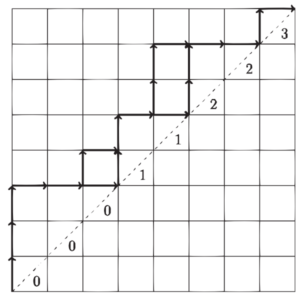

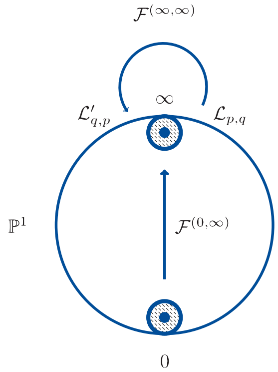

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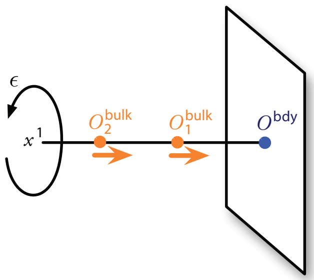
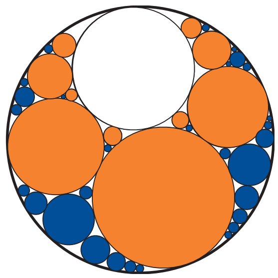
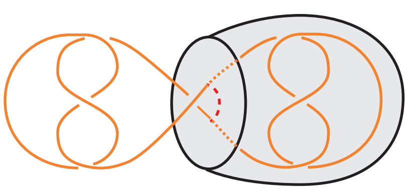
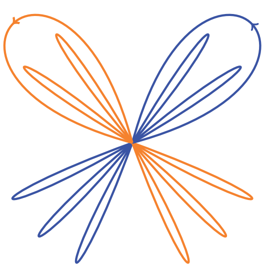
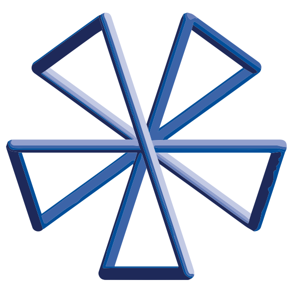


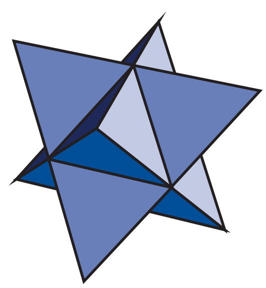


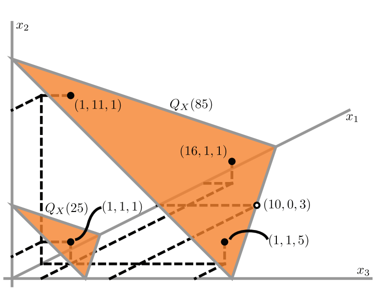
UCDAVIS MATHEMATICS NEWSLETTER

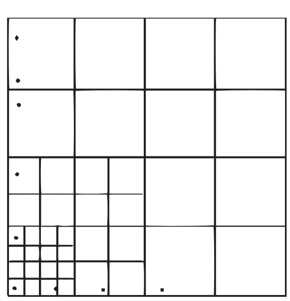












Letter from the Chair

by Dan Romik

At the UC Davis Department of Mathematics we have the dual and complementary missions of educating UC Davis students and doing basic research in mathematics. Of course, there is a lot of synergy between those two activities, which is precisely why the work of an academic is founded on the two pillars of teaching and research: research work provides great educational and training opportunities for graduate students and undergraduates; conversely, teaching provides us with ample opportunities to discuss with our students ideas that are at the forefront of scientific knowledge, and by making the teacher reflect on long-established, well-understood concepts it allows her to juxtapose that knowledge against the more mysterious, tenuous knowledge that underlies the important mathematical questions of the day she considers in her research. Thus, teaching and research are eternally in dialogue with each other, and this dialogue catalyzes progress in both areas.

Success in research is hard to measure, and often becomes widely apparent only months or years after it has taken place in the form of awards and honors. The coming year has seen a good number of such hallmarks of recognition bestowed on our faculty. I would like to use this letter to highlight those achievements, as a way of convincing you – in case there was any doubt! – of the high level of talent, dedication and passion with which we approach our work.

Kevin Luli, an assistant professor who joined our Department in 2013, was awarded a Faculty Early Career Award by the National Science Foundation (NSF). The NSF describes these awards as the Foundation's "most prestigious awards in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research within the context of the mission of their organizations." Kevin's highly acclaimed work is in the area of mathematical analysis, but also has connections to other areas such as algebraic geometry and theoretical computer science. (The fact that I only have nice things to say here about Kevin is entirely unrelated to his being the editor of this newsletter.)

Eugene Gorsky, an assistant professor who joined the Department in 2014 and works on knot theory and representation theory, won the 2016 Hellman Fellowship, an award whose goal is to support the research of promising early-career scholars who exhibit the potential for great academic distinction.

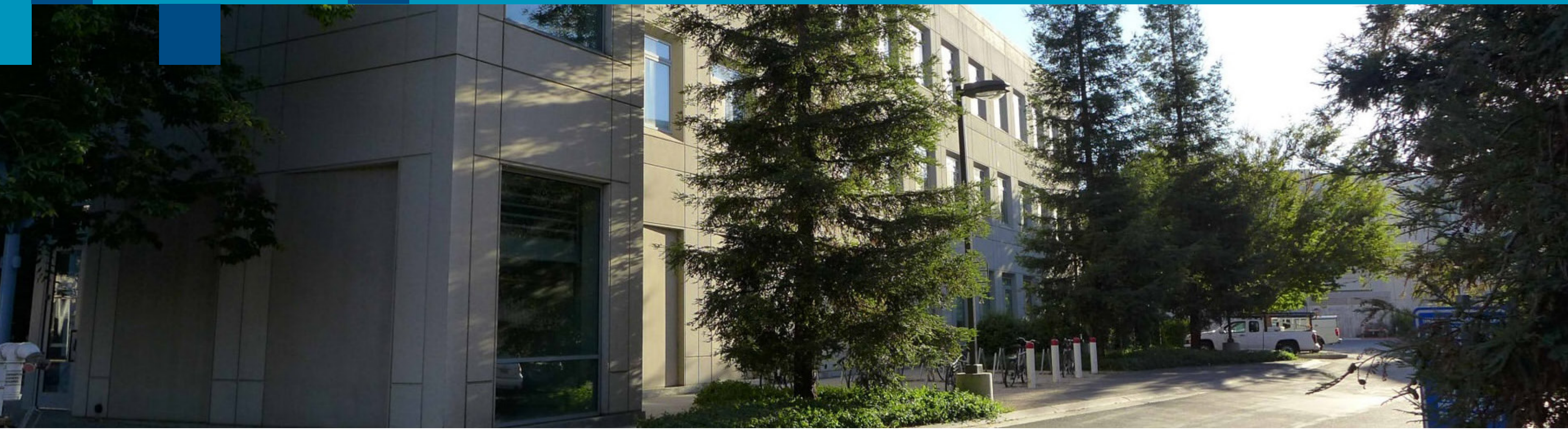
Among our more senior faculty, Mariel Vazquez, who holds a joint appointment between our Department and the Department of Microbiology and Molecular Genetics, received the 2016 Blackwell-Tapia award. This award "recognizes a mathematician who has contributed significantly to research in his or her area of expertise, and who has served as a role model for mathematical scientists and students from underrepresented minority groups, or has contributed in other significant ways to addressing the problem of underrep-

Kevin Luli

Eugene Gorsky

Mariel Vazquez

Naoki Saito



resentation of minorities in math."

Naoki Saito, an applied mathematician who has been at UC Davis since 1997, was awarded with two separate awards, a Best Author award and a Best Paper award presented to him by the Japan Society for Industrial and Applied Mathematics in connection with two of his recent papers.

An honor of a different sort fell this year to our Distinguished Professor Craig Tracy. In 1993 Craig was the co-discoverer of a new mathematical function arising from random matrix theory, now known as the Tracy-Widom distribution. Tracy and Widom's work on this function has been recognized with numerous awards over the years. As a sign of the Tracy-Widom distribution's growing importance and recognition as not just a fundamental, but also a ***useful***, mathematical discovery, this year the function was finally added as a new command in the mathematical software application Mathematica, used around the world by hundreds of thousands of mathematicians, scientists and engineers.

Another of our Distinguished Professors, Joel Hass, who works on geometry, topology and their applications, had his career achievements celebrated at the "JoelFest" conference, held at UC Berkeley this past May in Joel's honor on the occasion of his 60th birthday. I attended this very successful event and had a great time hearing stories about Joel's mathematical work, career, and quirky adventures over the years, as told by his friends, family members, and colleagues – many of them world-renowned mathematicians.

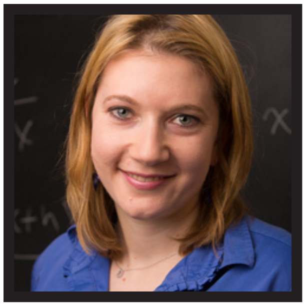
I would also like to report on impressive recent successes by a graduate of our Department, Deanna Needell. Deanna graduated from our Department with a Ph.D. in mathematics in 2009. Her career trajectory in the first few years since her graduation, which she told us about in an article she wrote for our 2014 newsletter, already included an impressive list of honors. The recent news is that Deanna was awarded the 2016 IMA Prize in Mathematics and its Applications. She will also be moving in 2017 from her current position at Claremont McKenna College to take up a professorship at the University of California, Los Angeles. Congratulations Deanna – I hope you will serve as an inspiration for all our students!

Finally, another of our big successes over the past year was a collective one achieved by the entire Department, when we succeeded in hiring four excellent new assistant professors: Martin Luu, Elena Fuchs, Erik Carlsson and Luis Rademacher. A fifth new assistant professor, Tudor Dimofte, was hired in 2015 but also joined us this fall after spending the past year doing research at the Perimeter Institute. These world-class mathematicians each have their own impressive personal achievements to brandish, which you can read about on pages 4-5. We are proud to have such promising young researchers and educators join our ranks, and expect to enjoy the fruits of their talents for years to come.

I would like to conclude by thanking all of you who supported our Department's missions of education and research with donations over the past year. To those of you looking to give, either continuing a past tradition or starting a new one, see the insert in this newsletter for details on how to donate.

Craig Tracy

Joel Hass



Deanna Needell

Interested in the Past?

Prior newsletters back to 1994 are available on the Department of Mathematics website.

https://www.math.ucdavis.edu/research/news/archive/

Incoming

New Faculty
Luis Rademacher

Luis Rademacher was born in Santiago, Chile, and completed his undergraduate degree in Mathematical Engineering at Universidad de Chile. As an undergraduate under the supervision of Alejandro Jofré, he conducted research on applying game theory to the modeling of the electrical energy generation market in Chile. In 2007 Luis obtained his Ph.D. in Mathematics from the Massachusetts Institute of Technology under the direction of Santosh Vempala. In his thesis, he studied the computational complexity of several geometric problems, such as the computation of the center of mass in high dimension. Before coming to Davis, he held positions at Georgia Institute of Technology and The Ohio State University.

Luis' research lies around convex geometry and theoretical computer science, including the foundations of data science and optimization. In 2014 he received the prestigious NSF CAREER Award.

Luis lives in West Davis. When he is not doing mathematics, he enjoys listening to music, traveling and taking part in occasional outdoor adventures.

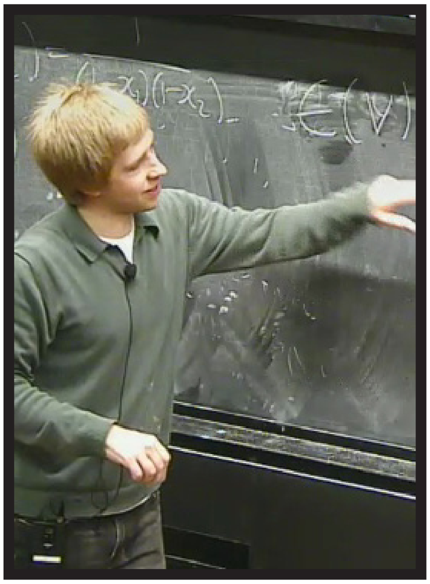
New Faculty
Elena Fuchs

Elena Fuchs grew up here in Davis after moving from Russia in 1990. After completing her undergraduate degree at UC Berkeley in 2005, she moved to the East Coast to get her Ph.D. in mathematics at Princeton University in 2010, under the supervision of Peter Sarnak. Since then, she spent a year as a member at the Institute for Advanced Study, three years as a Simons postdoctoral fellow at UC Berkeley, and two years as an assistant professor at the University of Illinois at Urbana-Champaign.

Her research involves studying the arithmetic aspects of integer matrix groups using tools from analytic number theory and geometric group theory. She is most interested in thin groups, which are small in the sense that they are infinite index in their Zariski closure (for example, congruence subgroups of the modular group are not thin). She is a recipient of the Sloan Research Fellowship in 2016.

She lives in Davis with her husband Martin and her son Nikolai. If she had free time, she would spend it baking, running, and ice skating.

Faculty



New Faculty
Erik Carlsson

Erik Carlsson received a B.S. in Mathematics with a minor in computer science from Stanford University in 2003, and a Ph.D. in Mathematics from Princeton University with professor Andrei Okounkov in 2008. After receiving his degree, he has held post-doctoral positions at Northwestern University, The Simons Center for Geometry and Physics, the International Center for Theoretical Physics in Trieste, Italy, and at the Center for Mathematical Sciences and Applications at Harvard University.

Erik has relatively broad research interests, most involving representation theory, algebraic geometry, symmetric functions, combinatorics, mathematical physics, and computational topology. Several of his research projects involve the study of sheaves on the Hilbert scheme of points on a smooth complex surface, and some surprising applications to combinatorics, number theory, and string theory. He also has applied interests, especially in applications of persistent homology to computer science and optimization.

Outside of mathematics, he enjoys tennis, restaurants, and the Settlers of Catan.

New Faculty
Martin Luu

Martin Luu obtained his undergraduate degree in 2006 in London. Afterwards he came to the US and obtained his Ph.D. in mathematics from Princeton University in 2011. He then switched coasts, and spent three years at Stanford University as a Szego Assistant Professor. This was followed by a two year stay in the Midwest, as an assistant professor at the University of Illinois, Urbana-Champaign. He now enjoys being back in California.

His work concerns various dualities in number theory and mathematical physics and their interconnections. That such a connection is possible is related to an event that took place in Princeton the same year that he came to start graduate school there. It was in that year that Kapustin and Witten published work that really opened up a new view on relating quantum field theoretic dualities and Langlands dualities. It is an important development, much cited, but probably not well enough understood.

He hopes to push further such connections while at UC Davis.

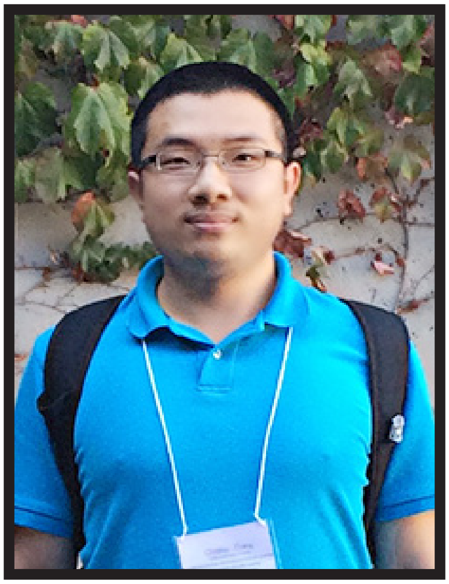
New Faculty
Tudor Dimofte

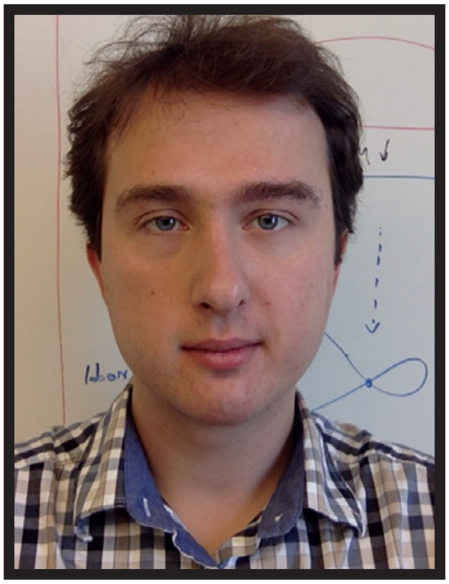
Tudor Dimofte started life in Romania, but grew up mainly in Ohio. His has an A.B. in mathematics from Princeton and a Ph.D. in physics from Caltech (under the supervision of Sergei Gukov). He spent further formative postdoc years in Cambridge (U.K.), at the Institute for Advanced Study in Princeton, and most recently at the Perimeter Institute for Theoretical Physics. He is thrilled to finally return to California, to be in this Department, and to be one of the inaugural members of the Davis Center for Quantum Mathematics and Physics.

Tudor's research centers around the interplay between quantum field/string theory and mathematics, especially in the areas of topology and geometry. Among other pursuits, he has enjoyed developing a quantization (and categorification) of 3d hyperbolic geometry, via Chern-Simons and related field theories. More recently, he has been interested in using gauge theories to understand geometric representation theory, and vice versa.

When not doing math and physics (or sometimes while doing math and physics), Tudor enjoys running through the farmlands around Davis, tasting the delights of wine country, hiking, traveling, and playing music.

Incoming Academic





New Krener Asst. Professor
Qingtian Zhang

Before moving to North America in 2011, Qingtian Zhang studied mathematics and mechanics at Fudan University in Shanghai. In 2016, he received his Ph.D. in Mathematics from the Pennsylvania State University. His thesis adviser is Professor Alberto Bressan. His mentor at UC Davis is Professor John Hunter.

Qingtian's current research interests include hyperbolic conservation law, nonlinear wave equations, and fluid mechanics.

Outside of mathematics, Qingtian likes running and hiking. He also enjoys bodybuilding: He is still a beginner now (and will probably remain so forever).

New Krener Asst. Professor
Adrian Zahariuc

Adrian Zahariuc was born and grew up in Bacau, Romania. As a high school student, Adrian was an active participant in national and international math competitions.

When he was eighteen, he came to the US for college. After college, he decided to stay a little longer for graduate school and now even a little longer for his first job. He received his Ph.D. in May 2016 from Harvard University, under the supervision of Professor Joe Harris. Adrian is a classical algebraic geometer, who likes to specialize and degenerate geometric objects. His approach to research is roughly "degenerate first, think later". At Davis, he hope to become of a master of this technique, as well as others, with the help from his mentor, Professor Brian Osserman.

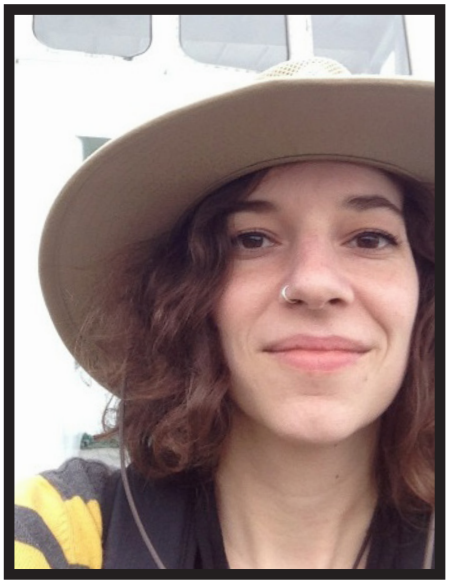
Outside of math, he enjoys traveling, reading, strategy games and (since three weeks ago) cooking.

New Krener Asst. Professor
Chaim Even-Zohar

Chaim grew up in Israel, and completed his master's and Ph.D. degrees in Mathematics at the Hebrew University of Jerusalem, under the supervision of Professor Nati Linial from the School of Computer Science and Engineering. During Fall of 2016, he is a postdoctoral fellow in the semester program "Topology in Motion" at ICERM, Brown University. Starting in the Winter of 2017, he will join the Department as a Krener Assistant Professor.

Chaim's research interests lie mainly in Combinatorics, and its connections with Topology as well as other fields. He has done work in local graph theory and additive combinatorics. In his Ph.D. thesis, he studied random knots and links, and he would like to continue applying combinatorial and probabilistic methods to various mathematical objects. In Davis, Chaim will be working with Joel Hass and other researchers.

Staff



New
Krener Asst. Professor
Allison Moore

Allison Moore has research interests in geometric topology, specifically low-dimensional topology and knot theory. Her work involves knot Floer homology and Khovanov homology, often in combination with tools and techniques from more classical areas, like Dehn surgery or contact topology. Before coming to Davis, she was an RTG postdoc at Rice University in Houston. She received her Ph.D. at the University of Texas at Austin in 2013 under the direction of Cameron Gordon. Her dissertation work involved the behavior of knot Floer homology under genus two mutation and the classification of knots admitting L-space surgeries. In Davis, she will be joining the Arsuaga-Vazquez Topological Molecular Biology lab. In this group she will be exploring how theoretical disciplines (like knot theory) can be combined with graph theory, statistics, and other applied areas to tackle problems in molecular and cellular biology.

New
Krener Asst. Professor
Chris O'Neill

Originally from the San Francisco Bay Area, Christopher O'Neill began his undergraduate work at San Francisco State University in Computer Science, but later added Mathematics as a second major. He earned a B.A. in Mathematics and a B.S. in Computer Science in 2009, and a Ph.D. in Mathematics from Duke University in 2014. He is still interested in software development and frequently incorporates software packages like Sage, GAP, and Macaulay2 into his research.

Chris' research lies in combinatorial commutative algebra of rings and monoids. He is also interested in discrete geometry and its connections to computation, algorithms, and the development and use of software in mathematical research. As a graduate student, he worked under the guidance of Ezra Miller on questions related to mesoprimary decomposition, used to construct primary

...continued on page 19.


The Undergraduate Program

by Tim Lewis, Undergraduate Program Chair

This past year, the Department of Mathematics awarded 111 undergraduate degrees (93 majors and 19 minors) – up by over 20 from the previous year! 63 students graduated in Mathematics, 21 students graduated in Applied Mathematics, 3 students graduated in Mathematical and Scientific Computation, and 6 students graduated from our new Mathematical Analytics & Operations Research major. Nine of these graduates received citations for outstanding performance, and nine students received Department citations. In addition, Kevin Summers, Christian Smith, Jeff Arata and Samuel Asher completed senior theses. Furthermore, many of last year's graduating students went on to graduate school at prestigious institutions, including University of Michigan, Columbia, and Harvard. Many other graduates went on to jobs as K-12 teachers or got jobs in industry such as Financial Advisors in Insurance Companies. These achievements testifies to the commitment and dedication of our students.

We began the 2016-2017 academic year by welcoming the largest incoming class in the history of the Mathematics Department. With this large influx, the total number of students in our four majors is now over 750, including 106 in the new Mathematical Analytics and Operations Research program!

The Math Department places great importance in providing our students with a supportive and encouraging environment throughout their time with us. All of our students were invited to attend our Undergrad Welcome Event, which took place on September 27th. At the event, we discussed the great things that one can do with a major in mathematics. We also talked about the importance of starting early to plan their individual program of study in concert with the staff and faculty advisers. We stressed that we are here to help all our students succeed, and we described the multiple sources of support that are available when needed.

A variety of activities are designed to foster this atmosphere. Two important mathematics interest groups are focused on undergraduates. The Math Club meets weekly (Wednesdays 5:30-7:30pm in the Mathematical Sciences Building). It provides a place where students with common interests in mathematics can meet and socialize, and learn about a variety of topics in current mathematics research. All mathematics students are also welcome at the Math Café, where faculty and graduate student volunteers are available to tutor any student in any course.

In response to a college-wide directive, the Mathematics Department is implementing a new mandatory advising model for our students. This model combines online assessment with individual advising appointments and group advising events, focusing adviser time and effort to maximize impact on student success. We believe that this initiative will increase the level of communication between students and faculty and staff, smooth students' progress through our programs, better prepare our students for life after college, and develop a stronger community within our programs.

To help with the increased advising load, we have added a new member of our student advising team — Stephanie Myers. Stephanie recently graduated with an AB in Human Development and Psychology at UC Davis. She worked as an orientation leader, and she was a student assistant in the UC Davis Office of Student Support and Judicial Affairs, as well as Undergraduate Admissions. Undergraduate advising sparked Stephanie's interest when she was able to see the behind the scenes working as an adviser in the various positions on campus. Stephanie enjoys cooking and hiking ... and laughing a lot. Welcome to the team, Stephanie!

The Department of Mathematics continues to expand our course offerings and to hone its curriculum to enhance the experience of our undergraduate students and to attract more students to mathematics. This year, we will offer three special topics courses for undergraduates (MAT 180): "Surfaces" (Prof. Jennifer Schultens) in the fall quarter, "Analyzing Structural Molecular Biology using Topological Methods" (Profs. Mariel Vazquez and Javier Arsuaga) in winter quarter, and "Mathematical Algorithms for Big Data Analysis" (Prof. Thomas Strohmer) in the spring quarter. Also, we will be introducing a new one-unit seminar course, "Careers and Resources in Mathemat-

ics”, in the spring quarter.

Once again, the Department ran a vigorous Research Experience for Undergraduates (REU) program over the summer. Students worked on a variety of projects spanning pure and applied mathematics. Many of the students who participated in this Summer REU displayed posters of their work at the Fall Welcome event, and they will present their research in the UC Davis Undergraduate Research conference.

To see samples of the research that our students have done and to get information on how to get involved in undergraduate research visit

http://math.ucdavis.edu/undergrad/research

Undergraduate research is a great way to jump start a mathematics career!

There are many opportunities available in the Department for enrichment of the undergraduate experience. Everyone is welcome; please join us!

The Graduate Programs

by Sasha Soshnikov, Graduate Program Chair and Matthias Köppe, GGAM Chair

This year the Graduate Program in Mathematics welcomed 11 new graduate students. The total number of students in the program is 61. The Graduate Program in Applied Mathematics (run by GGAM) welcomed 17 new graduate students this Fall, 16 to the Ph.D. program and 1 to the M.S. program. They were selected from a highly competitive pool of applicants. This brings our number of graduate students currently in the Applied Mathematics program to 54.

Several graduate students received prestigious prizes during the 2015–2016 academic year. Shuyang Ling (Math) won the MPS Dean’s Graduate Student Prize for his research in inverse problems. Yuan Zhou (Math) received an Honorable Mention in the 2016 Mixed Integer Programming poster competition. We are also pleased to see that our recent Ph.D. graduates are doing well. Robert Hildebrand (Ph.D., 2013) received the prestigious Herman Goldstine Memorial Postdoctoral Fellowship at IBM Research for 2015–2016. Jeff Irion (Ph.D., 2015) received the 2016 JSIAM Letters Best Paper Award together with his coauthor and adviser, Professor Naoki Saito.

The Department and its graduate programs hosted numerous distinguished visitors during the year. Notable highlights include colloquium talks by Peter Constantin, the John von Neumann Professor and Director of PACM at Princeton University; Charles Fefferman, a Fields Medalist and the Herbert Jones Professor at Princeton University; and Professor Gregory Seregin from Oxford University.

The scientific activities of GGAM included two GGAM Colloquia with distinguished speakers: Professor Raissa D’Souza (Computer Science and of Mechanical Engineering, UC Davis) and Professor John Hunter (Mathematics, UC Davis). The GGAM Miniconference, an annual day-long event bringing together the faculty and students of GGAM to share research problems and results, was held in February.

Our Mathematics and Applied Mathematics graduates go on to successful careers in academia and industry. As examples, this year two of our graduates, Brandon Dutra and Reuben La Haye (adviser: Professor Jesus De Loera), joined the research staff at Google. Axel Saenz-Rodriguez (adviser: Professor Motohico Mulase) joined the University of Virginia as a Pitts Postdoctoral Fellow.

GGAM is growing with the launch of the new website. We welcome new members from the Statistics and Computer Science departments: Dr. Miles Lopes, Dr. Cho-Jui Hsieh, Dr. James Sharpnack, Dr. Dave Doty, and Dr. Xiaodong Li. We are happy to see the successful trajectory of growth.

Are You a Graduate?

We want to hear from you! Please send us information about yourself so that we can stay in touch and share in your experiences outside of UC Davis.

Please complete our Alumni Questionnaire:
http://www.math.ucdavis.edu/news/alumni_quest
or send e-mail to:

mso@math.ucdavis.edu

We will do our best to include it in the next newsletter.

Life After Davis

Yvonne Kemper
Ph.D., 2013

After graduate school (and after taking several months to travel around Europe and Northern Africa), I worked as a post-doc in the Applied and Computational Mathematics Division at the National Institute of Standards and Technology (close to Washington DC). In the second year there, however, I found out about a position in the research group of Ilse Fischer, at the University of Vienna. I sent her my CV, crossed my fingers, and eight months later I moved to Vienna!

I am currently a postdoc in the combinatorics group at the University of Vienna in Austria. My position consists of research, and all the associated responsibilities (and opportunities!). That is, I spend a lot of my time reading, writing, and thinking about different problems, but also attending and/or speaking at seminars, conferences, and workshops. One of my favorite parts of the job is the fact that I get to travel so much: this year alone I went to Switzerland, France, Colombia, Canada, and Germany, as well as to various cities within Austria.

I think one of the most important aspects of my graduate experience at Davis is that it had many different aspects! That is, as a graduate student, I not only had the chance to work with many excellent people, I had opportunities to participate in outreach programs, organize seminars and conferences, have an active role in various committees, and work with younger students. In addition, the availability of travel funds allowed me to attend conferences all over the world — I still talk to and work with some of the people I met during these travels. And, of course, I have to mention the supportive and enthusiastic community at Davis. I was encouraged in my interests and aided in my goals, and I am grateful to everyone who helped me along the way.

I always have a strong passion for traveling around the world (while doing math!). In between undergrad and grad school I rode the Trans-Mongolian railroad from Moscow to Ulaanbaatar, and then in a jeep to Beijing, and in between grad school and my post-doc at NIST, I walked the Camino from St. Jean Pied de Port to Finisterre. I currently sing in the Wienerbeschwerdechor (the Vienna Complaining Choir), and am planning a cycling trip in Montenegro.

Corina Putinar:
The Algorithm of Mentorship
originally published by UC Davis Stories

Without math, we would be less protected, less informed and literally lost.

Math makes possible Internet security, Google searches and GPS technology. Yet many people fear it, mathematics professor Jesús De Loera says.

“They only learn the most boring aspects in school, never seeing its playful, inquisitive elements,” he says. “They never learn its relevance and beauty.”

De Loera uses math to find the best way to solve real-world problems — research called optimization — and encourages students like Corina Putinar to experiment with new forms of research.

After taking a linear algebra class from De Loera in her second year, Putinar joined his undergraduate research team. Under his mentorship, she’s grown passionate about being on the front line of problem solving and applying new algorithms to continually improve solutions.

The senior computer science major from Santa Barbara credits De Loera with inspiring her to get more involved with math events, including the UC Davis Undergraduate Research, Scholarship and Creative Activities Conference, where she presented a research paper last year.

“Professor De Loera is a mentor to me because he is passionate about his research, mathematics and the applications of mathematics,” Putinar says.

De Loera describes Putinar as dedicated, enthusiastic and positive — a great communicator and team player.

Now, both say they want to encourage others. For Putinar, that means showing fellow undergraduate students the value of pursuing research and leadership positions on top of their normal class load.

For his part, De Loera is interested in educating more women and minority groups in math to ensure a healthy economic future for California.

“As great as I think my books and research publications are, I am even more proud of the many students I have trained and influenced,” he says.

UC Davis mathematics professor Jesús De Loera mentors senior Corina Putinar. Having graduated, Putinar plans to pursue a career that melds her technical and theoretical skills in mathematics and computer science.

Faculty Mentor
Jesús De Loera

“They only learn the most boring aspects [of math] ... They never learn its relevance and beauty.”
Jesús De Loera

Mathematics for the Future

The Department of Mathematics wishes to thank all alumni, parents, students, faculty, staff and friends who support the Department each year. For a list of our endowed funds, please see our web site:

http://www.math.ucdavis.edu/about/donation/

Your gift to the Department is tax deductible, and you can choose to have your name published or remain anonymous.

Your gift can be used towards undergraduate and graduate support, faculty and research support, and/or Departmental priorities. Your gifts ensure our future success.

Give Online

If you would like to give, please go to the UC Davis secured giving site at:

https://give.ucdavis.edu/MATM

Please choose “Mathematics General Support” for the gift designation and follow the prompts.

A list of donors can be found on the back cover of this newsletter. Thank you for your continuing support.

We appreciate the many donors who double or triple the impact of their gifts through their employers’ matching gift program. For more information about matching gifts, you can go to:

http://matchinggifts.com/ucdavis/

For additional questions please contact the Development Office at (530) 752-3429. For your reference, disclosures can be viewed at:

http://giving.ucdavis.edu/ways-to-give/disclosures.html.

Research Highlight

Eugene Gorsky

Eugene Gorsky is an assistant professor who joined the Department in 2014, researching knot theory and representation theory. This year he won the 2016 Hellman Fellowship, an award whose goal is to support the research of promising early-career scholars who exhibit the potential for great academic distinction.

Read More by Gorsky

You can read more about the research this article is based on at the arXiv:

http://www.arxiv.org/

Immersed concordances of links and Heegaard Floer homology. arXiv:1601.07507

Cable links and L-space surgeries. arXiv:1502.05425.

Flag Hilbert schemes, colored projectors and Khovanov-Rozansky homology,. arXiv:1608.07308.

A Knotty Problem

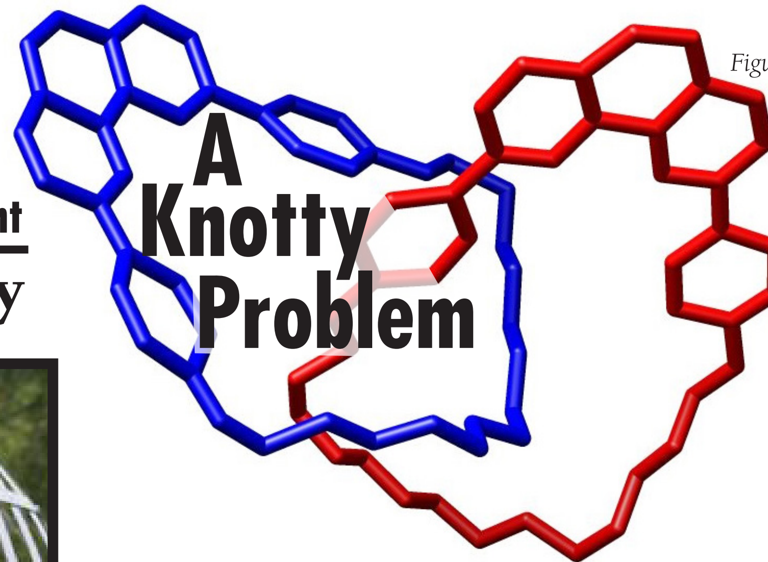


Figure 1

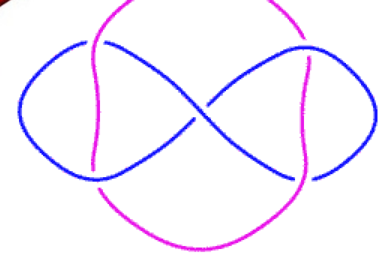


Figure 2

The research of Eugene Gorsky focuses on the study of various invariants of knots and links using the methods from algebraic geometry, representation theory and combinatorics. A knot is a closed curve in three-dimensional space, whereas a link is a collection of several such curves. Knot theory can be applied to the study of long molecules: the 2016 Nobel Prize in Chemistry was awarded to researchers who constructed a new type of molecules called "catenanes" consisting of several linked loops (see Figure 1). Although the loops are not connected by chemical bonds, being linked, they can move around freely without separating. These properties eventually enabled the development of molecular machines in which different parts can move independently in a controlled way. Although we will not elaborate it here, knot theory is also related to the 2016 Nobel Prize in Physics, concerning the entanglement of quantum particles on the plane.

Two knots or links are equivalent if one could be transformed to another one by a continuous deformation and stretching (without tearing). For example, Figure 2 shows a link with two components. Each component separately is a trivial knot (equivalent to a circle), but they cannot be untangled. However, if one modifies the central crossing, the components can be easily separated. This simple example motivates the following basic questions in knot theory: Is a given knot or link trivial? Could one untangle its components? If not, what is the minimal number of crossings that should be changed so that the components can be separated?

All these questions are usually answered with the help of link invariants. An invariant is a quantity that does not change under the deformations of a link. If two links have different invariants, they cannot be deformed into each other. The number of components is the most obvious invariant, but in the last decades a whole zoo of link invariants have been found: Alexander, Jones and HOMFLY-PT polynomials are just a few. Heegaard-Floer homology and Khovanov-Rozansky homology are more recently developed tools that have been successful in producing lower bounds for the unknotting numbers. Despite having a lot of common features, they are defined in a completely different way: Heegaard-Floer homology is defined in terms of the differential geometry of the 3-space and a knot in it, while Khovanov-Rozansky homology has a purely combinatorial definition based on a link diagram such as in Figures 2 and 3.

Heegaard-Floer homology was originally defined using analytic tools such as counting solutions of some partial differential equations. Later explicit formulas for these invariants were found for various classes of knots. They enabled topologists to compute unknotting numbers for such knots and to prove a lot of long-standing conjectures in topology. However, the mere computation of these invariants for links with several components is not an easy task. In a series of joint works with Jennifer Hom (Georgia Tech) and Andras Nemethi (Renyi Mathematical Institute, Hungary) Gorsky found an explicit description of these invariants for several classes of links with arbitrary number of components. This opens a possibility to study the topological properties of links with the same tools that were already developed for knots, and their generalizations.

A joint paper of Gorsky with Maciej Borodzik (University of Warsaw, Poland) studies the splitting numbers of links. Imagine that the components of a link are rigid, and one is allowed only to change crossings between different components. What is the minimal number of crossings needed to be changed to separate the components? In general, only a few bounds for a splitting number are known, and they are usually far from being optimal. For example, if in the Figure 3 one pulls the blue circle "out of the plane," one needs to

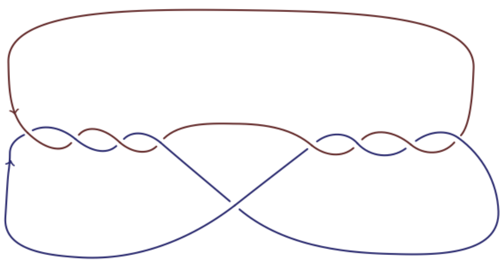


Figure 3

change 4 crossings between it and the second circle to separate them. Borodzik and Gorsky found a new bound for the splitting number of two-component links using Heegaard-Floer homology and proved that one always needs to change at least 4 crossings in this case.

Despite having a more combinatorial definition, Khovanov-Rozansky homology is much harder to compute. Even for torus knots (the simplest class of knots) no closed formula for Khovanov-Rozansky homology is known. In a series of joint papers with Andrei Negut, (MIT), Alexei Oblomkov (UMass Amherst), Vivek Shende (UC Berkeley) and Jacob Rasmussen (Cambridge University) Gorsky have proposed several conjectures relating the Khovanov-Rozansky homology to the geometry of the configuration space of points in a 4-dimensional space. The structures appearing in these conjectures are closely related to combinatorics of lattice paths and representation theory of double affine Hecke algebras. If true, they would give a very effective way of computing these knot invariants. Some of these conjectures have been recently proved by Matt Hogancamp (USC) and his collaborators. It is hopeful that this line of investigation will yield the full proof of the remaining conjectures.

Graduate Degree Recipients

Barnett, Nix : Ph.D., Applied : *Mechanisms within the Black Box: Prediction, Computation, Randomness, and Complexity of Input-Output Processes via the E-Transducer*, Crutchfield

Brattain-Morrin, Eric : Ph.D., Applied : *The Completeness of the Bethe Ansatz for the Asymmetric Simple Exclusion Process*, Tracy : Assistant Professor , SUNY New Paltz

Dutra, Brandon : Ph.D., Applied : *Decomposition Methods for Nonlinear Optimization and Data Mining*, De Loera : Google Research Staff, Google Inc.

Halabi, Ryan : Ph.D., Applied : *Surface Plasmon Polaritons in Nonlinear Media*, Hunter

Irion, Jeff : Ph.D., Applied : *Multiscale Transforms for Signals on Graphs: Methods and Applications*, Saito : Postdoctoral Researcher, Bosch

Kopel, Philip : Ph.D., Applied : *Hermitian and Non-Hermitian Random Matrix Theory*, Soshnikov

La Haye, Reuben : Ph.D., Math : *Quantitative Combinatorial with Applications to Number Theory and Optimization*, DeLoera : Google Research Staff, Google, Inc.

Lydon, Mark : Ph.D., Math : *On the Chromatic Symmetric Function of Graphs*, Babson

Miller, Jacob : Ph.D., Math : *Transportation Networks and Matroids:Algorithms through Circuits and Polyhedrality*, DeLoera : Data Analyst, All State Insurance

Mossessian, George : Ph.D., Math : *Stabilizing Heegaard Splittings of High-Distance Knots,* Thompson : Software Engineer, Constructorio

Navarro, Gustavo : Ph.D., Math : *Local well-posedness and Global stability of the Two-Phase Stefan problem*, Shkoller

Patel, Swati : Ph.D., Applied : *The Effects of Ecological and Evolutionary Feedbacks on Community Dynamics*, Schreiber : Postdoctoral Researcher, University of Vienna

Qin, Chuan : Ph.D., Applied : *Card Shuffles, Genome Rearrangements, and Social Networks,* Morris : Senior Financial Economist, Securities Litigation and Consulting Group

Saenz-Rodriguez, Axel : Ph.D., Math : *Integrability and Tau-functions on Random Walkers & Isomonodromy Deformation Systems*, Mulase : Post-Doc, University of Virginia

Schenthal, Kevin : Ph.D., Math : *On the Free-Boundary Euler-x Equations and the a-0 Water Waves Limit*, Shkoller : Vice President, Professional Boundaries, Inc.

Stein, David : Ph.D., Applied : *The Immersed Boundary Smooth Extension (IBSE) Method: A Flexible and Accurate Fictitious Domain Method, and Applications to the Study of Polymeric Flow in Complex Geometries*, Thomases

Tian, Ruoguang (Roger) : Ph.D., Math : *Top to Random Shuffles and Characterization of Rigged Configurations of B(oo) in Type A*, Schilling

Weaver, Chelsea : Ph.D., Math : *Analysis and Extension of Sparse Representations in Signal Classification*, Saito

Westenberger, Christopher : Ph.D., Math : *Knots and Links from Random Projections*, Babson : Research Assistant, FactSet

Young, Amanda : Ph.D., Math : *Spectral Properties of Multi-Dimensional Quantum Spin Systems*, Nachtergaele : Postdoctoral Research Associate, University of Arizona

Corliss, Joseph : M.S., Applied

Docken, Steffen : M.A., Applied

Hu, Yang : M.S., Applied : Bai

Johnson, Benjamin : M.S., Applied

Li, Lu : M.S., Applied : Fannjiang

Ling, Shuyang : M.S., Applied : Strohmer

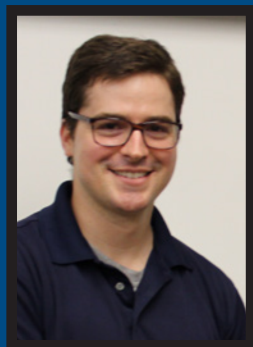
Liu, Xiaochen : M.A., Math

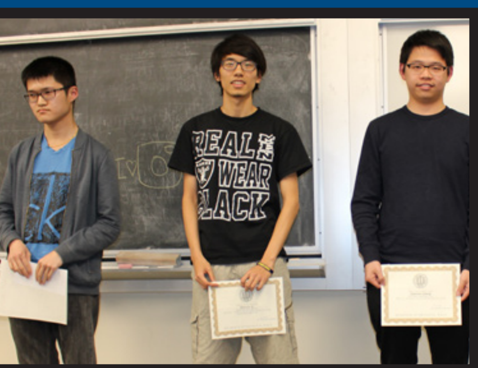
Shu, Jingyang : M.A., Math

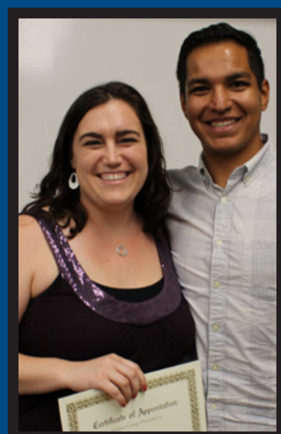
Wan, Ning : M.S., Applied : Bai

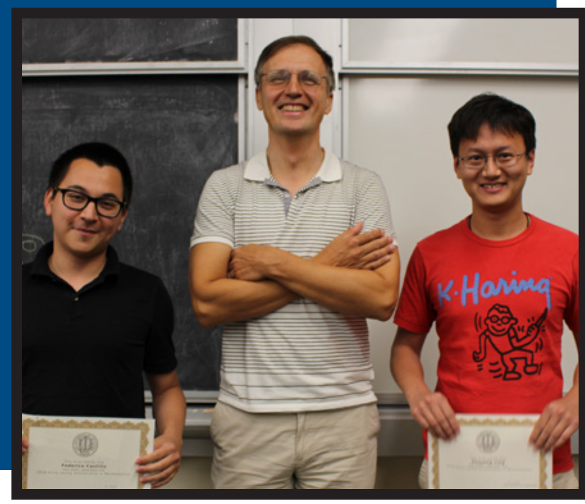
Wang, Yutong : M.A., Math

Department Awards









G. Thomas Sallee Mathematics Teaching Award

The G. Thomas Sallee Mathematics Teaching Award honors Professor Emeritus Tom Sallee's 40-year career with the Department, his dedication to being an excellent teacher, and his life goal of developing and supporting talented mathematics educators.

An endowment was established in his name that allows the Department to recognize the best teaching of lower-division mathematics courses on an annual basis.

Recipient – Edward Tavernetti, Ph.D.

G. Thomas Sallee Mathematics Prize

This award is also given in recognition of Professor Emeritus Tom Sallee, and reaffirms his life goal of developing and supporting talented individuals in mathematics. This prize recognizes exceptional undergraduate students of junior or senior standing who competed in this year's Spring Mathematics Competition.

Recipients – Jiannan Jiang, Steven Li and Junyu Ge

William K. Schwarze Scholarship in Mathematics

William Karl Schwarze was born in 1942 in San Francisco. He excelled in mathematics in high school and at UC Davis, where he received a bachelor's degree. He went on to graduate school at Berkeley and a career as a mathematics teacher in San Francisco. Perhaps due to his mathematical insights, Bill also became a successful investor in real estate. After his death in 1988, a trust he established with the SF Foundation has donated to a variety of humanitarian purposes, in particular to the Schwarze Scholarship to be presented today. This award is given to graduate students in Mathematics who have demonstrated outstanding mathematical scholarship and exceptional promise of making a strong professional contribution as a mathematics teacher and educator at the pre-college or college level.

Recipient – Jamie Haddock

Robert Lewis Wasser Memorial Scholarship

Robert Lewis Wasser was born in 1973 in Sacramento. He excelled in many areas—he was selected as a National Merit Scholar in 1991 and participated in the Academic Decathlon. Robert began at UC Davis in 1991. His academic achievements were numerous and impressive. He was one of the few students in our Department who had already taken as a sophomore some of our most challenging courses, such as Math 127. His instructor in that course, Professor Don Chakerian, said how much he was inspired by their discussions and that Robert's presence made the whole class much more lively and spirited. After his tragic death in an automobile accident in 1993, prior to his Junior year, his grandmother, Vera May Wasser, initiated the Robert Lewis Wasser Endowment in his memory, with contributions from family and friends. Its goal is to benefit promising mathematics students at UC Davis.

Recipient – Jiannan Jiang

Eric C. Ruliffson Scholarship in Mathematics

Eric Canady Ruliffson attended UC Davis from 1964-1968, loved the study of math and excelled in it. He was first and foremost a problem solver, which helped him to achieve life-long personal and professional success. While attending UC Davis, Eric worked as a summer intern in the actuarial department of Pacific Mutual Insurance in Los Angeles and was hired by them upon graduation. After serving in the Navy, Eric attended graduate school in demography at UC Berkeley. In 1973 he resumed his actuarial career at Pacific Mutual Insurance. He became a partner at the San Francisco office of Coopers & Lybrand and named a Fellow in the Society of Actuaries. He was subsequently elected to the Board of Partners for Coopers and Lybrand, the first actuary to be so honored, and later served on the Board of Partners for PricewaterhouseCoopers, the world's largest consulting firm. The Eric C. Ruliffson Scholarship in Mathematics is awarded annually to students of junior or senior standing majoring in mathematics.

Recipients – Bryan Villegas and Phuong Le

Alice Leung Scholarship in Mathematics

Alice Siu-Fun Leung received a Master's degree in Mathematics in 1975 from UC Davis. She later worked as a global property management accountant in Hong Kong. She remembered with fondness her days at UC Davis. She enjoyed gardening and working as a volunteer helping animals.

In her will, Ms. Leung generously provided funding to award scholarships annually to graduate students in Mathematics. This award is given to students who have shown exceptional promise in all aspects of mathematics, including research, scholarship and teaching.

Recipients – Federico Castillo and Shuyang Ling

Yueh-Jing Lin Scholarship in Mathematics

Yueh-Jing (Jean) Lin and Chau-Hsiung (Mike) Chuang created the Yueh-Jing Lin Fund in 2009. This endowment provides scholarship support to one or more mathematics students each year. The scholarships are available to high-achieving mathematics students, either undergraduate or graduate. Mr. and Mrs. Chuang are alumni of UC Davis who met while they were graduate students on campus. Jean received her Master's degree in mathematics in 1971, and Mike received his master's degree in agricultural education in 1969.

Recipients – Olivia McQuigan and Hannah Polterock

Henry L. Alder Award

Professor Henry L. Alder received his Ph.D. from UC Berkeley in 1947. After spending a year on the faculty in the Department of Mathematics at Berkeley, he joined the Davis faculty as an Instructor of Mathematics. He advanced to the rank of Professor in 1965, and officially retired in 1992. He then served as Department Chair from 1992 to 1994. After his retirement, Professor Alder continued to teach in the Department for many years.

Professor Alder was also active in other campus programs and was always a strong advocate for quality teaching. In 1999, Professor Alder gave a gift to the UC Davis Foundation to establish an endowment. This provides support to mathematics graduate students at UC Davis through the Henry L. Alder Prize for Excellence in Teaching, an award given each year to the graduate student who is deemed to be the top teacher among all graduate students in mathematics.

Recipients – Jacob Miller and Tynan Lazarus

Evelyn M. Silvia Scholarship for Future Mathematics Teachers

The Evelyn M. Silvia Scholarship for Future Mathematics Teachers was established by generous donations from family and friends of the late Professor Evelyn Silvia. Evelyn was hired by the Department in 1973 after receiving her Ph.D. from Clark University. The focus of Evelyn's passion and unwavering commitment was to develop talented mathematics teachers at the K-12 grade level. She was extremely generous with her time, whether it was as a campus committee member or as an adviser assisting students.

This scholarship honors Professor Silvia's memory by encouraging students who aspire to be future mathematics teachers. It recognizes a junior or senior with a major in mathematics, applied mathematics or statistics who has shown an interest in teaching mathematics.

Recipient – David Williamson

Galois Group Service Award

The Galois Group is "the official voice of the graduate students in Mathematics." All graduate students in the Department of Mathematics are members of Galois; this is how graduate students in mathematics collectively communicate with Department faculty and staff. The group also coordinates and facilitates various activities, such as Monthly Game Nights and New Student Welcomes.

Every year, the Galois Group presents an award to recognize outstanding service and/or sustained commitment to the graduate group.

Recipient – Sarah Driver

Departmental Citation Awards

The Department recognizes undergraduate students of exceptional ability who have taken both a very strong selection of mathematics courses and have made substantial contributions to the Department or their program. In addition, they have all received strong recommendations from the faculty.

Recipients –

Samuel Asher, Maya Nelson,
Kathryn Ely, Olivia McGuigan,
Darya Chumakova,
Hannah Polterock,
Benjamin Souvey, Season Yang,
Brett Williams

Citation for Outstanding Performance

These citations honor undergraduates who have taken a very strong selection of mathematics courses and distinguished themselves with exceptionally high grade point averages.

Recipients –

Samuel Asher, Christian Smith,
Kathryn Ely, Jeffrey Arata,
Darya Chumakova, Grace Gordon,
Matthew Luszczak,
Hannah Polterock, Season Yang

Research Highlight

Naoki Saito

Analyzing Data on Graphs and Networks

In recent years, the advent of new sensors, measurement technologies, and social network infrastructure has provided many research opportunities for recording data of interest at various locations in complex networks, visualizing and analyzing complicated interconnected network structures, and making inferences and diagnostics. Network-based problems are ubiquitous: They appear in biology and medicine (e.g., voltages at dendrites connected to neurons, blood flow rates in a network of blood vessels); computer science (e.g., Internet traffic, email exchanges); electrical engineering (e.g., sensor networks); hydrology and geology (e.g., river flow measurements in a ramified river network); and civil engineering (e.g., traffic flow on a road network), to name just a few. Consequently, there is an explosion of interest and demand to analyze data sampled from irregular grids, graphs, and networks.

What about the mathematical and computational tools for analyzing such datasets? Time-honored harmonic analysis tools such as Fourier and wavelet transforms have been the "crown jewels" for examining regularly-sampled data. These tools have a wide range of applications, e.g. data compression, image analysis, and statistical signal processing. However, these conventional tools cannot directly handle datasets recorded on general graphs and networks: a fundamental difficulty is a lack of a proper notion of *frequency* on general graphs.

In collaboration with his former Ph.D. student Jeff Irion, Naoki Saito has developed the *Hierarchical Graph Laplacian Eigen Transform* (HGLET) and the *Generalized Haar-Walsh Transform* (GHWT). These transforms generate a redundant collection of basis vectors called basis dictionaries, consisting of a large number of orthonormal bases through which one can view an input signal defined on the graph nodes from many different perspectives. The fast best basis algorithm can select an orthonormal basis from these dictionaries that is most suitable (or offers the "best view") for a given task, such as compression and classification. In the graph setting, HGLET and GHWT are true generalizations of classical hierarchical block discrete cosine transform and Haar-Walsh wavelet packets, respectively. Note that these classical tools are adopted for the JPEG and JPEG 2000 image compression standards. The essential idea behind them is as follows:

1) generate a hierarchical set of subgraphs by recursively bipartitioning a given graph; and

2) compute the expansion coefficients of an input signal on the nodes of each subgraph relative to the eigenvectors of Laplacian matrix for that subgraph (HGLET) or the basis vectors generated by recursive averaging and differencing operations (GHWT). Note that the Laplacian matrix of a graph is an analog of the finite difference approximation of the Laplace operator for the graph. Hence it is natural to use its eigenvectors for analyzing data on the graph: sines and cosines are the central objects

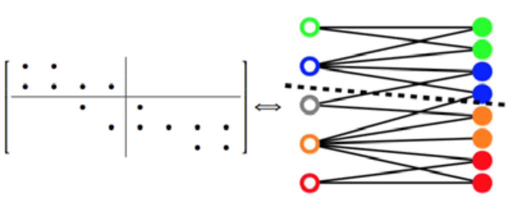
Read More by Saito

Naoki Saito, at UC Davis since 1997, was awarded Best Author and Best Paper presented to him by the Japan Society for Industrial and Applied Mathematics in connection with two of his recent papers.

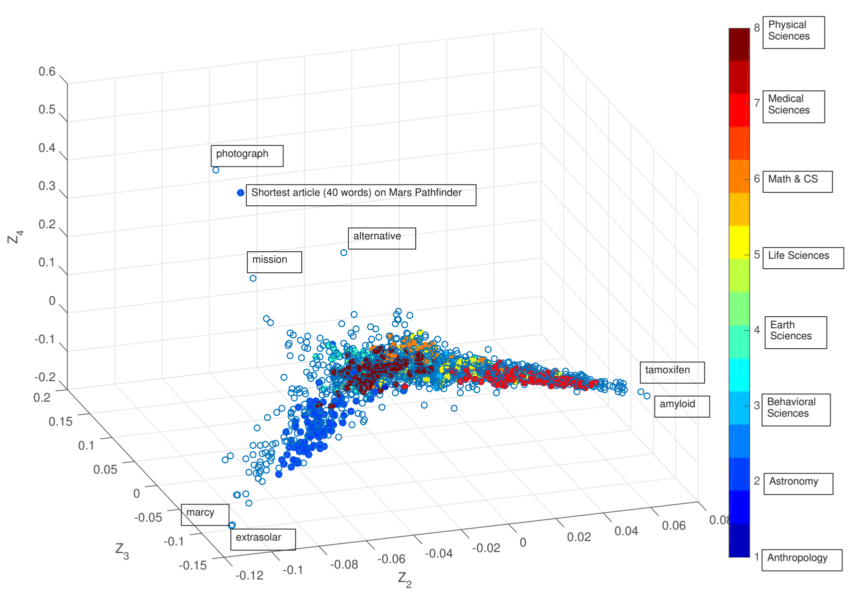
Numerous articles can be found online at Saito's publication list:

www.math.ucdavis.edu/~saito/publications/

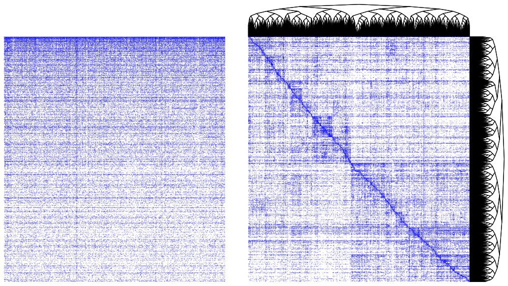
Figure 1: A small scale matrix (•= nonzero entries) and its bipartite graph representation (a); Words/documents embedded in the 2nd, 3rd, and 4th bipartite graph Laplacian eigenvectors of the Science News database (b).



(a) A small matrix of size 5x8

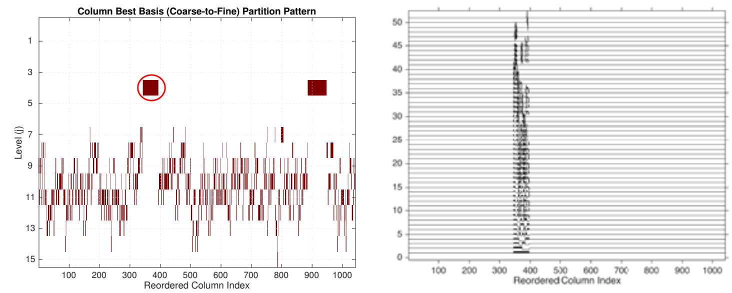


(b) Embedding of the Science News matrix data (1153x1042)



(a) Original order (b) Rows/cols reordered

Figure 2: The sparsity pattern of the original Science News matrix is shown in (a) while (b) is the result of reordering its columns and rows by the Irion-Saito algorithm; (c) the partition pattern of the columns by the column best basis; and (d) some of the corresponding basis vectors.



(c) Column partition (d) Basis vectors on ○

in classical Fourier and Harmonic Analysis; they are nothing but the eigenfunctions of the Laplace operator on an interval subject to certain boundary conditions.

One of the important emerging applications of these newly developed tools is analyzing matrix data. For example, ratings of commercial products by their users lead to a matrix in which columns represent products, rows represent users, and matrix entry a_{ij} represent user *i*'s rating of product *j*, say, on a 1–5 scale. Another example is a *term-document matrix*. Here, the rows correspond to words and the columns correspond to documents, and matrix entry a_{ij} is typically the (relative) frequency with which word *i* appears in document *j*. In the case that the documents are journal articles from different fields, one would expect the prevalence and absence of certain words to be relatively consistent across documents from within each field. Such matrices are quite different from usual images and photographs. In fact, they are often more like shuffled and permuted images, possessing *no spatial smoothness or coherency* in general. Yet, those rows and columns are interrelated, and thus the rows of the matrix can tell us about the underlying structure of the columns, and vice versa. But how can we do that? Tools developed by Irion and Saito now come to our rescue. They allow us to discover, learn, and exploit hidden dependency and geometric structure in the matrix data in an innovative way. Here is their strategy:

Step 1: Apply *spectral co-clustering* to a given matrix in order to recursively bipartition its rows and columns

Step 2: Analyze row vectors of the input matrix using the GHWT dictionaries based on the column partitions and extract the basis that most *sparsifies* its column representation, i.e. *the column best basis*

Step 3: Repeat Step 2 with interchanging columns and rows to extract the *row best basis*

Step 4: Expand the input matrix with respect to the *tensor product* of the column and row best bases

Step 5: Analyze the expansion coefficients for a variety of tasks, e.g., compression, classification, etc.

In Step 1, the *spectral co-clustering method*, initially developed by I. Dhillon in 2001, is recursively applied to an input matrix to organize its rows and columns. Given a nonnegative data matrix *A*, Dhillon's method treats its rows and columns as the two sets of nodes in a *bipartite* graph, where matrix entry a_{ij} is the edge weight between the node for row *i* and the node for column *j*. Fig. 1a illustrates a small scale example. Using the *Fiedler* vector, i.e. eigenvector corresponding to the smallest positive eigenvalue of the Laplacian matrix of the resulting bipartite graph, the rows and the columns of *A* can be partitioned simultaneously. Here is a real example: the term-document matrix consisting of 1042 columns representing documents obtained from the *Science News* website and 1153 rows representing preselected most relevant words. Each document belongs to one of the eight categories ranging from Anthropology to Physics. Fig. 1b shows that both words and documents are embedded in the same Euclidean space using the spectral co-clustering! At the left side of the boomerang shape cluster, a majority of documents are of Astronomy (blue points) and the related words (e.g. *extrasolar*) are clustered closely to those documents while the right side of the boomerang mainly consists of Medical Science documents (red points) and the related words (e.g., *tamoxifen*).

Fig. 2b shows the reordered matrix using the Irion-Saito algorithm; the total number of orthonormal bases searched via their algorithm exceeds 10^{370}. It is reassuring to see that the resulting best basis does in fact sparsify the input matrix nicely. However, the fine scale information may be too much emphasized in the original algorithm, which may be sensitive to "noise." More robust and useful information is contained at the *medium scale* coefficients in this matrix. To emphasize such coefficients, one possibility is to *weight* all the coefficients in the GHWT dictionaries depending on the size of the subgraphs so that the magnitude of the finer coefficients become bigger, which discourages the best basis algorithm from selecting fine scale subgraphs. This new best basis sparsifies *A* less than before, yet well captures information on intermediate scales as shown below. Fig. 2c shows the partition pattern of the column best basis: the vertical axis indicates the scale information from the top (the coarsest) to the bottom (the finest) whereas the horizontal axis indicates the reordered column indices. In this figure, two coarse scale blocks stand out; one of them is marked with the red circle. Fig. 2d shows the column best basis vectors corresponding to the coefficients marked by the red circle in Fig. 2c, whose support corresponds to 51 documents with 48 belonging to Astronomy. The titles of the remaining three turn out to be the following:

- "Old Glory, New Glory: The Star-Spangled Banner gets some tender loving care" (Anthropology; on the preservation of the Star-Spangled Banner (flag) using the space-age technology)
- "Snouts: A star is born in a very odd way" (Life Sciences; on star-nosed moles)
- "Gravity tugs at the center of a priority battle" (Math/CS; on the priority war on the discovery of gravity between Newton, Halley, and Hooke)

These three articles are picked out along with the Astronomy articles because they contain some astronomical keywords as one can see. Similarly, one can analyze another coarse block in Fig. 2c, which supports 62 documents: 56 of which are in Medical Sciences and the remaining six are non-medical articles that just happen to contain medical terms.

These results are based on the examination of the particular best basis vector and the corresponding coefficients at one intermediate scale. Saito thinks that their approach can further advance the state of clustering and classification of documents by linking information at multiple scales. In collaboration with Eugene Shvarts, a current Ph.D. student of his, Saito has been investigating basis vector selection algorithms that are fundamentally different from the above best basis algorithm. He envisions that these tools will be useful for finding "patterns" hidden in unorganized massive datasets of various kinds.

A Treasure Trove of Fundamental Questions

Emeritus Focus

Roger Wets

Roger Wets entered the "Emeritus" stage of his association with the Mathematics Department about eight years ago. Fortunately, with the encouragement and support of the Department, he was able to continue working on a number of very interesting projects and essentially became a full time "Research Professor."

My present research interests can be roughly divided in two major thrusts: (1) *Multi-agents Optimization with Equilibrium Constraints* in an uncertain (or stochastic) environment which is related to a number of classical problems ranging from competitive games, physical and economic equilibrium problems, (stochastic) variational inequalities to minimal surfaces, and (2) a more "applied" project that has been a treasure trove of fundamental questions. Here I shall give a brief account of the problems.

In the US, and similarly in many other countries, ISO (Independent System Operators) must provide individual and industrial consumers with a reliable source of energy (electricity) by entering into delivery-contracts with electricity suppliers; each ISO is reponsible for a specific region, for example, New England, California, the Northwest and so on. Generally, these contracts take into account the predicted load (demand) and renewables-supply for the day-ahead who, in turn, will be based on the day-ahead atmospheric predictions (temperature, cloud cover, humidity, etc.). The selection of an optimal mix of contracts, known in the industry as the *unit commitment problem*, that will minimize the overall cost to the consumers while assuring the electricity grid well-balanced performance turns out to be a *stochastic optimization problem* with binary decision variables (a generator is either turned on or idle).

Because of our expertise in this area, our UC Davis team (Woodruff, me and our assistants) in collaboration with a number of colleagues at Sandia National Labs were selected by Advanced Research Projects Agency-Energy to develop and implement the methodology that would enable the ISO's to find an optimal mix of contracts. We expected that we would have to develop a solution procedure for problems of this type by extending the so called *Progressive Hedging* algorithm, a method that I had proposed earlier (with R.T. Rockafellar), to one that would generate optimal, or nearly-optimal, binary-solutions.

What was unexpected was the lack of usable data to build a probability distribution of the uncertainty about the day-ahead loads and renewables-supply, obviously a key component of the formulation of these (stochastic) optimization problems. Providing robust estimates of these distributions became particularly challenging because only very limited observations are available making classical statistical technology essentially not applicable. This led me to suggest that when deriving estimates in such instances one should supplement the "hard information" (prior observations) with "soft information" that might be explicitly or implicitly available about the random phenomena. This gives rise to constraints in the formulation of the estimation problem. This renders the estimation problem more complex and required a totally new theory that would validate the resulting estimates.

What rendered this approach so compelling was the quality of the actual results when compared with those derived by relying on a more classical approach. However, solving the estimation problem itself presented new challenges: We are dealing with an infinite dimensional constrained optimization problem and to solve it one must approximate it by an appropriate finite dimensional solution before one can rely on existing computational means. With Johannes Royset, we laid the foundation of a function approximation theory when the functions must satisfy constraints (side conditions). The well-developed standard approximation theory cannot deal with such situations mostly because the domain of constrained function is no longer either open or a differentiable manifold (smooth surface); the solution usually lies on the boundary of a closed set.

This work was supported, in part by the National Science Foundation and later, by the Army Research Offce who is particularly interested in the possibility of fusing hard and soft information when assessing particular situations or environments. Rather than phrasing the question in terms of the approximation of continuous or smooth functions, the major concern is with the approximation of *semicontinuous functions* usually only defined on some subset of the underlying space. We showed that any function in this very rich family can be approximated arbitrarily closely by an *epi-spline*, a function defined by a finite number of parameters, which enables us to derive the day-ahead probability distributions of loads and renewables-supply.

Although, I received some minor honors during the last few years, what I valued most was being told by the organizers of the premier meeting in stochastic optimization, "your [two] students represented your UCD program very well." It seems that the future is assured!

Alumni Update

Jeffrey C. Sklar

B.A.S., 1995

After graduating from UC Davis with degrees in both Mathematics and Philosophy, Sklar continued his studies. Branching out into Statistics, in 2004 he became a lecturer in the Department of Statistics and Applied Probability, as well as the Gevirtz Graduate School of Education, at UC Santa Barbara.

In 2005, he joined the Statistics Department at California Polytechnic State University in San Luis Obispo, and has recently become a full Professor there.

He currently lives along the coast of California, in Pismo Beach.

Douglas Harik

B.S., 1971

While at UC Davis, Harik felt he particularly benefitted from Dr. Sallee and Dr. Stein's courses, and appreciated Dr. Milton's teaching style and support. During his studies, Harik didn't realize he was headed towards a teaching career himself. He felt lucky to be steered into the STEP program at Stanford where he received his teaching credential and then started a rewarding career.

A few years after graduating, Harik began teaching Math. From 1973-2009, he taught at Westborough Middle School in South San Francisco, with a short stint at Capuchino High School in San Bruno in 2000.

He is currently retired and living in San Francisco.

Pat McGowan VanderBeek

M.A., 1973

Jerry Martin VanderBeek

B.S., 1970; M.A., 1972

Jerry and Pat VanderBeek both studied at UC Davis, and were married a few years after obtaining their Masters degrees.

Jerry taught high school math full time and community college part time for 35 years. He then served as supervisor of student teachers part time for Chapman College for 3 years until his retirement in 2010. During that time, he also served in the Army National Guard for 36 years, retiring from the 59th Army Band in 2008. Jerry now plays trombone in the Moonlight Swing Big Band in Sacramento.

Patricia taught math in local high schools until she retired. She continues to volunteer in the local elementary school.

They are both very active in their local church in Lotus, as well as in Gideons International.

They have 3 sons and 5 grandchildren, and are currently living in Garden Valley, California.

New KAP

Chris O'Neill

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decompositions of binomial ideals from the combinatorics of monoid congruences. His thesis, titled "Monoid congruences, binomial ideals, and their decompositions," explores several generalizations of mesoprimary decomposition. After assisting Scott Chapman and Vadim Ponomarenko at various summer research programs, he now also studies nonunique factorization in commutative monoids.

Aside from the world of mathematics, Chris' primary hobby is software development. He typically programs in C++ and Objective-C/Cocoa, though he has been known to use Python, Java and Perl on occasion as well. He has worked on a variety of projects, including (but not limited to) Mac apps, iPhone apps, and Gameboy Advance games. Most recently, he was involved in the recoding of an old Mac freeware game Mantra. Long live Saric!

Staff News

by Gladis Lopez

This has been a very productive and exciting year. It is great to experience the energy and enthusiasm that students bring to the Campus and the Mathematics Department. I am happy to share with you that this year we added a new student advising position and hired Stephanie Myers as a student advising assistant. This is a much needed help to meet our student needs as mandatory advising for undergraduate students was implemented in Fall 2016.

Zach Johnson renewed his appointment as MPS IT representative. This assignment requires a very little time commitment and should not impact his position in the Mathematics Department. My appointment split between Mathematics and NEAT has changed and I now have only a 10% commitment with NEAT, allowing me to dedicate most of my time to the Mathematics Department.

This year, a total 75 research proposals were submitted to different granting agencies. A total of 16 proposals were approved for a total of $2,817,157 in funding. We also had a busy year handling academic personnel actions. A total of 13 academic personnel actions (merits and promotions) were processed.

The Campus is rolling out new systems such as Canvas (replacing SmartSite as UC Davis' learning management system-LMS), AggieBuy (e-procurement system replacing UCDBuy), MyDegree (advising tool that allows both students and advisers to track students' progress towards completing a degree) and AggieTravel (replacing MyTravel). We continue to adapt to these changes and continue with our commitment to high quality customer service.

Congratulations are in order for Sarah Driver, Graduate Student Coordinator who received the Galois Service Award; Leng Lai, who completed 20 years of service; and Marianne Waage, who completed 15 years of service at UC Davis. Also, congratulations to Malina Gillies-Doherty and Laura for the arrival of their daughter, Eleanor.

I praise the staff for their hard work and dedication to the Department and look forward to the challenges and opportunities that the new academic year brings.

UC DAVIS MATHEMATICS

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Cover Feature

The cover diagrams feature illustrations from articles that the incoming academic staff felt portrayed their recent research.

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Featuring the 2015-16 Academic Year

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