew Felton

***Rebecca McGraw** is an Associate Professor in the Department of Mathematics. She conducts research on mathematics teaching and learning, and works with Tucson area schools to provide professional development to elementary, middle, and high school teachers.*

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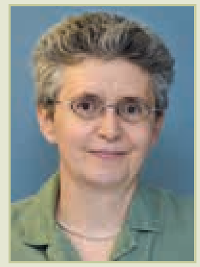
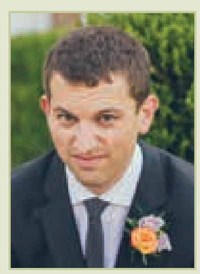
BIOGRAPHIES

Faculty



Marta Civil is a Professor of Mathematics Education and the Roy F. Graesser Endowed Chair. She is originally from Spain. Marta received her PhD from the University of Illinois at Urbana-Champaign and joined the Department of Mathematics at the University of Arizona in 1990. In 2011 she became the Frank A. Daniels Jr. Distinguished Professor of Mathematics Education in the School of Education at the University of North Carolina at Chapel Hill, where she stayed until 2014, before returning to Arizona. Marta's research focuses on cultural, social, and language aspects in the teaching and learning of mathematics, linking in-school and out-of-school mathematics, and parental engagement in mathematics. She has led several NSF-funded initiatives involving children, teachers, and parents, always with a focus on reaching out to underrepresented students in mathematics. In her free time she likes to travel, cook, read, and go for walks with friends.



Andrew Gillette is a tenure-track Assistant Professor originally from Berkeley, CA. He completed a PhD in Mathematics from the University of Texas at Austin in May 2011 and was a Postdoctoral Researcher in Mathematics at UC San Diego for two years before joining the University of Arizona Department of Mathematics in 2013. His research interests center around finite element methods, both theoretical developments and practical improvements, as they pertain to

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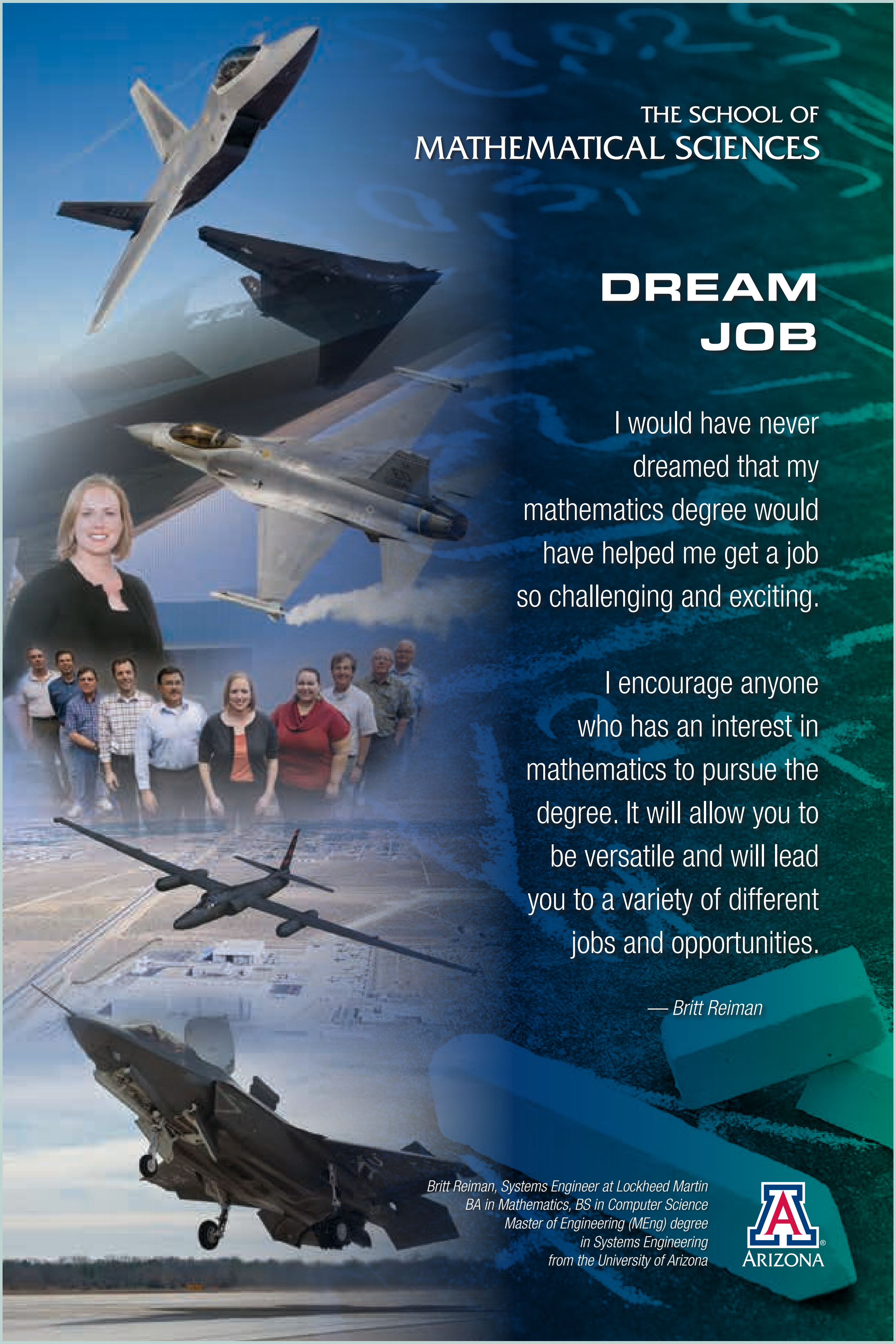
BIOGRAPHIES



Alumni Poster Design

To highlight mathematics alumni and share career options for Math graduates, a series of posters were created for display in the department. A quote was included from each alum as well as photos of math as they use it in their daily work.

Nonacademic Mathematics Careers: Numbers, Facts, and Outlook

BY DAVID GLICKENSTEIN

According to CareerCast.com, "Mathematician" is the top ranked job of 2014, followed by University Professor, Statistician, and Actuary, in that order. Projections predict salaries of over $100K by 2022 and a 22% job growth, with primary growth in the private sector. This news suggests the value of a doctorate in mathematics is being increasingly recognized in non-academic job markets, where innovation and critical thinking ability are essential. Thus, these are great times for mathematics graduate programs like UA's. While many of our graduates have excel in academic positions—many win national awards or are recognized at their home institutions, our mathematics graduates are also having great success securing jobs in industry and government. But what is the scope and context of nonacademic jobs for mathematics PhDs?

The 2012 SIAM Report on Mathematics in Industry looked at graduates during the period 2004-2008. According to the report, approximately 15% of PhDs recipients in the mathematical sciences went on to industry jobs, and more than 50% of these specialized in statistics. In each of the top 25 mathematics programs with most PhD graduates going into industry (excluding statistics only programs), between 10% and 40% of new mathematics doctorates secured industry jobs.

Data from UA's Graduate Program in Mathematics over that last 10 years shows that about 10% of PhD graduates took nonacademic jobs immediately after graduation. This data also indicates that more than 20% of PhD graduates from the last 10 years currently have jobs in industry and government, with employers that include the National Security Agency, Raytheon, IBM, and Amazon. The kind of mathematical expertise leveraged in industry jobs is quite varied. Our recent alumni have titles such as Data Scientist, Software Engineer, Business Intelligence Developer, and Performance Engineer. Another recent graduate has founded a startup working to bring a combination of science and optimization techniques to nutritional advising.

No matter the particular industry focus or field, both our graduates and the corporations that seek them agree: mathematics PhDs offer nonacademic venues a critical set of know-how and skills. Mathematicians are, for instance, great problem solvers and serve an important role in teams. They have the ability to think abstractly. They have the ability to research cutting edge algorithms and learn technical skills quickly. They have the ability to teach and communicate with other scientists and engineers. Dr. Bonnie LaFleur Director of Biostatistics at Ventana Medical Systems, Inc. (a member of the Roche group) and Member of the School of Mathematical Sciences Advisory Board, sums it well:

> *"Science is increasingly a team endeavor, and mathematics is a critical component of this enterprise. Open problems in science often have mathematical components, and central to all scientific hypotheses is the ability to build from first principles. Galileo's famous quote, mathematics is the language of science, still holds true."*
>
> — Dr. Bonnie LaFleur

David Glickenstein *got his PhD in Mathematics from University of California at San Diego and has been a faculty member in the UA math department since 2003. He has been the Associate Head for the Mathematics Graduate Program since May 2014.*

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Give! To find out more about our graduate students or learn about opportunities to help fund their teaching and research training, please visit: math.arizona.edu/outreach/give/

Dynamics Of Noisy Systems or Why It Is Good To Work With Physicists

BY JANEK WEHR

Noise is ubiquitous in physical systems. In some cases it is small and insignificant, and can be neglected. In other situations even a small amount of noise can be a decisive factor for a system's behavior. The mathematical way to model noise is by introducing a random process into the equations describing the system's dynamics. The resulting system of stochastic differential equations becomes the model mathematicians study.

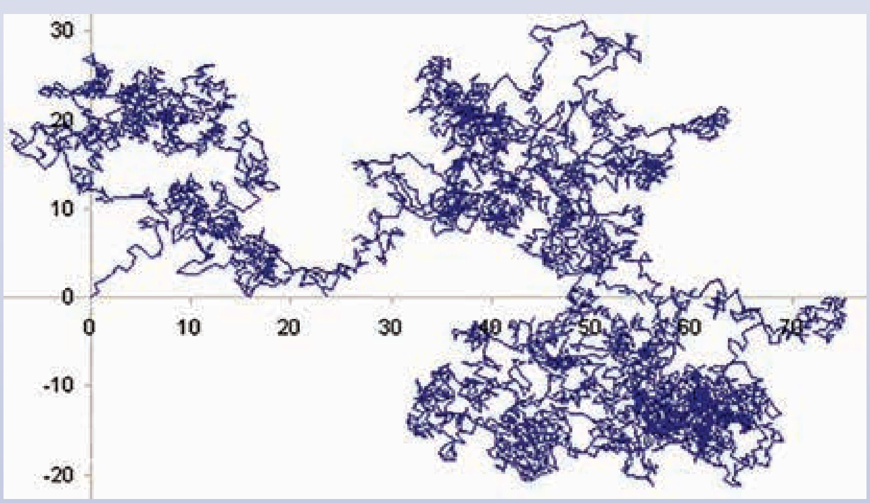
I started working with physicists on such systems in 2008, during one of the annual visits at the Institute for Photonic Sciences in Castelldefels, Spain. A young man came to me and said: "I attended your lectures on probability theory here last summer and I was very intrigued by something. I have an idea of an experiment and I would like you to work on the theory related to it." Since then, Giovanni Volpe and I have been working on dynamics of stochastic systems and it is getting more interesting with every year.

A mechanical system is described by Newton's equations—a second order ordinary differential equation (ODE) or, equivalently, by a system of two first order ODE's. If noise is taken into account, we obtain a system of two stochastic differential equations (SDE). Giovanni wanted to study the motion of a Brownian particle—a colloidal (jelly-like) particle suspended in water. The diffusion coefficient in the corresponding equation varied with the particle's position, becoming smaller near the walls of the container. The particle's mass was to be small and we wanted to derive its effective equation of motion when the particle has infinitely small mass: in this zero mass limit the effective motion is governed by a single SDE. We expected the equation would contain an additional term—a noise-induced drift. The question was: what would this drift be equal to? (See Figure A, and corresponding online demonstration link.)

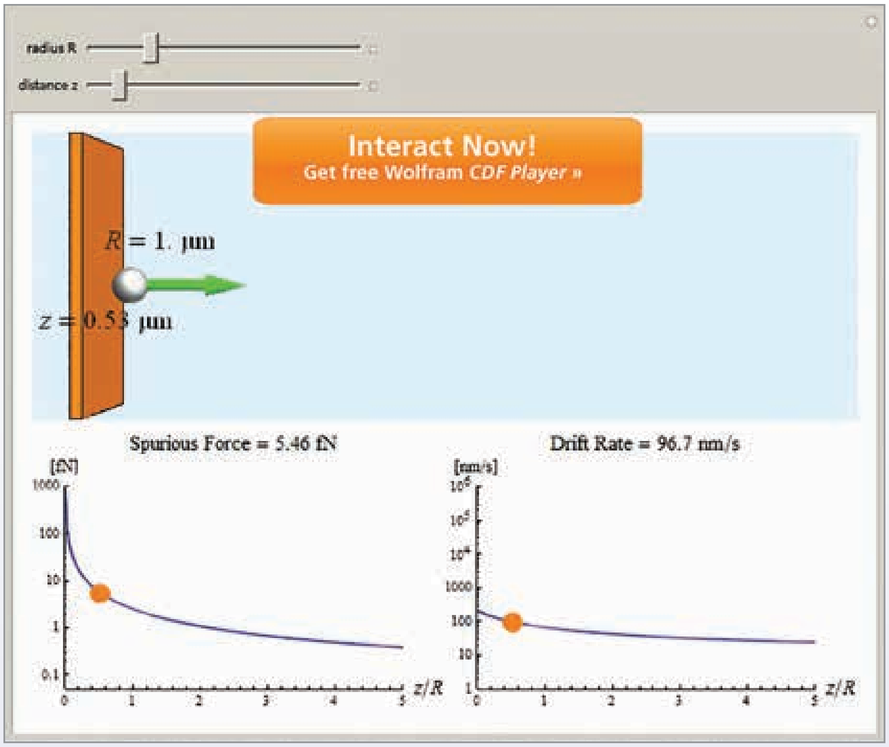
The experiment was conducted in Stuttgart in the fall of 2009 and two months later I had a first heuristic argument, justifying the measured noise-induced drift. Made mathematically rigorous and vastly generalized, it became the main result of Scott Hottovy's dissertation, defended in 2013. Working on this project we developed stochastic analysis techniques and estimates that enabled us to calculate noise-induced drifts and, more generally, effective limiting equations in several other situations, such as the one described next.

The mathematical model of a noisy system depends on whether the random variables representing the noise are correlated in time—if they are, we are dealing with a colored noise. Our analysis of SDE's applies to several models of this type. It also covers models where the noise magnitude depends on the state of the system at an earlier time—stochastic differential delay equations (SDDE). Both colored noise and a time delay were present in an experiment performed by Giuseppe Pesce and Giovanni Volpe in 2011. Their experiment investigated the dynamics of a noisy electrical circuit with a nonlinear feedback. Together with Scott and Austin McDaniel we were able to explain the results of the Pesce-Volpe experiment, including the specific formula expressing dependence of the noise-induced drift on the delay time and the correlation time of the noise, the two fundamental time scales of the system. While motivated by the circuit experiment, our mathematical analysis is much more general and can be applied to systems involving several independent noises which interact with the system.

The next challenge came from an experiment done recently at Bilkent University, Turkey, which studied the motion of a small light-sensitive device—a robot. A noise source was coupled to the system with a delay. The equations describing the robot's motion had a different form and hence could not be studied using the



Two-dimensional Brownian Mouvement by Alexis Monnerot-Dumaine—August, 28 2006. Wikipedia web link: http://meta.wikimedia.org/wiki/File:Mouvement_brownien.gif



This still of an interactive applet on the Wolfram Demonstration Project page (see the link at the foot of the article) shows how the noise-induced drift (right) and the related spurious force (left) decrease as the distance of the Brownian particle from the wall increases. The distance, shown in the horizontal axis, is given in units of the particle's radius.

stochastic analysis methods developed earlier. A multiscale technique, also known as homogenization, was applied instead and reproduced the results of the experiment, including a qualitative change of behavior taking place at a certain value of the delay parameter. In a system of many robots interacting by shedding light on each other, this qualitative change is manifested as a change from repulsive to attractive behavior. Thus, a technique able to pinpoint the value of the delay parameter signaling the qualitative change is both interesting and potentially very useful. Swarms of micro-robots that attract each other and are able to aggregate at a desired location are expected to be useful in medical applications, for example. While we do not work on such applications directly, our analysis contributes to understanding the dynamics of such swarms at the basic level.

This work frames just the beginning of the most exciting adventure in my life as a mathematician. Future projects include a study of qualitative changes of the dynamics (bifurcations) caused by noise-induced drifts, analysis of entropy production in the zero mass and related limits, and noisy quantum systems. ▲

Janek Wehr, is a Polish mathematician who earned his PhD at Rutgers. When he does not work in mathematics, Janek enjoys martial arts, playing guitar, hiking and learning languages.

Contact him at: wehr@math.arizona.edu

Interactive Demo Site: demonstrations.wolfram.com/SpuriousForcesOnABrownianParticleInADiffusionGradient

T U R E A R T I C L E

BIOGRAPHIES

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applications in biology, engineering, and physics. Andrew is also an Affiliate Member of the Program in Applied Mathematics. He enjoys biking to work, swimming when the weather is nice, and attending live music performances.

Instructors

Antonio Rubio is from Tempe, Arizona and is glad to be back in his home state after four years teaching and doing research as part of a postdoctoral fellowship at University of Colorado at Boulder. Antonio's research interests include simulation and modeling of rotating convection and turbulent energy transfer. Outside of work he enjoys participating in recreational sports and spending time with his fiancée and three cats.

Mitch Wilson is a Mathematics Instructor, originally from Douglas, Arizona but has been in Tucson for over a decade. He received bachelor degrees in Mathematics and Mechanical Engineering from the University of Arizona, and also received a Master's degree in Applied Mathematics from UA. Mitch graduate research, under the guidance of professor Joe Watkins, concerned leveraging statistics to study DNA—more specifically, the migration patterns of indigenous people. While completing his graduate work, Mitch earned a G-TEAM fellowship (Graduate STEM Fellows in K-12 Education) that enabled him to teach at a local public middle school for one year. There, he helped young pre-college students learn the foundations of secondary-level Mathematics while encouraging them to enter STEM fields. Outside of the classroom, Mitch enjoys writing and going to trivia night with friends.

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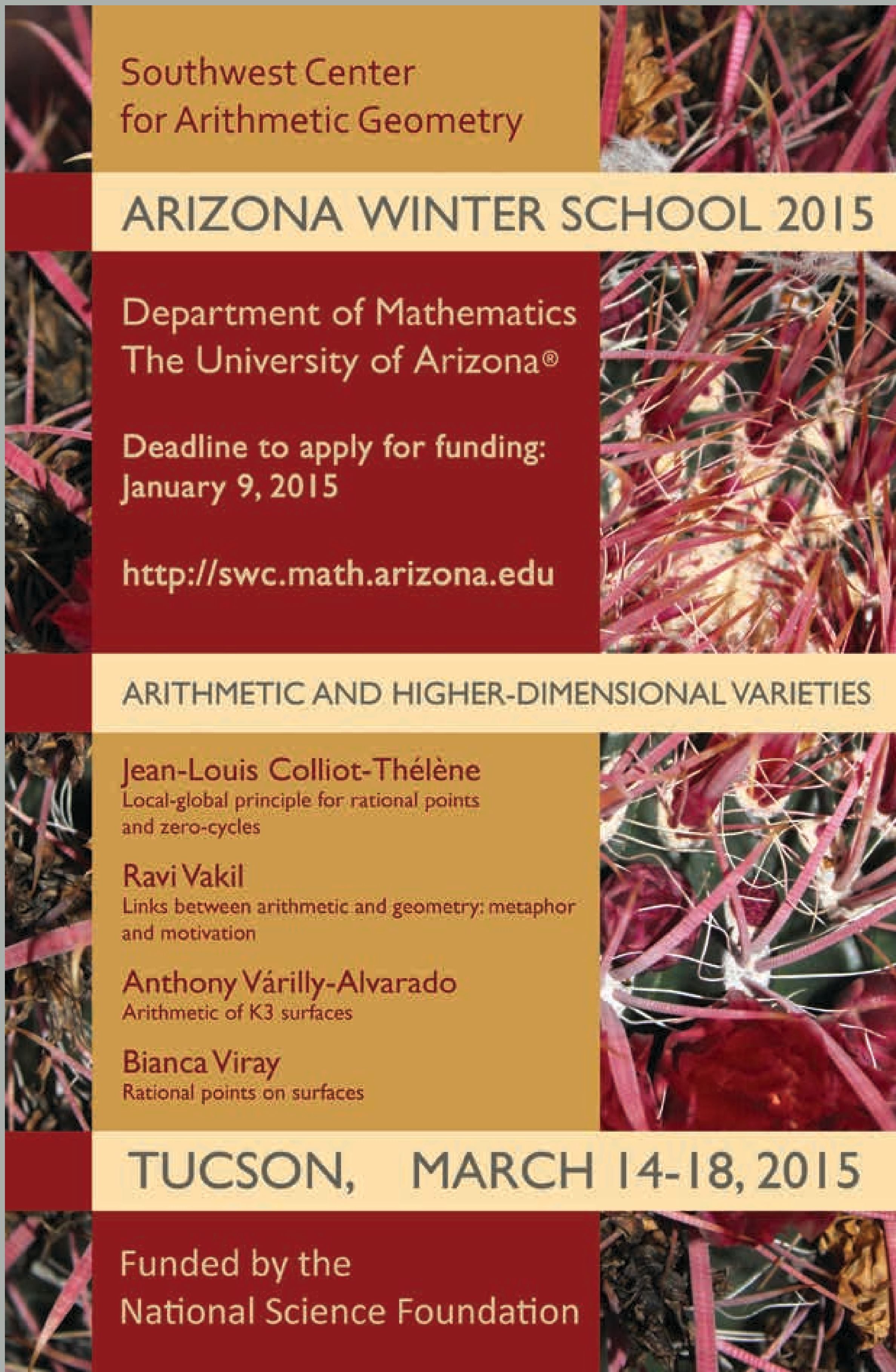
BIOGRAPHIES



The seventeenth annual Arizona Winter School (AWS) will focus on the arithmetic of the geometric spaces carved out by the solutions to polynomial equations in several variables. At the AWS, arithmetic geometry PhD students from around the world attend distinguished mathematicians' lectures by day, and work collaboratively and intensely on research projects by night.

Arizona Number Theory Shines:

A Faculty White House Award and Two Alumni National Awards for Excellence in Expository Scientific Writing

On April 15, **David Savitt**, UA Associate Professor of Mathematics, was honored as a recipient of the Presidential Early Career Award for Scientists and Engineers (PECASE), the highest honor bestowed by the United States Government on science and engineering professionals in the early stages on their independent research careers. David, who earned his PhD at Harvard University in 2001, works on number theory, focusing specifically on Galois representations, modular forms, and p-adic Hodge theory. He is also the Deputy Director of Canada/USA Mathcamp, a summer program for high school students.

David Savitt (Photo by Beatriz Verdugo)

Susan Hammond Marshall, who earned her PhD in number theory at UA in 2001 working under Minhyong Kim, won both the Carl B. Allendoerfer Award and the Paul R. Halmos—Lester R. Ford Award of the Mathematical Association of America (MAA). Susan was recognized for her excellent expository writing in two articles on number theory topics: "Feedback, Control, and the Distribution of Prime Numbers" (Mathematics Magazine, 86, no.3, June 2013, bit.ly/ZgKTGn), and "Heronian Tetrahedra Are Lattice Tetrahedra" (American Mathematical Monthly, 120, no. 2, February 2013, 140-149, bit.ly/1rGBOgM). Susan co-wrote the latter article with **Alexander Perlis**, another UA number theory PhD alumni, who worked under Bill McCallum and graduated in 2004. Susan, currently an Associate Professor of Mathematics at Monmouth University, especially thanked her co-author Alex, upon receiving the second award:

President Barack Obama talks with the Presidential Early Career Award for Scientists and Engineers (PECASE) recipients in the East Room of the White House, April 14, 2014. (Official White House Photo by Pete Souza) (Official White House Photo)

Alexander Perlis, Bob Devaney, and Susan Marshall

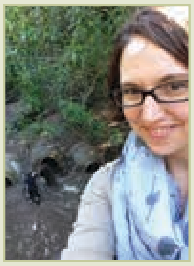
> *I just want to say this is especially meaningful to share with a very dear friend who since our grad student days together has taught me a lot of mathematics, a lot about doing mathematics, and a lot about writing mathematics.*
>
> —Susan H. Marshall, *MAA Focus October/November 2014*

BIOGRAPHIES

Instructors

Janice Takagi has taught math in the Tucson Unified School District (TUSD) for 30 years. During that time she also taught numerous evening classes at the Wilmot State Prison, Pima Community College, and the University of Arizona. Originally from Rapid City, South Dakota, Janice earned her master's at UA in 1994 and has three college-age children who have or will be graduating from UA soon. Twenty years ago, Janice took part in a yearlong teacher exchange program between UA and K-12 local schools, getting to connect, first hand, K-12 and college level mathematics through her teaching. As a public school teacher, Janice has been very involved with the UA Center for Recruitment and Retention of Mathematics Teachers and its yearly Mathematics Education Appreciation Day (MEAD) Conference. Janice plans to retire from TUSD this May and continue to work in public education.

PostDoctoral Fellows



Diane Holcomb, a Richard Pierce postdoctoral fellow, is originally from Delaware. She completed her PhD at University of Wisconsin, Madison in 2014. Diane is interested in a wide range of topics in probability, including, but not limited to, random matrices, and particle systems. While at Arizona she would like to continue to expand her mathematical interests in both theoretical and applied mathematical directions. Away from the office, Diane is interested in almost anything that can be done outside, from hiking to

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BIOGRAPHIES

The Arizona Mathematics Road Show Wins Koffler Prize and Goes Global!

BY BRUCE BAYLY

"I am enormously honored," Bayly said. "I'm grateful for the recognition of my efforts, and many colleagues and students, to inspire youngsters throughout Arizona with the excitement of math, science and engineering. But most importantly, this award will allow us to expand the range and impact of our outreach efforts to reach many more children in the future."

— Bruce Bayly, on winning the
Henry and Phyllis Koffler Prize in
Public Service/Outreach in Mathematics
UA News, April 21, 2014

The Arizona Mathematics Road Show, a mobile, UA based hands on museum of mathematics, set a new record for miles traveled in 2014, with trips to Poland and China in addition to the Math Awareness 2014 National Tour.

The National Outreach Tour began in April as Dr. Bruce Bayly, his son Devin, and mathematics graduate student Shane Passon set out on a two-month long road trip in the ubiquitous refurbished bus. Preparations involved redesigning the interior of the Arizona Mathematics Road Show bus to store both an extensive collection of educational materials and 500 gallons of used vegetable oil—the journey's fuel.

The Road Show spent a week at the USA Science and Engineering Festival in Washington DC, which brought the crew in touch with fellow math and science educators from all over the world. They met thousands more as they visited schools and youth clubs in New York, Boston, Chicago, and many other cities.

In June Bruce accepted an invitation from the Polska Akademia Dzieci (Polish Academy of Kids), to be the keynote speaker at the end-of-year conference in Gdansk. Besides learning a few words in Polish, it was fascinating to experience first-hand how children from all over Poland work on science projects and share their findings at regional and national gatherings.

The 2014 tour visited the Valentine Boys and Girls Club on Emerald Avenue in Chicago.

And Poland led to Beijin! In September Bruce and Shane were invited to the Beijing Science Festival where they fueling the public's excitement for hands-on mathematics and made presentations at six Chinese schools.

Earlier this year Bruce received the University of Arizona's Henry and Phyllis Koffler Prize for outstanding commitment to public mathematics outreach with emphasis on originality. Yet as the show goes global and excitement for mathematics permeates through the nation, the bus and the equipment are wearing out. Dr. Bruce Bayly and UA Math are starting a fundraising effort to buy a new vehicle, and to build a suite of all-new materials. Please give below! ▲

Bruce Bayly and Shane Passon gave several stage shows at the 2014 Beijing Science Festival, which was held on the grounds of the 2008 Olympic Games.

*Associate professor **Bruce Bayly** studied Applied Mathematics at Cambridge and Princeton Universities. He joined the University of Arizona Department of Mathematics in 1988. His outreach programs The Physics Factory and Arizona Mathematics Road Show have reached tens of thousands of children since 2003.*

Contact him at: **bjb@math.arizona.edu**

Website:
math.arizona.edu/outreach/programs/az-math-roadshow

Give!

To find out more about the Arizona Math Road Show and/or help support their fundraising efforts, please visit: math.arizona.edu/outreach/give/

Serendipity Methods: Using Mathematics to Accelerate Computation

BY ANDREW GILLETTE

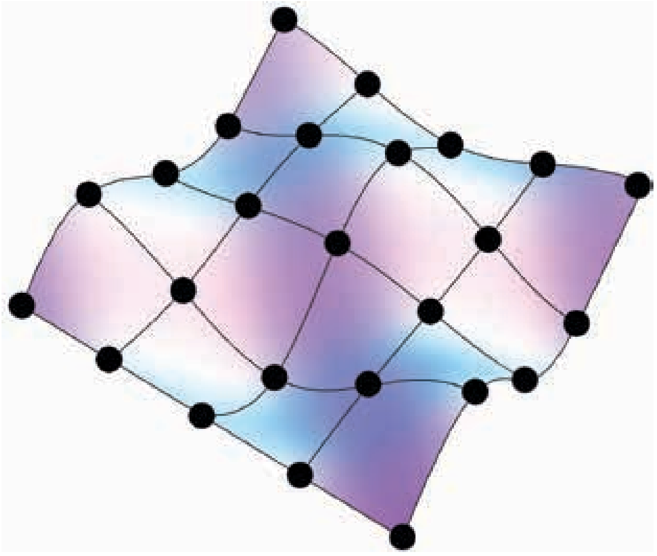
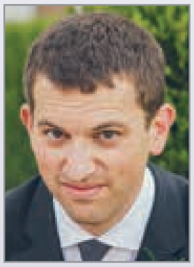


Figure A. Building a surface model by a standard approach: look up the terrain height at all 25 grid points.



When you hear the term "serendipity" in reference to scientific research, any number of essential discoveries may come to mind. When the term "serendipity" is used in the mathematical community of numerical analysts, however, it refers to a particular computational methodology discovered in the 1970s whose unexpected effectiveness is indeed serendipitous. The term "serendipity finite element method" has appeared in engineering textbooks and software documentation for the past 40 years, and scientists have leveraged the method for at least as long. Remarkably, a mathematical understanding of this phenomenon is still being developed today.

To get an idea of the serendipity finite element method, imagine that you want to build a high-resolution model of the surface of the Tucson Catalina Mountains, based on a flat map of the area. Suppose your map is partitioned into a grid of 1 mile by 1 mile blocks. You decide to divide each of these square blocks into 16 sub-blocks that are 1/4 mile on each side. You then look up the height at the corner of each small block and build a surface model of the terrain (see Figure A). The serendipity method reveals that you could construct a surface model of the terrain that is "just as good," in a certain mathematically precise sense, by looking up the heights of a much smaller number of points: the ones along the perimeter of each square mile block and just the point at the center of each square mile block (see Figure B). In this way, you can spend much less time building a surface representation without degrading the quality of the result - a truly serendipitous occurrence!

In scientific applications, the serendipity method is most useful when the object you are trying to model is not something so visible as a mountain range. Astronomers use the finite element method to model extremely large-scale events, such as the development of galaxies over billions of years. Biologists use the finite element method to model extremely small-scale events, such as the diffusion of calcium ions during the contraction of a muscle fiber. Engineers use the finite element method for a wide variety of problems, such as evaluating the stress on bridges and roadways. In any of these contexts, serendipity methods reduce the computational effort and resources needed to gain new insights from the models being developed. Mathematicians now face the challenging and exciting task of explaining why the serendipity method is not just a matter of "blind luck" but in fact a rigorous method derived from a thorough understanding of approximation theory and numerical analysis.

***Andrew Gillette**, originally from Berkeley, CA, earned his PhD in Mathematics at the University of Texas at Austin. His work on finite element methods concerns theoretical developments and practical improvements applied to various scientific disciplines.*

Contact him at: **agillette@math.arizona.edu**

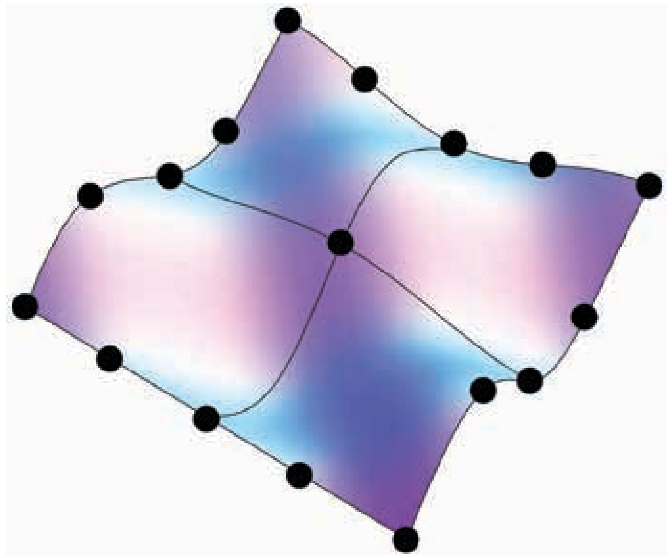
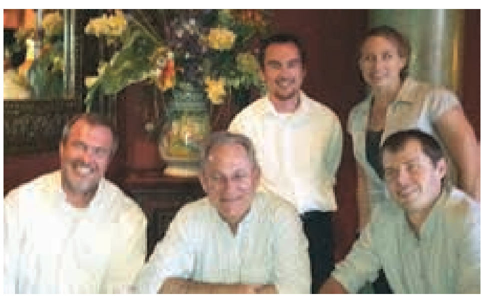


Figure B. Building a surface model via the serendipity finite element method: look up the terrain height only at perimeter grid points and at the central grid point.

Talking Group Theory with Tucson Mayor Jonathan Rothschild

In the summer of 2013 I had the opportunity to meet Tucson Mayor Jonathan Rothschild, along with three other graduate students. As we waited for dinner, Mayor Rothschild went around the table asking each of us about our research. My peers in applied mathematics and statistics described their work and its practical utility with relative ease. As my turn got near, I prepared for what I knew would be a more difficult task. Those of us who work in abstract fields struggle to describe what we do, let alone why or how it matters.

I introduced abstract algebra to the mayor as a generalization of number systems. If we think about the usual numbers we deal with daily (integers, fractions, etc.) and the four common operations we use to combine them (addition, subtraction, multiplication, division) we might notice relationships that we normally take for granted. Subtraction "undoes" addition and multiplication "undoes" division, for example. Also, multiplication is commutative: if we have 3 groups of 5 pennies, we also have 5 groups of 3. But could we shrink the "size" of our world of numbers without such properties breaking down? If we considered a world just of integers (the counting numbers, including zero, and their negative counterparts), we could add and subtract without "stepping out" of it. But the moment we divide two integers we might get something outside of the integer world—a fraction. What kind of properties can we expect will hold in a good number system? Will the operation 3×5 always be the same as 5×3? If we want to warrant certain relationships will hold, how large does our number world need to be?



Graduate students from the UA School of Mathematical Sciences dinning with Tucson Mayor Jonathan Rothschild. Summer 2013. From top-left: Brendan Fry, Mandi Schaeffer Fry, Brian Mannakee, Mayor Rothschild, Jeff Hyman.

Such questions extend to non-numbers, and this is where group theory and group representations come in. Still capturing Mayor Rothschild's attention, I flipped and rotated a square napkin as a means to illustrate the symmetries of a square. I showed him how combinations of these symmetries act like multiplication does: a configuration can be "undone" by reversing the movement, a reversal akin to "division." Yet in this world of napkin symmetries, the commutative property of multiplication no longer exists. If we twist the napkin by 90 degrees and then flip it along an imaginary vertical line, we get a configuration that is different from the one resulting from doing these motions in the reverse order (first flipping along the line, then rotating by 90 degrees).

Fascinated by my excitement, the mayor reasonably asked what I did with these mathematical objects—what did I do beyond rotating a napkin around? At this point I used the technical word *group* for the first time. I told the mayor that part of what I study is the structure of these objects (groups) and how they act on other objects. The dihedral group illustrated by the napkin, for example, isn't the square itself, but rather a group of symmetries that acts on a square.

Symmetries like the one in the dihedral group show up elsewhere, like in communication networks and codes. On some level, abstract algebra is responsible for how our computers and iPhones work. This intrigued Mayor Rothschild, and we mused over the fact that we all use these things without really understanding the mathematics behind them—the same abstract mathematics that years ago seemed to have no immediate application.

While some us still exclusively use paper and pencil to craft complicated proofs of simple statements, others model, test, and compute with the irreplaceable aid of expensive machinery. Topics and research methodologies vary, but, at the core, mathematics remains the same for all: the more or less abstract underpinnings that ultimately explain how our world ticks. ▲

***Mandi Schaeffer Fry** received her PhD from the UA Department of Mathematics in 2013, working under professor Pham Tiep. Mandi is now a tenure-track Assistant Professor at the Metropolitan State University of Denver. Mandi was the 2013 recipient of the Daniel Bartlett Memorial Scholarship.*

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PostDoctoral Fellows

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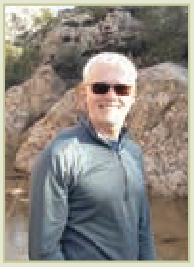
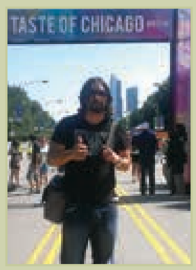
flying kites, to skiing. Her indoor interests include reading and playing music.



Tyler Kloefkorn, a Teaching Postdoctoral Fellow, is originally from Tucson, Arizona. Tyler earned his PhD from the University of Oregon with a focus on non-commutative algebra and combinatorial topology. At the University of Arizona, Tyler is excited to continue his research with new colleagues. Tyler is also looking forward to teaching a wide variety of courses and participating in department outreach opportunities. In his spare time, Tyler enjoys running, biking, swimming, and relaxing with family.

Katie Walsh, a Teaching Postdoctoral Fellow, earned her PhD in June 2014 from UC San Diego. She is originally from Delaware. Katie's research interests are in knot theory. Much of the work she has done focuses on finding geometric properties of knots from their polynomial invariants. She also collaborates with another mathematician and a plastic surgeon from UCSD to create and use mathematical and computer models of plastic surgery techniques. The models allow doctors to do a virtual side-by-side comparison of these techniques. Katie has a passion for teaching and is very interested in mathematical outreach activities. She is excited to work with the various outreach groups here at University of Arizona. When not doing math, Katie enjoys hiking, camping, swimming and running.

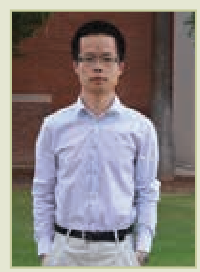
The Mathematics building at the University of Arizona, Tucson, Arizona. Photo by Margaret Hartshorn, AHSC BioCommunications.



Saulo Orizaga is an NSF-Alliance Postdoctoral Associate. He recently moved to Arizona from Ames, Iowa, where he earned a PhD in applied mathematics from Iowa State University (ISU). Before arriving to Iowa, Saulo earned bachelor and masters degrees at the University of Texas, Pan-American. Saulo's recent work at ISU focused on understanding nonlinear instabilities of viscous fluid flows induced by electric fields. More generally, Saulo enjoys leveraging modeling techniques and computational mathematics to better understand problems of interest to the scientific community. While at Arizona, Saulo hopes to extend some of his previous research ideas to contribute to new applied research projects. Beyond mathematics, Saulo enjoys watching championship-boxing fights. In Texas, Saulo also played semi-pro football as a kicker.

Visiting Assistant Professors

Nham Ngo, originally from Vietnam, got his bachelor in mathematics and informatics at the University of Natural Science, Ho Chi Minh City, Vietnam. In 2006, Nham came to the US and studied both in New Mexico and Georgia, earning his PhD in mathematics at the University of Georgia in 2012. After his doctorate, Nham held a lecturer position in mathematics at the University of Wisconsin-Stout for one year. He then became a Senior Research Associate in pure maths at Lancaster University, in the UK before coming to the University of Arizona. Broadly speaking, Nham works in abstract algebra. He studies, in particular, the modular representation and cohomology theory of algebraic groups and related structures. Beyond mathematics, Nham enjoys playing soccer, badminton, and jogging.



Yichao Zhang received his PhD from the University of Toronto and came to UA as a visiting assistant professor after one year at POSTECH (South Korea) and three years at University of Connecticut. Yichao works in number theory and related areas, and is most interested in the theory of modular forms, one of the central objects in modern number theory. Yichao loves Chinese food and is, and will always be, a fan of his wife's meals. He used to spend much of his spare time playing badminton and gathering with friends, but he is now devoting many of these hours to his 9-month-old daughter.

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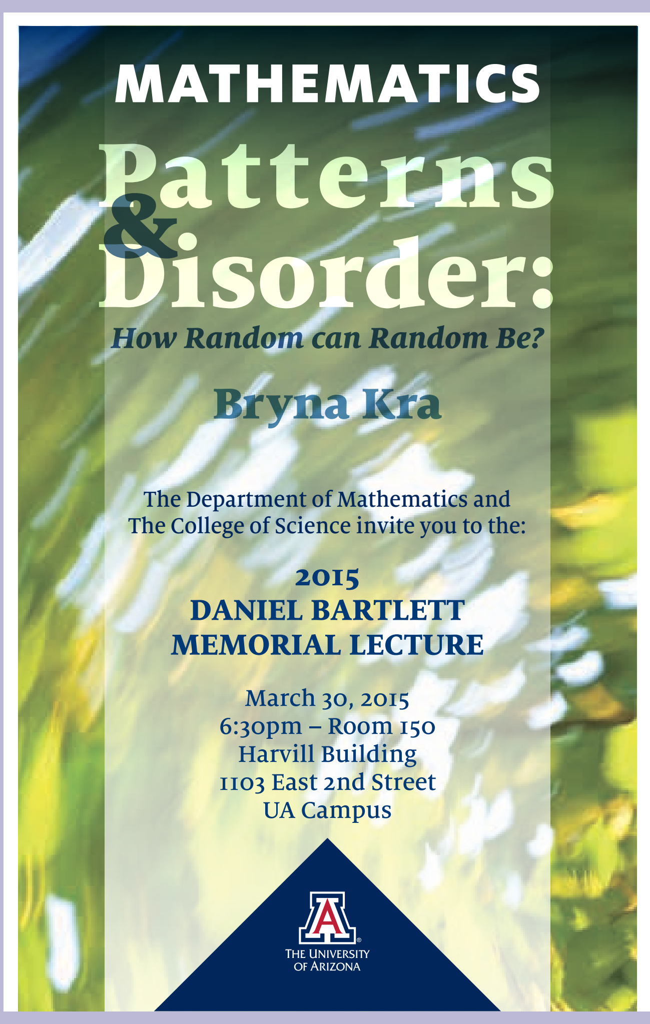

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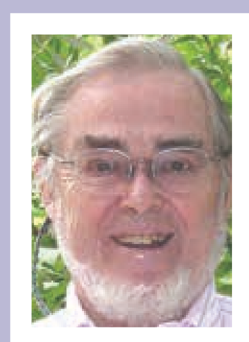

After 41 years of dedicated and effective mathematics teaching at the University of Arizona, **John Lander Leonard** died on March 24, 2014, at age 78. As an undergraduate at Carnegie Mellon University, majoring in physics and mathematics, John began his musical development as a bagpiper. After earning a PhD in analysis from the University of California, Santa Barbara, he joined the Department of Mathematics at the University of Arizona in 1966. As a teacher, John believed passionately that his students could, and would, learn to understand mathematics. This dedication carried on outside of the classroom. For many years John organized the showing of mathematical movies and worked with the undergraduate society Pi Mu Epsilon. During the latter part of his career John developed an interest in graph theory, teaching a senior/graduate level course in that topic. John led a rich life beyond mathematics, playing oboe in the Southern Arizona Symphony Orchestra, supporting the Sierra Club, and enjoying a wide range of outdoor activities.