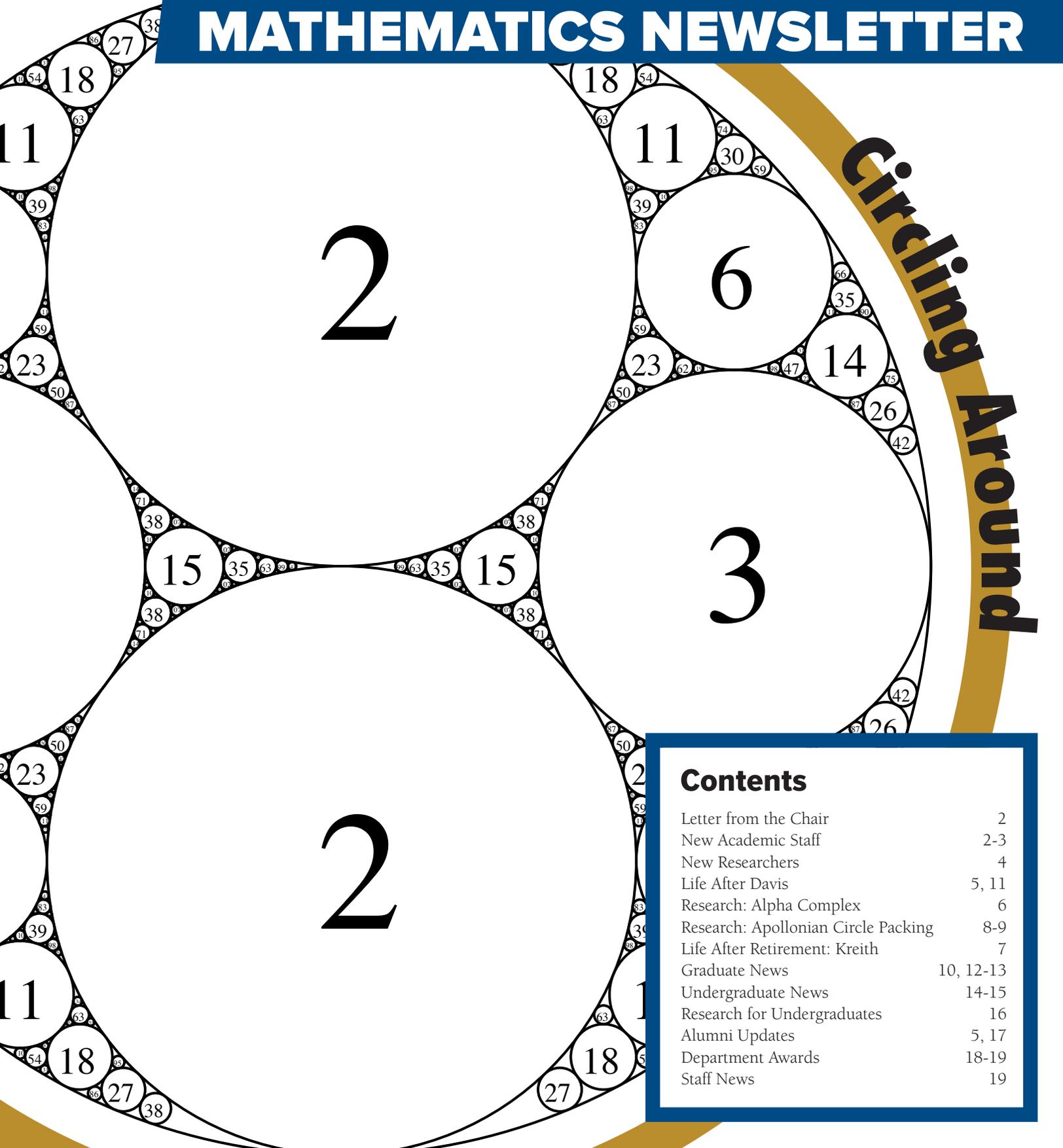


UC DAVIS

MATHEMATICS NEWSLETTER



Circling Around

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LETTER

from the chair

by Bruno Nachtergaele, Department Chair

It is Fall and another academic year is underway. I am still somewhat astonished that I am occupying the Chair's office once more. Inevitably, I think back to the time of my first term (2007-2010). And wow, this Department does not stand still!

We have seen impressive growth in all parameters. The number of students, faculty, lecturers, Krener assistant professors, all have increased by a significant percentage. The pursuit of excellence has been a guiding principle for the Department the past decades. Since 2010, Department members have been awarded 6 CAREER grants, 5 Sloan Fellowships, 9 Hellman Fellowships, 3 Chancellor's Fellowships, 6 distinguished teaching awards at the college or campus level, 15 Fellows of national learned societies, and 9 new Distinguished Professors. At the moment, the Department is hosting 5 postdocs with distinguished fellowships, and several graduate students have been selected for premier fellowships. The research of a majority of our faculty is supported by federal grants. The Department is clearly thriving and unrelenting in its pursuit of excellence.

In the staff office too there are several new people, and also a distinguished long-time staff member in a new role. Last Spring our Chief Administrative Officer Gladis Lopez transitioned to retirement, and Tina Denena succeeded her in that position.

Other things have remained the same. We want to continue our pursuit of excellence in all its aspects. Excellence is a culture that generations of Department members have built up and continue to cherish. We are currently taking advantage of some matching

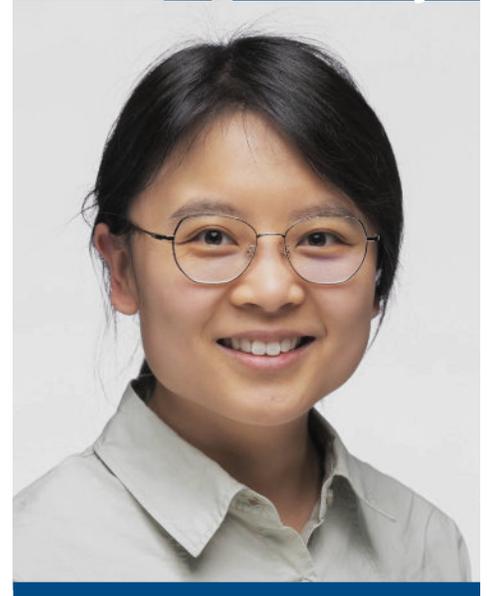


grant opportunities to upgrade our facilities and IT infrastructure. This includes replacing the furniture in the graduate student offices. To be able to complete this project, I hope you'll donate towards Excellence in Mathematics. You can find out how to make a contribution on page 11 of this newsletter.

Together, we have the capacity to make things happen. Since last month, the Craig A. Tracy Research Prize for postdoctoral researchers is fully endowed. The prize recognizes outstanding research by a postdoc or Krener Assistant Professor in the Department. The prize was first awarded to Daniel Martin in 2022 and to Melissa Zhang in 2023. The longevity of this annual award is now secure.

I invite you to find out more about the recent activities of our staff, students, and faculty, including alums, retirees and emeriti, in this new edition of the Department's annual newsletter.

Faculty



Junxian
Li

Junxian Li received her Ph.D. from University of Illinois at Urbana-Champaign under the supervision of Alexandru Zaharescu in 2018. Then she moved to Germany for her postdoc, where she spent a year at Georg-August Universität Göttingen, two years at the Max Planck Institute for Mathematics, and two years at Universität Bonn.

Her research interests lie mainly in number theory, especially questions involving primes, solutions to Diophantine equations and analytic properties of L-functions. Recently she has been using tools from algebraic geometry, automorphic forms as well as harmonic analysis to study these number theoretic questions. She is also interested in exploring the interactions between number theory and dynamical systems.

incoming Academic Staff

Faculty



**Yunpeng
Shi**

Yunpeng Shi joined UC Davis as an assistant professor in mathematics this Fall.

He obtained his Ph.D. in Mathematics from University of Minnesota, where he was supervised by Prof. Gilad Lerman. After his graduation, he joined the Program in Applied and Computational Mathematics (PACM) at Princeton University, working with Prof. Amit Singer from 2020 to 2023 as a postdoctoral research associate.

His research is centered on developing fast and robust algorithms for 3-D reconstruction.

KAP



**Jarosław
Kosiński**

Jaroslaw Kosiński completed his Bachelor's degree at Adam Mickiewicz University in Poznan, Poland, and his Master's at the University of Warsaw. Subsequently, he remained at the University of Warsaw to pursue my Ph.D. in theoretical physics, with a focus on mathematical relativity, under the supervision Jacek Tafel.

After earning his Ph.D., he spent the next three years as a postdoctoral researcher in Pawel Nurowski's group at the Center for Theoretical Physics, Polish Academy of Sciences.

In July 2023, he joined the Department of Mathematics at UC Davis. Currently, he is collaborating with Andrew Waldron on the applications of conformal geometry in general relativity.

KAP



**Stefan
Mihajlović**

Stefan Mihajlović finished his Ph.D. in February 2023 in a joint program between Central European University and Alfréd Rényi Institute of Mathematics in Budapest, Hungary. He previously did his Master's and Bachelor's in mathematics at the University of Belgrade, Serbia.

His main research interest is low-dimensional topology and more specifically smooth 4-manifolds. At UC Davis, he is interested in small exotic 4-manifolds, immersed surfaces, slice knots, trisections, corks, as well as moduli spaces of Higgs bundles. He will be working under Prof. Laura Starkston.

Stefan enjoys thinking in pictures and discussing mathematics and physics ideas more broadly. Playing music or board games is something he will rarely say no to.

incoming Researchers

Researcher



**Daniel
Spiegel**

Daniel Spiegel received his Ph.D. in May 2023 from the University of Colorado Boulder under the direction of Markus Pflaum. His research involves applications of operator algebras and algebraic topology to the classification of topological phases of quantum matter, but he just as often finds himself using physics as inspiration to think about more abstract C^* -algebraic problems. At UC Davis, Daniel looks forward to growing his expertise in quantum statistical mechanics through the mentorship of Bruno Nachtergaele.

Outside mathematics, Daniel enjoys most physical activities, where he makes up for a lack of skill with an abundance of heart. He's thinking about getting into pickleball next.

Researcher



**Antonio
Torres Hernandez**

Antonio Torres Hernandez is originally from Querétaro, Mexico. He earned his Ph.D. degree in Mathematics from the National Autonomous University of Mexico (UNAM), under the supervision of Professor Deborah Oliveros Braniff.

His research revolves around the interplay between geometry, combinatorics, and data analysis. In particular, he is interested in problems related to point configurations and extremal problems in combinatorial geometry.

Researcher



**Denae
Ventura**

Denae Ventura acquired her mathematical preparation in Mexico, earning her bachelor's degree from Autonomous University of San Luis Potosi, and her master and doctorate degrees from National Autonomous University of Mexico (UNAM).

Her main research field is Combinatorics, particularly extremal graph theory and Ramsey theory. She worked on unavoidable patterns in 2-edge colorings of the complete bipartite graph, balanceability, and amoeba graphs in her doctoral thesis. She is currently working as a postdoc with Professor Jesús De Loera on Ramsey-type problems that involve geometry and number theory.

Researcher



**Lea
Kenigsberg**

Lea Kenigsberg studies problems in the intersection of Floer and Homotopy theory. In particular, she is interested in relating fixed point invariants to Algebraic K-theory and to periodic orbits of Hamiltonian dynamics.

In her free time she likes to dance, hike, travel, discover new music, and spend time with her teenage son.

Alumni Update



Jennifer Luke (formerly Cordial)

B.S. — 2001

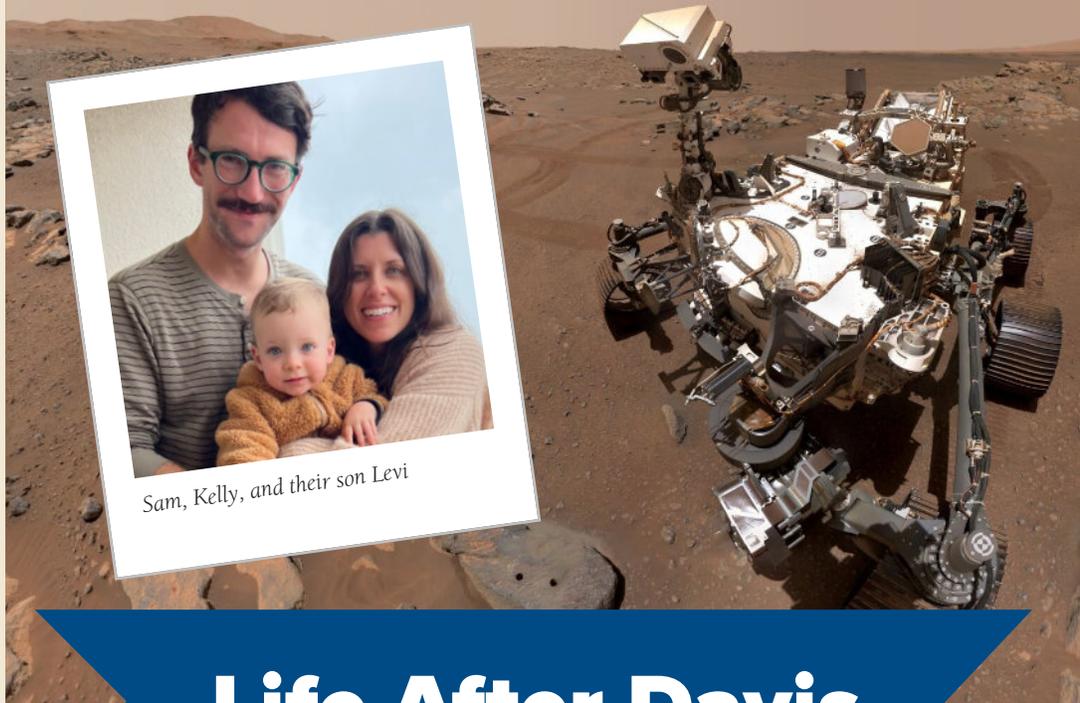
Jennifer Luke earned degrees in Mathematics and Economics at UC Davis and continued her education at University of Washington, with a masters in Industrial Engineering and certified in Global Trade, Transportation, and Logistics.

Jennifer Luke presently lives in Seattle, WA, and has been working at Microsoft as a Director for over nine years. She most recently became Chief of Staff of Xbox Game Studios.

Of her work, she says, “Standing out in a giant, matrixed company like Microsoft requires demonstrating passion, exceptional listening, strategic patience, and conviction in everything I do—especially when championing changes with global scope and significant financial impact.”

“I believe it’s even more important to pass on my passion and leadership strengths to the next generation of innovators. Career development and mentorship are two of the best gifts I can give. Over the course of my career, I am proud to have developed strong teams and incredible performers who have continued to grow their careers within and outside of our organization.”

“My career background includes deep experience in finance, strategy, compliance, operations, and readiness—all geared toward business transformation, operational excellence, and growth. I excel at pulling multiple workstreams together, scaling up fledgling organizations, and synthesizing the complex into digestible soundbites. I place incredible value on listening—to the voice of the customer and to internal stakeholders.”



Sam, Kelly, and their son Levi

Life After Davis Sam Fleischer

After graduating with my Ph.D. in Applied Mathematics in 2020, I started working full-time as a Systems Engineer at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, CA. I had previously interned at JPL during my undergraduate and graduate years, making the transition to a permanent position relatively smooth. As a mathematician in the engineering department at JPL, I tackled a variety of modeling tasks related to both project planning and operations.

On the project planning side, I worked on planetary protection models to prevent forward contamination on missions to icy moons. One of NASA's requirements for such missions is proof that the probability of introducing Earth microorganisms to liquid water on, say, Europa or Enceladus, given a successful launch, is less than a certain threshold. My role for both the Europa Clipper (set to launch next year) and the proposed Europa Lander was to prove to NASA HQ that the projects met this requirement. It was deeply satisfying to use my mathematical modeling and communication skills to drive these projects forward. I also developed several cost models for various early concept missions. I was a part of JPL's Team X, which serves as a consulting group for principal investigators and project scientists to evaluate the feasibility of their concepts from scientific, engineering, and financial perspectives.

On the operations front, I assisted the Perseverance Rover team with several unique requests. Using Bayesian statistics, I ad-

ressed questions about the reliability of the sample tubes used to collect Martian soil, which will eventually return to Earth as part of the Mars Sample Return campaign. I also advised on the risk of depositing these sample tubes on the Martian surface instead of storing them on the rover.

During my time at JPL, my interest in Bayesian statistics grew, leading me to a part-time consulting gig with the Tampa Bay Rays for the 2022 Major League Baseball season.

With the Rays, I used player tracking data to create models for valuing the defensive performance of outfielders and infielders. This interest evolved into a new career path, and I transitioned to a full-time position with the Los Angeles Dodgers in January 2023. Now, as a Senior Quantitative Analyst for the Dodgers, I aid executives in decisions about trades, drafts, and potential long-term contract risks. My team also creates models to support Dodgers' coaches and players in making better in-game decisions. Additionally, I assist with research for player arbitration and helping in the recruitment of front office staff.

On a personal note, my wife Kelly and I welcomed our son, Levi, in February 2022. His room is adorned with JPL memorabilia, and he's seldom without his baseball. Go Dodgers!

Pictured at top:

Mars rover

collecting samples. Learn more:

mars.nasa.gov/mars-rock-samples/



Computing the alpha complex using Lagrangian duality

by Erik Carlsson

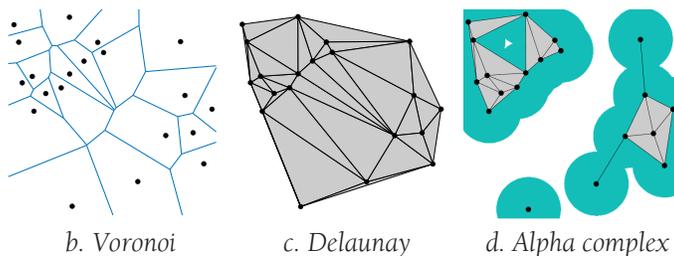
In 1983, Edelsbrunner, Kirkpatrick and Seidel introduced the concept of the alpha shape, which is a piecewise-linear region surrounding a collection of points in the plane \mathbf{R}^2 , including the 2-dimensional convex hull as a special case [3]. Edelsbrunner and Mücke extended the alpha shape to three dimensions, a construction which was later used to create beautiful models of the shapes of certain biomolecules [4, 5]. An example of the alpha shape is shown in Figure a, reproduced from the CGAL manual.

I will share a new algorithm developed with J. Carlsson for computing a closely related combinatorial structure known as the *alpha complex* in higher dimension [1]. The reason we began looking at the alpha complex has to do with the discovery of a different type of shape associated to Gaussian mixtures, which is naturally approximated by weighted versions of the alpha complexes [2].

Formally, given a collection of points $S = \{x_1, \dots, x_n\} \subset \mathbf{R}^m$ and a real number $r > 0$, let $V_{x_i}(r)$ be the collection of points $y \in \mathbf{R}^m$ with the property that $\|y - x_i\| \leq r$ and $\|y - x_i\| \leq \|y - x_j\|$ for any x_j , which is the usual Voronoi cell intersected with a ball of radius r centered at x_i .

Definition. The *alpha complex* is the collection of subsets (called simplices) $\sigma = \{x_0, \dots, x_k\} \subset S$ with the property that the intersection of the Voronoi regions $V_{x_0}(r) \cap \dots \cap V_{x_k}(r)$ is nonempty.

As one might expect from the definition, the alpha complex is a fundamental object in the subject of *Topological Data Analysis*, including persistent homology. However, it suffers from a numerical crisis in higher dimension, which is that nearly every method for constructing it begins by building the full Delaunay complex, and removing triangles that do not respect the bound on the radius, as illustrated in Figures b, c and d. While the alpha complex is the smallest of the standard constructions in persistent homology, the size of the full Delaunay complex is enormous in higher dimension, making this standard pipeline impossible.



Our method, which avoids computing the full Delaunay complex, is essentially a straightforward application of the duality principle in mathematical optimization, which associates to each “primal” optimization problem an equivalent but inverted “dual” problem. In this way the dual of a minimization problem becomes a maximization problem, whose feasible states determine lower bounds of the

optimizing value, which is often used in practice to determine a certificate of infeasibility. One discrete example of the duality principle is described by the famous “max-flow min-cut” theorem. In a different direction, the dual of a linear program is another linear program, which was given explicitly by George Dantzig, after being conjectured to exist by von Neumann.

The connection with the alpha complex is that the problem of determining the existence of an individual simplex can be formulated as a quadratic program, meaning a convex optimization problem with a quadratic loss function and linear inequality constraints. Despite the potentially huge number of simplices, computing the alpha complex one simplex at a time becomes feasible using dual programming, because it optimizes ruling simplices out rather than ruling them in. Another benefit is that the origin always satisfies the constraints of the dual problem, whereas primal methods would have to begin by generating an initial feasible point for every potential simplex.

We built the alpha complex on a well-known data set of 6040 conformations of the cyclooctane molecule describing a point-cloud in \mathbf{R}_{24} , which is known to have topological type of the union of a Klein bottle and a sphere [6]. At an appropriate radius, the alpha complex consists of under 100,000 total simplices, whereas the full Delaunay complex would have on the order of 1045 simplices. In a purely mathematical example, we computed the cohomology of the pure Artin braid group on up to 4 strands by modeling a compact version of its classifying space by an alpha complex, and extracting the Betti numbers using sparse linear algebra methods. These numbers are also known as the Stirling numbers of the first kind, and they encode a certain graded version of the regular representation of the symmetric group, making for a particularly intricate homology calculation.

I have uploaded an implementation of our algorithm written in MAPLE on my Department homepage, along with some illustrative worksheets—I invite anyone interested to check it out.

References

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- [6] S. Martin, A. Thompson, E.A. Coutsias, and J.P. Watson. Topology of cyclo-octane energy landscape. *J Chem Phys.*, 23, 2010.

Life After Retirement

Kurt Kreith

In the years 1992-94, the University of California offered a golden handshake under the acronym VERIP. In 1994, having twice refused the lure, I signed up for VERIP III, making 2024 my 30th year of retirement.

Many of my early retirement activities reflected a desire to give meaning to the study of differential equations, an enterprise that had put food on the table since 1960. In 1984 world population was fast approaching 5 billion, memories of OPEC's oil embargo were still fresh in our minds, and spurious use of the logistic equation to predict "peak oil" was in vogue. Against this background I made contact with The American Forum for Global Education and agreed to offer a series of summer programs for New York teachers under the heading "The Mathematics of Global Change."

These summer programs coincided with the development of new computer technology for schools. Notable here was the "systems dynamics" software named Stella whose development was closely related to the "World3" model underlying the 1972 best selling book, *The Limits To Growth*. Stella provides students with an icon-based format for formulating a system of differential equations whose numerical solution it then displays graphically. Not requiring mathematical understanding by its user, Stella was seen as a way of promoting "systems thinking" by students at large.

Jumping ahead to 2015 and a lessened zeal for travel, I was able to take advantage of UC Davis' program of First Year Seminars (FYS) to offer a course on "The Limits To Growth" (LTG). Meeting in a computer lab we read LTG, engaged in discussion about the use and misuse of models such as World3, and learned enough about difference equations and Excel to create our own spreadsheet versions of Stella.

This led to a mathematical discovery! By way of setting the stage for its applications of World 3, LTG describes "Four Possible Behavior Modes of the World Model" which can be termed exponential growth, logistic growth, overshoot and oscillation to equilibrium, and overshoot and crash. (See graphs at right.)

Using Excel, we were able to generate these

behavior modes and found that the last three correspond to solutions of the delay logistic equation $du/dt = ru(t) - cu(t-d)^2$. This realization led me to reflect on the number of times I had taught logistic growth without mention (or awareness!) of such modifications. It also led to reflections about the importance of delay differential equations in the biological and social sciences and the ease with which delays can be dealt with numerically.

Buoyed by this experience, I learned to make use of Excel's rich reservoir of built in functions to offer First Year Seminars in other areas. Here Excel's MOD function enabled us to address a variety of topics in number theory, including Fibonacci's numerical solution of the delay differential equation $du/dt = u(t-1)$ with $u(0) = 1$. By returning and undoing the ASCII code of a keyboard symbol, Excel's CODE and CHAR functions made possible a FYS on cryptology. Excel's COMBIN function and ability to generate random numbers enabled us to address a variety of topics from probability. In this way, First Year Seminars provided a context for continued learning as well as contact with students and the outside world.

With time, a hearing loss combined with a growing diversity in the first languages of students made instruction of First Year Seminars less satisfying. Then came COVID-19 and the need to adapt to remote instruction which I found challenging. Here I had the good fortune of obtaining the support of Al Mendle, an adventurous recently retired colleague from the School of Education who became a partner in such undertakings. Our collaboration included ways of modeling epidemics in a format appropriate for a First Year Seminar.

So what now? My colleague in the School of Education specializes in the preparation of elementary school teachers to face the challenge of teaching children basic arithmetic. A First Year Seminar on "Arithmetic In the Time of Computers" would allow us to associate the "moment of conception" of the computer age with the development of an electronic circuit for adding two binary numbers. I continue to ponder whether such insights are appropriate for future teachers of children, for students at large?



About Professor Emeritus Kurt Kreith

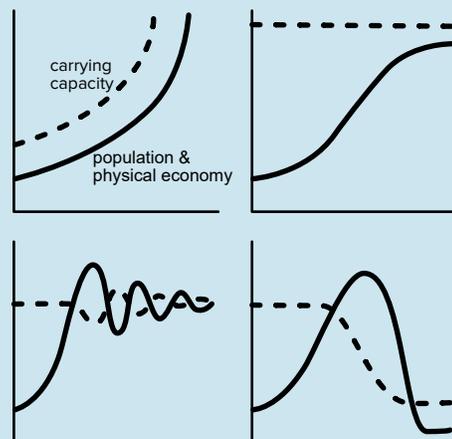
Having received his Ph.D. with Frantisek Wolf in Berkeley, Kurt Kreith arrived in Davis in 1960. In 1963 he accepted a position with the newly established U.S. Arms Control and Disarmament Agency, arriving just in time for the signing of the Partial Test Ban Treaty (and the Great March on Washington).

In 1965 he returned to Davis, serving as Department chair from 1970-75, and in various positions in the Academic Senate. His interest in mathematics education led to participation in the Northern California Mathematics Project, a visit to the Kolmogorov School in Moscow, and participation in COSMOS. An interest in mathematics education has marked his retirement years as well.

Epidemic Modeling for K-12

Read Kreith and Mendle's accessible intro to epidemic modeling on the AMS website.

<https://tinyurl.com/kreith-ams>



Excel graphs in the First Year Seminar.

The life and death of the local to global conjecture for Apollonian circle packings

by Elena Fuchs

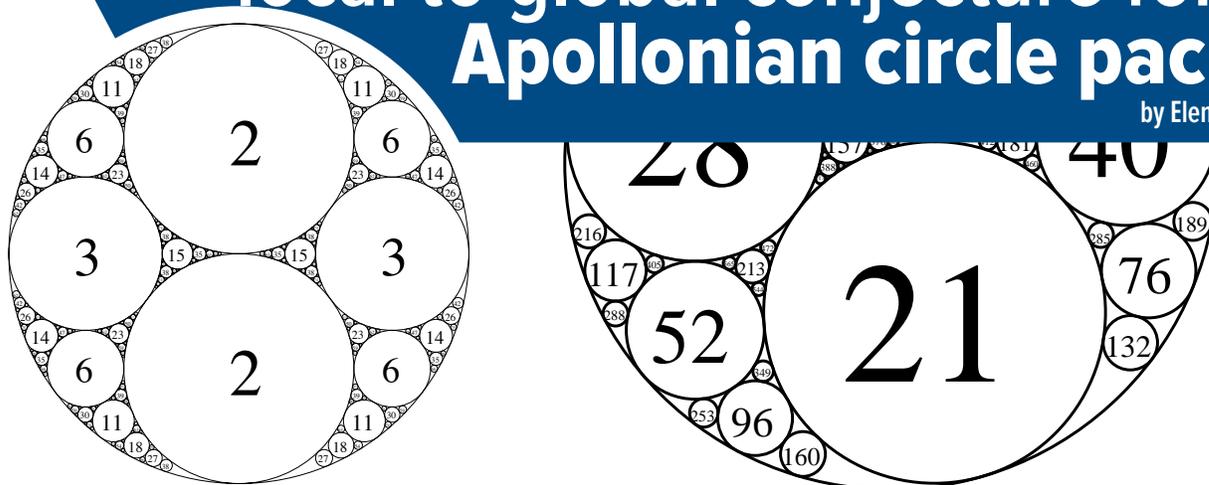


Figure 1. Two integral Apollonian packings.

Seventeen years ago, at a birthday conference for Dorian Goldfeld in New York City, Jeff Lagarias approached Peter Sarnak after a talk he gave on the arithmetic of so-called thin groups. He told him that he had recently written a paper on the number theory of Apollonian circle packings together with Graham, Mallows, Wilks, and Yan [GLMWY], and that the group governing the symmetries of these packings (the Apollonian group) was a thin group and so, perhaps he might find it interesting. I was just starting as Sarnak's Ph.D. student back then, and that conversation undoubtedly shaped the course of my career and served as a springboard to many deep and interesting works over more than a decade to come. When I met with him the following week, he told me he had just the project for me, and handed me the paper of Lagarias et. al., which came with a laundry list of open problems at the end. One of those open problems had to do with a potential local to global conjecture for Apollonian packings, and within a couple years of studying Apollonian packings I formulated and provided convincing data for a precise conjecture of this form together with my co-author Katherine Sanden, who was an undergraduate at the time. Everyone believed it, and several people, including myself, dreamed of proving it one day. Fast forward to this summer, when a paper of Haag, Kertzer, Rickards, and Stange [HKRS] showed that, in fact, the conjecture is false. The story is not over yet: while the conjecture is false as previously stated, there is still a version of it that is probably true and is still as hard to prove. It is riveting enough, in my opinion, to grace the pages of this newsletter.

What is a local to global principle? Generally, the idea is that one can glean global information just by knowing local information at all. In the case of Apollonian packings, the original conjecture stated that for any given integral Apollonian packing, there is a permissible set of residues modulo 24 such that any (large enough) integer whose residue modulo 24 is permissible is in fact a curvature (reciprocal of the radius) of some circle in the packing. For example, the first packing in Figure 1 only has integers that are in the set $\{2, 3, 6, 11, 14, 15, 18, 23\}$ modulo 24. For what turns out to be an orbit of a "thin" group (roughly speaking, one that is infinite index in the \mathbb{Z} -points of its Zariski closure), which had previously been dismissed as uninteresting in number theory, the potential presence of such a local to global principle is quite exciting.

Even more pleasing is the connection of this problem to mathematics

of ancient Greece, something far removed to the heavy machinery used to chisel away at the local to global conjecture, despite it being false. The story goes back at least to Apollonius of Perga around 200 BC: consider four pairwise tangent circles, one of them internally tangent to the other three. One might ask whether there is a unique way to inscribe a circle into each of the spaces between these circles. In fact, Apollonius, whose interest in this was attempting the difficult straight edge and compass construction of pairwise tangent circles and straight lines, showed that the answer to this questions is yes. Given this, one can inscribe new circles into each of the spaces, then inscribe a circle into each of the spaces resulting in this way, and so on, producing a packing of infinitely many circles which we refer to as an Apollonian circle packing (ACP). Since the local to global problem concerns the curvatures of the circles in an ACP, one first needs a systematic way of determining what these curvatures are. This systematic way dates back to the following theorem commonly attributed to Descartes, but, as laid out in this historical math article [B], is due in equal part to the Princess Elizabeth of Bohemia.

Theorem 0.1 (Descartes, Princess Elizabeth of Bohemia, 1643). Let a, b, c, d be curvatures of four pairwise tangent circles, where we take the curvature of a circle internally tangent to the other three to have negative curvature. Then

$$Q(a, b, c, d) := 2(a^2 + b^2 + c^2 + d^2) - (a + b + c + d)^2 = 0$$

With this theorem, one gets a very nice representation of curvatures in a packing via an orbit of a subgroup of $O_Q(\mathbb{Z})$, the orthogonal group fixing Q . The idea is that for any triple of pairwise tangent circles, one has precisely two circles that are tangent to all three, as shown in Figure 1. In fact, given a quadruple of curvatures (a, b, c, d) corresponding to pairwise tangent circles, one can solve the quadratic equation above to get another quadruple (a', b, c, d) where the sum of the two roots $a' + a = 2b + 2c + 2d$. The same can be done by solving for any one of the four coordinates, and so we come up with the following revelation. Given a quadruple of curvatures (a, b, c, d) in an ACP, the set of all quadruples in the ACP is precisely the orbit of the group generated by

$$S_1 = \begin{pmatrix} -1 & 2 & 2 & 2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}, S_2 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 2 & -1 & 2 & 2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}, S_3 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 2 & 2 & -1 & 2 \\ 0 & 0 & 0 & 1 \end{pmatrix}, S_4 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 2 & 2 & 2 & -1 \end{pmatrix}$$

acting on $(a, b, c, d)^T$ via matrix multiplication on the left. This group, called the Apollonian group and first discovered by Hirst [H], is a thin

group (it is Zariski dense in $\mathbf{O}_{\mathbb{Q}}(\mathbb{C})$ but infinite index in $\mathbf{O}_{\mathbb{Q}}(\mathbb{Z})$), and governs all of the arithmetic and geometry of Apollonian packings. It is now clear that if one has a circle packing where one quadruple of pairwise tangent circles all have integer curvatures, then every circle in the packing has integer curvature, as is the case in the packings in Figure 1. We call such packings *primitive* integer ACP's (of which there are infinitely many), where primitivity refers to the fact that the gcd of all the curvatures in the packing is 1.

With this neat way of expressing all quadruples of curvatures of pairwise tangent circles in the packing, fixing a prime p , we can now examine the question of what quadruples a given packing can contain modulo p . For example, if we look modulo 5, the packings in Figure 1 both have 144 different quadruples of curvatures of pairwise tangent circles; indeed, these are exactly all nontrivial solutions to the Descartes equation modulo 5. The same can be said modulo 7, 11, 13, and indeed any prime $p \geq 5$, as I showed in [F]. The idea is to consider the Apollonian group (actually, its preimage in the spin double cover of $\mathbf{SO}_{\mathbb{R}}(3,1)$) modulo various primes p . The main reason for working in this slightly different setting is that A is a subgroup of the orthogonal group $\mathbf{O}_{\mathbb{R}}(3,1)$ where strong approximation does not hold, and it is difficult to say anything about the projection of A into $\mathbf{O}_{\mathbb{Q}}(\mathbb{Z}/p\mathbb{Z})$ by working in the orthogonal group alone. However, the preimage of A under the spin homomorphism is a Zariski dense subgroup of $\mathbf{SL}_2(\mathbb{C})$ where general results regarding strong approximation are known (see [W], for example). What is this strong approximation? For us, the important feature is that, because of the Zariski density of A , one gets that its reduction modulo p is onto the whole group $\mathbf{SL}_2(\mathbb{Z}/p\mathbb{Z})$ for all but finitely many primes. With some work, we determine that these finitely many primes are only 2 and 3, and then it is not a far jump to conclude the statements we made about the orbit of A modulo p being simply the set of nontrivial solutions to Descartes' equation mod p for $p \geq 5$. Moreover, in [F] we show that this is true for not only primes but all numbers not divisible by 2 and 3. And, if one computes an orbit of A modulo 24 (it turns out this is equivalent to computing modulo 8 and 3), then one can piece together what the orbit modulo any number can be. In essence, the local obstruction for the Apollonian group, and hence integer Apollonian circle packings, is modulo 24.

This was the beginning of the local to global conjecture for ACP's as it was known for over a decade. In [FS], Sanden and I conducted several experiments and came up with some arithmetic heuristics to do with integral ACP's. In this paper, we state the local to global conjecture, which asserts that:

every packing contains integers belonging to certain residue classes modulo 24 (always either six or eight of them), and any large enough integer that is in one of the admissible residue classes modulo 24 must appear as a curvature in the packing.

We provided convincing evidence that the first packing in Figure 1 satisfies this principle, which showed that as one considered integers in intervals starting at higher and higher values, not only did one find no "admissible curvatures" that occurred zero times, one found that the frequency with which these integers were occurring were increasing (something that we could prove, at least on average). In the case of the second packing in Figure 1, the evidence seemed to point to the fact that, if our program could check integers larger than 10^8 we would also see the same evidence: we could still see some curvatures appearing with frequency 0, and the average frequencies were not as high in similar intervals as those for the first packing. Number theorists working in this area – Bourgain, Kontorovich, Lagarias, Sarnak, Stange, Zhang, myself and many others – all believed this to be true. Indeed,

Bourgain and I showed in [BF] that a positive fraction of all integers appears in any integral ACP as curvatures, and Bourgain-Kontorovich showed in [BK] that the local to global conjecture is true once you remove a zero density subset of the integers. Together with Stange and Zhang, I generalized this result to packings similar to Apollonian packings in [FSZ].

Fast forward to 2023, when, during an REU project in University of Colorado, Boulder, Stange was working with her postdoc Rickards, graduate student Haag, and undergraduate student Kertzer. This team was particularly proficient in programming, and both Stange and Rickards had worked on Apollonian packings extensively before. Neither doubted the local to global conjecture was true. However, as they considered the second packing in Figure 1 and tried to get data like we produced for the first packing by considering larger and larger curvatures, they failed. They looked then at data that no one had thought to look at before: what curvatures were still missing at that point, despite being in the correct congruence classes modulo 24? The answer was astounding: they all followed an obvious pattern: they were all squares or thrice a square. What followed was a revelation that showed that, in fact, the Apollonian group has certain obstructions coming from quadratic and quartic reciprocity, reminiscent of so-called Brauer-Manin obstructions. It turns out that the first packing in Figure 1 is in a type that does not end up missing any quadratic or quartic values, but the second packing, and infinitely many other packings, is.

What now? The local to global conjecture is not dead: it has merely been fine-tuned to include the quadratic and quartic obstructions discovered by Haag et. al.. It is still just as hard to prove as the previous conjecture. But it is fascinating how the mathematics we believe to be true, supported by evidence that we believe is incontrovertible, can be so fragile and so much more mysterious than we see at any given time. With the rise of computer experimentation in mathematics, one may hope that we will see this more and more.

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Graduate Program

by Laura Starkston, Vice Chair for Graduate Affairs



Laura Starkston, Vice Chair

We are excited to start a new year in the mathematics graduate program. Thirteen new students are welcomed into the Math Ph.D. program this year, bringing our program to a total of 84 graduate students. We are looking forward to seeing our students learn, grow, achieve their goals, and form new and stronger connections with each other as well as with faculty, postdocs, and staff.

Our students continue to do excellent work and accomplish much. This past year, we had 11 students complete their Ph.D. and continue on towards exciting opportunities in postdoctoral positions, teaching, and jobs in industry.

Congratulations to our numerous GMAT award winners. James Hughes and Joseph Pappé received the Yue-Jing Lin Scholarship. Alexander Black was the recipient of the Alice Leung Scholarship. Mary Claire Simone received the William K. Schwarze Scholarship. Tonie Scroggin received the Hazel B. Jacoby Fellowship. Colby Brown and Trevor Oliveira-Smith received the Henry L. Alder Award. More can be read about these awards on page 10. Jonathan Erickson received the National Defense Science and Engineering Graduate Fellowship. Hans Oberschelp won third place in the UC Davis Grad Slam talking about his research on “Securing Data by Shuffling Cards.”

Graduate program coordinator Diana Bond continues her first full year in this position, and we welcome our new student services supervisor Marji LeGrand. Diana and Marji are working hard to support our students and keep our program running smoothly.

This Fall, we are introducing a new Graduate Student Success Seminar to help guide students through key steps in their Ph.D. and to provide advice on important mathematical professional skills. When Bruno and I met with graduate students to assess the state of the program, we found that the pandemic had significantly broken down communication, disrupting the flow of knowledge that gets passed down from more experienced graduate students to the newer

students. Consequently, many of our current students lacked a consistent source of key information and advice to successfully progress through the program. At the same time, Diana was planning our 2023 New Grad Orientation. In reviewing what we had done previously, she realized the back-to-back sessions of the one-day new grad orientation were information overload, and it was important to prioritize socialization and bonding. Diana wanted to help make the information more palatable and retainable, as it was very important for grads to know. We realized that the Graduate Student Success Seminar could help to address both of these challenges by providing information to new and old grads in a consistent manner. Each week we visit a different topic, such as goal setting, grad school milestones, applying for jobs, finding an advisor, balancing your time, etc. We hope to continue this seminar every Fall Quarter.

The Galois Group is reviving old and introducing new initiatives this year as well, to build a strong collegial support network among graduate students.

Moreover, our continuing graduate students are actively involved in fostering the mathematical interests of our undergraduates by mentoring in the Directed Reading Program (DRP). The DRP is a program that pairs up graduate students and undergraduate students to engage in mathematical readings that go beyond the material undergraduates are likely to encounter in their coursework. More details on the DRP can be found in the undergraduate program update on page 14.

We are looking forward to a productive and exciting year, working towards supporting all of our students in accomplishing their goals and finding joy in mathematics.



Jonathan Erickson,
NDSEG Graduate
Fellowship recipient



Hans Oberschelp, at the
Grad Slam

Watch Hans Oberschelp’s talk on better data security through shuffling on YouTube. Search for “Oberschelp grad slam” or use this link.



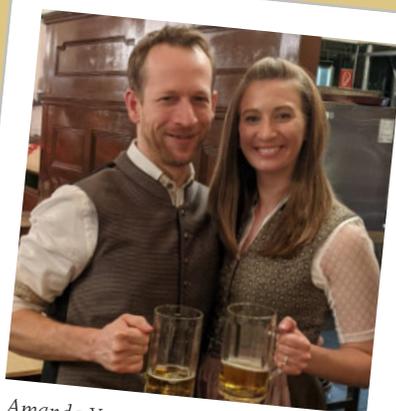
Life After Davis

Amanda Young

It's strange to think it's been seven years since I finished my Ph.D.. My time as a student at Davis was very formative, and the mentors I met during that time have continued to guide me on my path to a tenure track position. Their support is the reason I just started as an assistant professor at University of Illinois Urbana-Champaign.

After graduating in 2016, my first stop was a postdoc at the University of Arizona with Bob Sims. Bob and I first started collaborating during my Ph.D. while he was on a sabbatical at Davis, so it was great to step into a postdoc with someone whom I already shared active research projects. The Department created a postdoc program focused on gaining experience in research, teaching, and outreach, which gave the participants a realistic picture of what life would be like as a faculty member. I was part of the first cohort of this program, and the members quickly became close friends - many of whom I still keep in touch with. During my last few months in Arizona, I got married to my husband, Stuart, whom I met through friends at a swing dancing event in Sacramento. Jamie Haddock and Kristin Lui, two of my officemates at Davis, served as bridesmaids in our wedding.

While in Arizona, I decided that I wanted to spend some time as a postdoc in Europe to develop contacts with researchers outside of the US. Munich has multiple institutes that have strong mathematics researchers in quantum physics, and Simone Warzel from TU Munich offered me a position through the newly founded Munich Center for Quantum Science and Technology. We started pursuing a long-standing conjecture of Haldane's regarding the existence of a spectral gap for his family of pseudopotentials. We've made significant progress, and plan to continue the program. Moving to a foreign country six months before Covid had its challenges, but Stu and I were still able to embrace our new home. We loved going to



Amanda Young, at right

Christmas markets in the winter, and riding bikes in the English Garden in the summer.

Throughout the years, I have continued to collaborate and remain close with my Ph.D. advisor, Bruno Nachtergaele. His advice, perspective, and support has been invaluable, and I would not have been nearly as successful without his guidance. He even arranged for me to spend six weeks working from Davis during my tenure track interviews so I would not have to coordinate interviews from Europe during the pandemic. In fact, I was on campus when I got my first tenure track offer, and he was the first person I got to share the news with.

Now I am starting my most exciting position - as a faculty member myself! Of course it's a lot of work, but so far I am really enjoying it. I actually grew up in Woodland, and frequently make trips back to Davis when I'm visiting my family. For those of you still in the Department, I am sure we will have a chance to catch up again in person. Until then, auf Wiedersehen!

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 as allowable by law, 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.

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<https://give.ucdavis.edu/Go/MathAlumniNews2324>

Please click on "Donate to this Fund" and follow the prompts.

A list of donors can be found at the end of this newsletter. Thank you for your continuing support.

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<http://matchinggifts.com/ucdavis/>

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<https://giving.ucdavis.edu/resources/disclosures>



Graduate Group in Applied Mathematics

by F. Javier Arsuaga, Chair of the Graduate Group in Applied Mathematics



F. Javier Arsuaga, GGAM Chair

The 2022-2023 year was my first year as chair of GGAM. I was delighted to serve students and faculty in the program and I am looking forward to a second year of service.

The past academic year was a very active year for GGAM. I would like to highlight three achievements. First, in collaboration with the GGAM executive committee and with input from faculty, we redesigned the GGAM academic program. The goal was to update the course content and admissions to better align with the interests of our students and faculty. I am currently working to have the new program accepted by Graduate Council by the next academic year. Second, in collaboration with the Department of Mathematics, we obtained a grant from the College of Letters and Science to purchase new desks and chairs for our students. Third, also with the Department of Mathematics, we organized the first dinner for women and gender expansive people. The goal of this dinner was to create bonds between faculty and students in a relaxed and friendly atmosphere. The dinner also featured an invited speaker and last year Professor Anne Schilling gave the dinner talk. This year we were honored to have Professor Tatiana Toro, director of the Simons Laufer Mathematical Sciences Institute (Berkeley), as our invited speaker.

There were many changes on the Mathematics Department staff. Vanessa Bravo and Tina Denena, who were graduate coordinator and supervisor respectively moved to other positions. They were true pillars to the program and helped it thrive. Tina will continue working in the Department of Mathematics serving as the new Chief Administrative Officer. We want to thank Vanessa and Tina for the unconditional support of our students and for the service they provided to GGAM, and wish them luck on their future endeavors.

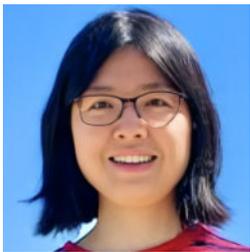
We were fortunate to recruit two excellent staff members to fill the positions of graduate group coordinator and student supervisor. Diana Bond is our new GGAM coordinator and Marji LeGrand the student support supervisor. Diana joined us right before graduate student recruitment season. This is probably the most hectic time of the year. She not only rose to the occasion but ex-

ceeded all expectations. Diana designed many creative activities to engage participants during our graduate student spring recruitment event and her contributions were key in attracting students to our program. More recently Diana designed a 1 unit graduate course on 'how to succeed in graduate school.' This course will be taught by Professor Laura Starkston. Marji LeGrand joined in September but she is not new to UC Davis. She was a student advisor in the Electrical and Computer Engineering Department before and is bringing 20 overall years of experience to her position. I want to welcome both Diana and Marji to GGAM and thank both for their service.

In Spring of 2023, we recruited 16 excellent new students to the program. I extend my heartfelt thanks to all our students, faculty, and staff for their contributions to this successful recruitment. Two of the new recruits received fellowships: Camille Korburt received the UC Davis NSF preparatory fellowship and was part of the Competitive Edge Summer Bridge Program and Salvador Ochoa received the UC Davis McNair fellowship. Continuing students also received prestigious awards. Kelli Loritsch and Jennifer Paige received the NSF and DOE graduate fellowships, respectively. Gregory DePaul was recognized for his service to the Society for Industrial and Applied Mathematics (SIAM) and Esha Datta received the S. Scott Collis Data Science Fellowship and joined the Sandia National Labs. Please join me in congratulating our students for these achievements.

During the last year, our program grew significantly. We welcomed 7 new faculty members: Professors Xiaoli Dong (Environmental Science and Policy), Mina Karzand (Statistics), Lifeng Lai (Electrical and Computer Engineering), Miriam Nuño (Public Health Sciences), Anne Schilling (Mathematics), Slobodan Mitrovic (Computer Science), Maike Sonnewald (Computer Science).

Our early-career faculty were highly recognized in their respective fields. Shirley Ahn (Chemical Engineering) won the 2023 Synergy Team Research with her colleagues in the Medical School, and 9600 GPU node hours by TACC Frontera Pathways for the project "Unveiling the mechanism of alpha-



Xiaoli Dong,
Environmental Science



Miriam Nuño,
Public Health Sciences



Mina Karzand, Statistics



Anne Schilling,
Mathematics



Lifeng Lai,
Electrical & Computer
Engineering



Slobodan Mitrovic,
Computer Science



Maike Sonnewald,
Computer Science

synuclein aggregation and prevention with small molecules using molecular dynamics.” Rishidev Chaudhuri published his work in the Proceedings of the National Academy of Sciences. His paper studies the shape of geometric structures that appear in neural data and argues that they should be exceedingly nonlinear. Xiaoling Dong was awarded an NSF grant to work on ecosystem spatial self-organization and Turing pattern formation, applied to dry land ecosystems in the U.S. Southwest. Slobodan Mitrovic received a Google Research Scholar award in Algorithms and Optimization for his project entitled “Fast Fully Scalable Data Partitioning.” And Alex Wein received the prestigious Sloan Research Fellowship. These recognitions showcase not only the excellence of our faculty but also the interdisciplinary nature of GGAM.

Other GGAM faculty received special recognitions as well. Jesús De Loera gave a plenary talk at the SIAM conference in Seattle, one of our faculty attending the lecture commented on De Loera’s talk: “It made me proud to be from UC Davis!” Miriam Nuño (Public Health Sciences) was one of the recipients of the 2023 ADVANCE award. Mariel Vazquez (Mathematics and Microbiology and Molecular Genetics) gave an invited lecture at Rice University for the Hispanic heritage month. David Woodruff chaired the International Conference on Stochastic Programming that took place at UC Davis from July 24 to July 28.

Looking into the near future, two of our members and one former GGAM graduate student will give plenary talks at the 2024 Joint Mathematics Meeting (JMM) in San Francisco during the first week of January. Anne Schilling will give the AWM-AMS Noether lecture on Thursday January 4th. Mariel Vazquez will give the SIAM invited address on Friday January 5th. Julie Blackwood, a former student now working at William College, will give the Spectra Lavender Lecture on Thursday January 4th. Mark your calendars and make sure to come to support our faculty and colleagues!

Our commitment to teaching and mentoring is strong, and was recognized by our administration. Professors Jesús De Loera, Rishi Chaudhuri, and Krishna Balasubramani-ana received the 2023 UC Davis graduate program advising and mentoring award.

I am very much looking forward to a new year of exciting news and achievements by our students and faculty.

Graduate Degrees 2022-2023

Aguirre, Ander • Math • On Fluctuations of Eigenvalue Statistics of the Circular Beta Ensemble
Advisor: Alexander Soshnikov

Alameda, Andrew • Math • Computing the Kakimizu Complex for a special class of links
Post Ph.D. Placement: Lecturer, UC Davis
Advisor: Schultens

Arroyo Esquivel, Jorge • Applied • Modelling the Complex Ecological Dynamics of Kelp Forests
Advisor: Alan Hastings

Chen, Haolin • Applied • Overcomplete Order-3 Tensor Decomposition, Blind Deconvolution, and Gaussian Mixture Models
Post Ph.D. Placement: Data Scientist, Outreach
Advisor: Luis Rademacher

Chou, Raymond • Math • A Descent Basis for the Garsia-Procesi Module
Post Ph.D. Placement: Post Doc, UCSD
Advisor: Erik Carlsson

Datta, Esha • Applied • Topological Data Analysis for Precision Medicine Applications in Cardiovascular Health
Advisor: Leighton Izu

He, Ye (Leo) • Applied • Advances in Sampling and Stochastic Optimization
Post Ph.D. Placement: Hale Visiting Assistant Professor, Georgia Institute of Technology
Advisor: Krishna Balasubramanian

Hughes, James • Math • Legendrian Loops and Cluster Modular Groups
Post Ph.D. Placement: Elliott Assistant Research Professor - Duke University
Advisor: Roger Casals

Jacob, Cooper • Math • Topological Recursion for Generalized bc-Motzkin Numbers and Some Related Results
Post Ph.D. Placement: Lecturer, UC Davis
Advisor: Motohico Mulase

Jaramillo Rodriguez, Edgar • Math • Combinatorial Analysis of Barcodes and Interval Graphs for Applications in Data Science
Post Ph.D. Placement: Solutions Engineering Analyst
Advisor: Jesús De Loera

Kim, Jeonghoon • Applied • Machine Learning Applications and Developments for Swine Industry
Post Ph.D. Placement: Applied & Data Scientist
Advisor: Xin Liu

Leathers, Brittany • Applied • Immersed Boundary Double Layer (IBDL) Method
Advisor: Robert Guy

Litman, Matthew • Math • Explorations in Number Theory
Advisor: Elena Fuchs

Moore, Eli • Applied • Noisy Signal Correlation and Neural Network Pruning
Advisor: Rishidev Chaudhuri

Niu, Wenjun • Math • Representation Theory, Algebraic Geometry and Supersymmetric Field Theories in Low Dimensions
Post Ph.D. Placement: Postdoctoral Scholar, Perimeter Institute
Advisor: Evgeny Gorsky

Pappe, Joseph • Math • Catalan and Crystal Combinatorics
Post Ph.D. Placement: Postdoctoral Position, Colorado State University
Advisor: Anne Schilling

Senda, Alto • Math • A Mixing Time Bound for the Diaconis Shuffle
Advisor: Ben Morris

Shvarts, Eugene • Applied • Discrete Integral Operators on Graphs and Multiscale Transforms on Simplicial Complexes
Post Ph.D. Placement: Head of Data Science, Centralized Engineering Corporation
Advisor: Naoki Saito

Tran, Austin • Math • Improved Quantum Algorithms for Solving Abelian Hidden Subgroup Problems for Subgroups of Arbitrary Index
Post Ph.D. Placement: Researcher, Meta
Advisor: Greg Kuperberg

Wesley, William • Math • Algebraic and Boolean Methods for Computation and Certification of Ramsey-type Numbers
Advisor: Jesús De Loera

Almendra Hernandez, Felix • M.A., Math
Advisor: Jesús De Loera

Emami, Shahram • M.S.

Lee, Crystal • M.S., Applied

Sorenson, Darian • M.S., Applied

Yim, Richard • M.S., Applied
Advisor: Janko Gravner

Undergraduate Program

by Tim Lewis, Vice Chair for Undergraduate Affairs, and the Undergraduate Program Committee



Tim Lewis, Vice Chair



Undergraduate Clubs and Organizations

Information and meeting times can be found on the organization's website:

Math Club:

<https://www.math.ucdavis.edu/~mathclub>

AWM: <http://awm.math.ucdavis.edu/>

Math Club



AWM



Coffee with a Prof: Niels Gronbech-Jensen

This past academic year, the Department of Mathematics awarded an astounding 181 degrees (153 majors and 28 minors). Of these, 52 students graduated in Mathematics, 68 students graduated in Applied Mathematics, 16 students graduated in Mathematical and Scientific Computation, and 17 students graduated from our Mathematical Analytics & Operations Research major. An impressive 28 students received special citations, scholarships, and prizes for their exceptional performance and service. (You can read more about their citations and awards on our Department Awards page of this newsletter.) Furthermore, many of last year's graduating students went on to graduate school at prestigious institutions, and many other graduates went on to jobs as K-12 teachers or got jobs in industry as data analysts and software engineers. These achievements testify to the commitment and dedication of our students.

Information Sessions and Advising • The Department of Mathematics places great importance in providing our students with a supportive and encouraging environment throughout their time with us. This starts with good advising. To meet the challenge of advising our 839 majors and the many other students taking our classes, we have a multi-pronged advising approach. In addition to our initial Orientation Session, students can make appointments for in-person or online meetings with our faculty or staff advisors, and there is drop-in advising with our staff advisors (online) and peer advisors (online or in-person). We also run a series of Advising Workshops that provide group advising.

The clubs and events that the Department of Mathematics hosts also help to create a welcoming, supportive, and educational environment for our students.

Math Club • The Math Club is dedicated to advancing mathematics by building a strong community among people who enjoy math. In addition to fun math puzzles, snacks, and networking opportunities, Math Club meetings often include movies, workshops, and short presentations by guest speakers from

academia and industry. For more information about the UC Davis Math Club, please visit their website linked at left.

AWM • Our student chapter of the Association for Women in Mathematics (AWM) is a group that encourages and supports women, girls, and otherwise underrepresented minorities to study mathematics and pursue related careers. The AWM hosts networking, professional development, and outreach activities, and is open to everyone - all gender identities, and to faculty, researchers, and non-math majors, as well as to undergraduate and graduate math students. For more information and meeting times, see the UC Davis AWM website linked at left.

Final Exam Study Night • Our Final Exam Study Night at the end of the fall quarter have been very well received. On Final Exam Study Nights, we invite students to come study with their peers and form spontaneous study groups in a comfortable and welcoming space with delicious snacks. Appearances by our faculty members and graduate students help keep the atmosphere lively and productive.

Career Night • In Spring Quarter, we plan to hold our annual Career Night jointly with the Statistics Department. Career Night features mathematicians working in industry, in education/academics, or in public service — usually UC Davis alumni — who talk to our current students about their experiences pursuing their career, what their profession looks like from the inside, what skills are needed for the career, and general career advice. The 2023 Career Night last Spring, which was held virtually, had a fantastic lineup including two UC Davis Mathematics graduates Olivia Bailey (Mathematics Analytics and Operation Research, BS 2020) from Analytic Partners and Jacob Herbstman (Statistics & Economics, BA 2022) from the Federal Reserve Bank of Chicago, as well as Ian Alevy from MRSL Real-Time Systems Laboratory.

Coffee with a Prof ... and Pizza with a Prof too! In 2022-2023, we will continue both the "Coffee with a Prof" and the "Pizza with

Professors” program. These programs were started to facilitate undergraduate students connecting with faculty in a relaxed atmosphere. Students can ask questions to the Professors about careers, life-work balance, studying mathematics, or just about anything else. The coffee and pizza are on us!

Special Topic Courses • Each year, the Department of Mathematics offers a set of special topics courses (MAT 180) that give our undergraduate students the opportunity to learn fascinating material that is beyond our non-standard courses. This year, we are offering three special topics courses. In the Fall Quarter, Dr. Luze Xu is giving a course on Modeling and Analytics for Operations Research; in the Winter, Professor Naoki Saito will run a course entitled Invitation to Classical Analysis; and in the Spring, Professor Monica Vazirani will give a course on Linear Algebra over Finite Fields.

Directed Reading Program • The very successful Directed Reading Program (DRP) will continue for its third year. The DRP is a primarily graduate student run program that pairs undergraduates and graduate students to study advanced mathematics that are not typically covered in our undergraduate classes. Like our special topics courses, the DRP not only provides undergraduates an opportunity to explore fun new topics; it also provides them a possible entry point to research, graduate school, and beyond. This Fall there were over 100 undergrads interested in the DRP! As it did last year, the DRP plans to host a poster session in the Winter Quarter and a conference for undergraduate presentations in the Spring.

Undergraduate Research • Every year, many of our majors take part in undergraduate research experiences (REUs). Last year, six of our students (Samantha Shepard, Koby Taswell, Denise Cerna, King Lin, Katarina Merk, and Zach Ibarra) spun their research experience into their senior theses. These topics included modeling methane reducing feed-additives for ruminants and determining optimal strategies for resource allocation in areas such as counterterrorism and wildlife protection. Undergraduate theses from last year and previous years can be found on our website.

On October 17, we hosted the 2023 Mathematics Undergraduate Conference. The conference was organized by our dynamic student services staff and our undergraduate research coordinator, Professor Bob Guy. Seven undergraduates (Jonathan Chang, Naomi Ladenburg, Yaqing Pi, Runze Lu, Mani

Mojaveri, Katarina Merk, Josh Connor) gave presentations on research projects they conducted over the summer or the previous year. Professor Guy then gave a short presentation describing the benefits of doing an undergraduate research experience and giving tips for how to get started in research, and the event ended with a Q&A session with a panel of student research and faculty. About 55 interested students attended the conference, which was a fantastic showing.

Also, last Spring, as part of the DRP and our undergraduate research program, we held a research presentation workshop to help our student researchers prepare effective research posters and talks. The event included a panel discussion in which faculty gave general advice to all students, and this was followed by break-out sessions in which students shared drafts of their presentations and got direct feedback from faculty. It was extremely successful, and we plan to make the workshop an annual event.

Student Spotlight program • We are also continuing the Student Spotlight program, an opportunity to highlight the achievements of some of our wonderful undergraduate students and celebrate their hard work. Our student spotlights for the 2022-23 academic year included Teresa Dunn (Math and NPB), spotlighted for her dedicated work tutoring and helping her fellow students; and Chen Liang (Math and Physics) spotlighted for his passion in how math and physics support each other.

As you can see, our students, faculty, and staff have been extremely active with a variety of enriching activities that foster learning, engagement, and community, which is especially important in these extraordinary times.

Lastly, we would like to welcome Marji LeGrand and Shelby Kustak to our undergraduate program team. Marji has stepped into the Student Advising Supervisor position this Fall, and Shelby has been with us since the Spring as our new Student Services Assistant. We are thrilled to have them with us!

In closing, I want to thank all of the people who make these activities possible. Thank you to the wonderful faculty who volunteer their time and the many students who take leadership positions in our math community! Thanks to our tireless peer advisors, and our absolutely magnificent staff (current and past)! All of you make our undergraduate program vibrant and successful.

Directed Reading Program

To join, either as mentor or mentee:
<https://www.math.ucdavis.edu/~drp/>



Undergraduate Research

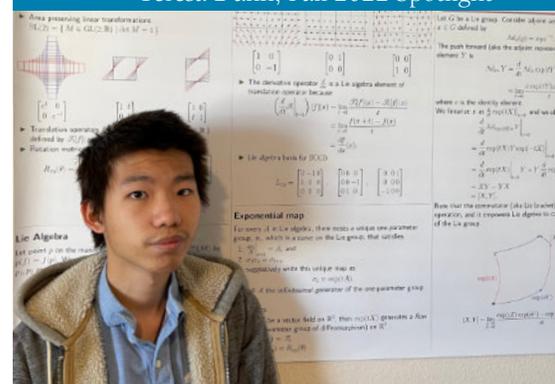
Read our undergraduates’ senior theses on our website:
<https://tinyurl.com/ucdmath-ugrad-res>



Student Spotlight



Teresa Dunn, Fall 2022 Spotlight



Chen Liang, Winter 2023 Spotlight

You can read the latest student spotlight on our Undergraduate website.

<https://tinyurl.com/ucd-major>





Summer Research Experience for Undergraduates

In the summer of 2021, the Department launched the UC Davis Pure and Applied Mathematics REU (Research Experiences for Undergraduates) summer research program, and it's been successfully running for three summers. The REU program was funded by a 3-year grant from the National Science Foundation, which was awarded in 2020 and then postponed by a year due to the pandemic. The Department awaits news from a request for renewal of the grant for another three years. Javier Arsuaga and Greg Kuperberg were the program directors, with substantial help from Jenny Brown, Rohit Thomas, and Haihan Wu.

Each spring, 12 NSF-funded REU students were selected from hundreds of applicants from all over the United States for a residential 8-week summer program that ran from June to August. The program also accommodated several independently funded undergraduates and local UC Davis math students. Each summer, the program ran four research projects in pure and/or applied math. Each research project was led by a faculty mentor or two, often along with postdoctoral and research scholars and graduate students.

The faculty mentors for the 12 research projects during these three years were Javier Arsuaga, Greg Kuperberg, Mariel Vazquez, Bob Guy, Becca Thomases, Elena Fuchs, Joseph Biello, Eric Babson, Roger Casals, Matthias Koeppel, Bruno Nachtergaele, and Motohico Mulase. The postdoctoral and research mentors were Daniel Martin, Katie Link, Matthew Igel, David Marisco, and Luze

Xu. Participating graduate students included Sanchayan Dutta, Rui Okada, Shanon Rubin, Tamara Christiani, Andrew Jackson, and Rahul Hingorani. Participating UC Davis undergraduates included Wanying Zhang, Kavish Purohit, Brittani Parrett, Camila Sanudo Thomas, Yaotian Ji, Tina Tan, and Yibo Wang.

The 36 NSF-funded REU students were (by design) from colleges and universities all over the United States. They came from 18 states, of which California was the best represented with 8 students. Their educational institutions also spanned the range from Harvard and Yale, to UC Berkeley and UT Austin, to Coe College in Iowa and Fullerton College in California. The single best-represented school was Haverford College, with 3 students over the three years. One of the 3 independently funded visiting students came all the way from Cambridge University in England. Most of the students from the first two years are now in graduate school in mathematics at various universities, including one joining us here at UC Davis, Jillian Eddy.

Besides intensive research activities in all of the research projects, the program also had many adventures on field trips over the three summers, including Calaveras Big Trees State Park, Armstrong Redwoods State Natural Reserve, Sonoma Coast State Park, Lake Tahoe, the Exploratorium in San Francisco, and (as a point of tradition each summer) the Davis Bike Loop.

Nearly all of the REU students were happy or very happy with their summer experience.

Here are a few of the various positive quotes from them from the post-summer surveys:

“My time in Davis was probably the best summer of my life. I had such a great time and I can't thank you enough for the experience!”

“Participating in the UC Davis Math REU program was an extraordinary experience. It was a privilege to work with so many people so passionate and talented in mathematics.”

“The program really helped me grow as a student of mathematics. From living in the Tri Co-ops to biking as my main mode of transportation, I really enjoyed the lifestyle in Davis.”

Last but not least, the UC Davis Math REU program benefitted greatly from the expert advice and long prior experience of Rena Zieve, who has led the UC Davis Physics REU program (along with other members of the UC Davis Physics Department) for 20 years.

Completed REU Research and News

Any updates as well as past projects can be found on the REU website:

<https://reu.math.ucdavis.edu/>



Alumni Update

R. J. Briggs

B.A.S. — 2000

After graduating UC Davis with a degree in both Math and Econ, R.J. Briggs earned his Ph.D. at University of Texas at Austin. He was an Assistant Professor at Penn State for several years.

R. J. Briggs is now an Economist at the RAND Corporation in Santa Monica, CA. His research focuses on cost estimation for disaster recovery, catastrophic risk and public policy, and predictive modeling for long-range strategic planning. R. J. has worked on a diverse array of RAND projects, from modeling the returns to education to measuring the efficacy of US Naval communications networks.

He's happily living in Houston, still engaged in mathematics as a language, as a tool, and as a pastime.

Read more on R. J. Briggs' joint research

Read some of the publicly published work that R.J. has collaborated on at RAND Corp.
<https://tinyurl.com/briggs-res>



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: 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.



Amrit Sidhu

B.S. — 2009

A few short years after earning their B.S. in Mathematics, Amrit was awarded a post baccalaureate diploma through The University of British Columbia.

Amrit has had a variety of accounting positions, and is presently an accounting manager for NMI Industrial in Sacramento.



Ralph Edward Morris

M.A. — 1979

After graduating from UC Davis with my masters, I joined Systems Application International (SAI), an air quality consulting firm, and became an expert in air quality modeling with expertise in emissions, meteorology, atmospheric chemistry and, of course, numerical methods for solving differential equations.

I have been at Ramboll Environment and Health for almost 30 years now, centered in the San Francisco Bay Area, and I am currently a Managing Principal with about 160 people reporting to me throughout six offices in Northern California, Colorado and Utah. I'm still a Subject Matter Expert in air quality modeling including developing ozone, particulate matter and visibility clean air plans for states and local government agencies.

Read more on Ralph Morris' joint research

Focusing on air quality studies, read more on haze, ozone trends, and aerosols.

<https://tinyurl.com/morris-res>



Kent Neuerburg

B.S. — 1987

After graduating UC Davis with an MAT in Mathematics in 1985, I began my career as a Mathematics Teacher at Luther Burbank High School in Sacramento, CA. I held this position from 1985-1989. At the time, Luther Burbank was home to a magnet program in Mathematics, Science, and Engineering. The bulk of my teaching was to highly motivated students in the magnet program.

In 1989, I joined Cosumnes River College in Sacramento as an instructor, a position I held until 1994. While there, I helped design and implement a Mathematics Lab focused at serving underprepared students.

I returned to graduate school in 1994 at the University of Missouri, Columbia earning my M.A. and Ph.D. in Mathematics. My dissertation was *On Puiseux Pairs and Resolution Graphs* under the supervision of Stephen Dale Cutkosky.

After earning my Ph.D., I accepted a position at Southeastern Louisiana University where I am now finishing my 25th year. As an algebraist, my research is primarily focused on rings and nearrings.

I am happy to say that the preparation I received at UC Davis has always served me well throughout my career. I daily rely on the mathematics and teaching strategies I learned while at UCD, and fondly recall the many professors and fellow students with whom I worked. Of course, the faculty members I knew are no longer on staff, but other alumni will surely recall the many excellent Mathematics professors we had the pleasure of knowing including Henry Alder, Evelyn Silvia, Kurt Kreith, Tom Sallee, David Mead, G. Don Chakerian, Sherman Stein, and many others.

Read more on Dr. Neuerburg's research

From climate change, to AI, to nearrings.

<https://tinyurl.com/neuerburg-res>



Craig A. Tracy Research Prize

To honor Professor Emeritus Craig A. Tracy, the Department created the Tracy Research Prize, to be awarded annually for research by one of its postdoctoral researchers or Krener Assistant Professors (KAPs). This prize is given to an individual to recognize the quality of their research.

Recipient – Melissa Zhang

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. The prize recognizes the best teaching of lower-division mathematics courses on an annual basis.

Recipient – Edward Goldsmith

G. Thomas Sallee Mathematics Prize

This prize recognizes exceptional undergraduate students of junior or senior standing who competed in this year's Spring Mathematics Competition.

Recipients – Zachary Graeber, Wei Wu Lu (runner up)

Eric C. Ruliffson Scholarship in Mathematics

Eric Canady Ruliffson attended UC Davis from 1964-1968, where he both loved the study of math and excelled in it. The Eric C. Ruliffson Scholarship in Mathematics is awarded annually to students of junior or senior standing majoring in mathematics.

Recipients – Emily Contreras, Victoria Horkheimer

William K. Schwarze Scholarship in Mathematics

William Karl Schwarze received a bachelor's degree at UC Davis and went on to become a mathematics teacher in San Francisco. After his death in 1988, a trust he established has donated 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.

Recipients – Eli Moore, Mary Claire Simone

Hazel B. Jacoby Fellowship

The Jacoby Fellowship is awarded by the Department of Mathematics for the purposes of both recruiting intellectually promising graduate students entering their first year of graduate-level study and retaining outstanding continuing graduate students.

Recipients – Makayla McDevitt, Tonie Scroggin

McCurdy Family Scholarship

The McCurdy Family Scholarship is awarded to undergraduate students in the College of Letters and Sciences at UC Davis. Selection of recipients is based on academic merit and promise. The Scholarship is restricted to students with junior or senior class standing, and may include any undergraduate major offered in the Department of Mathematics.

Recipient – Abigail McDaris

Robert Lewis Wasser Memorial Scholarship

Robert Lewis Wasser began studying mathematics at UC Davis in 1991. 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. Its goal is to benefit promising mathematics students at UC Davis.

Recipient – Mani Ebrahimi Mojaveri

Henry L. Alder Award

Professor Henry L. Alder was at Davis from 1948 till 1994, serving as Department Chair from 1992 to 1994.

Professor Alder was a strong advocate for quality teaching. This award provides support to mathematics graduate students at UC Davis and is given each year to the graduate students in mathematics who are deemed to be the top performing teachers.

Recipients – Colby Brown, Vincent Lovero, Trevor Oliveira-Smith

Alice Leung Scholarship in Mathematics

Alice Siu-Fun Leung received a Master's degree in Mathematics in 1975 from UC Davis, and remembered this time in her life fondly. This award is given to graduate students in Mathematics who have shown exceptional promise in all aspects of mathematics, including research, scholarship and teaching.

Recipient – Alexander Black

Evelyn M. Silvia Scholarship for Future Mathematics Teachers

Professor Evelyn Silvia came to the UC Davis Department of Mathematics in 1973. The focus of Evelyn's passion and unwavering commitment was to develop talented mathematics teachers at the K-12 grade level. This scholarship recognizes a junior or senior with a major in mathematics, applied mathematics or statistics who has shown an interest in teaching mathematics.

Recipient – not awarded this year

Jim Diederich Scholarship for Mathematics Majors

Made possible from an endowment that was initiated by a contribution by Jim and Paula Diederich. In making this gift, they wished to provide benefit to students whose interest in mathematics is not measured by grade point average alone, but who have special gifts deserving of support.

Recipient – Yaotian Ji

Awards

Staff Update

by Tina Denena,
Chief Administrative
Officer



Yueh-Jing Lin Scholarship in Mathematics

Yueh-Jing (Jean) Lin and Chau-Hsiung (Mike) Chuang are alumni of UC Davis who met while they were graduate students on campus. This endowment provides scholarship support to one or more mathematics students each year who are high-achieving mathematics students, either undergraduate or graduate.

Recipients – Denise Cerna, James Hughes, Zachary Ibarra, King Lin, Timothy Ng, Joseph Pappé, Raag Ramani

Galois Group Service Award

The Galois Group represents the voice of graduate students in the Department. Every year, the Galois Group presents an award to recognize outstanding service and/or sustained commitment to the graduate group.

Recipient – Anne Schilling

SIAM Recognition of Service

The SIAM Student Chapter Certificate of Recognition is awarded for exceptional service to a student chapter. SIAM and the student chapter community are appreciative of special contributions made by this individual to the program.

Recipient – Greg DePaul

Departmental Recognition of Service

The Department would like to recognize the efforts of Gladis Lopez, CAO, who will be retiring after many years of supporting and guiding the Department. Thank you Gladis, and enjoy your retirement!

Recipient – Gladis Lopez

Departmental Citation Awards

These Departmental awards recognize 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.

Recipient – Himshikha Nath

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 – Dongxuan Cai, Denise Cerna, Fengqin Dai, Yifeng (Ethan) He, Zachary R. Ibarra, Hannah Delanie Kennedy, King Zixuan Lin, Jiaqi Liu, Wei Jit Wu Lu, Timothy Jason Ng, Keer Ni, Alyssa Thanh Truc Phan, Jordan Olivia Roberts, Matthew Rozal, Tallon Scarpa, Vivek Shome, Benjamin Haii Sionit, Renjie Sun, John Wesley Walker

It is with great pleasure and humility that I write the Staff portion of the Department newsletter. As of May 1st I joined Gladis Lopez as the next CAO of the Department of Mathematics. After 27 years of dedication to UC Davis, Gladis took the opportunity to retire and began her new way of life on June 30th; she commenced her love of travel and new projects soon after leaving the university. We are most grateful for her time and commitment to the Department over the years.

I am beyond thrilled to continue my own journey with the phenomenal team of our staff from a new viewpoint. We are a supportive family striving for the best customer service we can offer while having all the fun. You know you work with a great bunch of people when they are excited to roll up their sleeves, get dirty and move out to the curb more than 60 (very old) desks and chairs from Graduate Offices to make room for new adjustable height desks. I could not have been more amazed at the efficiency and enthusiasm of the staff and a few graduate students to accomplish such a task in less than 2 hours. Hopefully, we can do this again soon for the second half of graduate offices!

I would also like to introduce two new staff members who have joined us this year. Our very own Diana Bond was promoted to be the Graduate Program Coordinator, working with Profs. Starkston and Arsuaga to provide the best care for our graduate students. This left an opening for our Student Services Assistant, Shelby Kustak, who joined us in March. Her addition felt so natural it's as if she has been here for decades. Shelby made her mark by juggling two conferences this summer with grace and zest.

As I moved offices in July, we made room for another great addition. Marji LeGrand started September 1st as the new Student Services Supervisor and has not missed a step. She comes to us from the College of Engineering. We are excited to see what new innovation awaits from her leadership.

Marianne, Zach and Leng have worked tirelessly getting our seminar and scholarly rooms outfitted with much improved "zoomified" technology.

Jose and Viviana move into their second year, joining the ranks of our well-seasoned staff, Thu, Matt and Alla. As our staff gain more experience we gain more ways to serve our students and faculty with novelty and creativity, and making lasting connections. We hope to create a space where undergraduate and graduate students, faculty and Krener assistant professors, post docs and lecturers alike can do the math that is inspiring and novel.

We are excited for the year and new beginnings!

Featuring the 2022-23 Academic Year

Newsletter Committee

Jennifer Schultens, Editor

Tina Denena, Chief Administrative Officer

Marianne Waage, Designer

The Department of Mathematics wishes to gratefully acknowledge the generosity of the following donors, who have contributed to its support over the past several years.

Howard Adams
Rex Allen
Marla Allentoff
Francisco Arsuaga & Mariel Vazquez
Estelle Basor & Kent Morrison
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Robert Broadhurst & Kathryn Anderson
Christopher Broski
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