The University of Arizona
Program in Applied Mathematics

January 2017 Number XVII

Greetings from the Interim Chair

Moysey Brio

Dear Alumni, Students, Colleagues, and Friends:

It has been another inspiring and busy year for the Program as it continues to be a vibrant place for applications of mathematics to a wide range of areas. In this newsletter we are delighted to report the recent accomplishments and developments from 2016.

The job market for our graduates in a knowledge-based economy is exceptionally strong, and according to the Bureau of Labor Statistics, the employment of mathematicians is projected to grow much faster than the average for all occupations.

The Chair Search Committee has finished their work and the new Chair of the Program is expected to start in the coming academic year. As we move forward, it is an exciting time and an opportunity to adapt the Program and formulate new strategies to the essential role of basic and applied research in modern society so that the Program can continue to thrive in the coming decades.

In this economy driven by innovation, the multidisciplinary and universal nature of mathematics plays a crucial role. Restructuring of the curriculum reflecting changes in employment opportunities and the needs of the discipline; developing partnerships with industry and with other departments; taking bold actions in targeted recruiting and focused mentoring to increase numbers of female and underrepresented minorities in the Program, are some of the steps that will strengthen and enhance the Program.

Our administrative staff, Keri Oligmueller and Stacey LaBorde, carried out their duties admirably and smoothly in a dedicated and professional manner that made my job as Interim Chair a breeze. We also sincerely thank our generous alumni and friends who have financially supported the Program this past year. Their support is critical for many of our student activities. I am also grateful to professors Andrew Gillette, Kevin Lin and Shankar Venkataramani for serving as de-facto executive committee and sharing in many of my responsibilities.

Please enjoy reading about our students, faculty and alumni achievements. Thanks for the great year!

Warmest regards,
Moysey

Michael Tabor Graduate Scholarship Award

Toby Shearman (8th Year Student)

The Michael Tabor Scholarship Award is a generous award and one fitting of its namesake; Dr. Michael Tabor dedicated much of his career to the health of the Program in Applied Mathematics and to the program's support of its students. Pursuing a PhD, and specifically a PhD in Applied Mathematics, is a challenging endeavor---intellectually as well as emotionally. The continued success of the Program in Applied Mathematics at the University of Arizona as well as my personal success as a student can in large part be attributed to Michael Tabor's unremitting professional and personal beneficence.

Under the guidance of Dr. Shankar Venkataramani, I am investigating the geometry of thin elastic sheets, addressing what determines their three-dimensional morphology. Initially, I was drawn to the problem by its geometric nature paired with the application of calculus of variations. As we investigated the problem further, our approach expanded to include topological methods from nonlinear analysis as well as discrete differential geometry, a technique essential to our progress.

The intricate wrinkling patterns observed in nature can be modeled as minimizers of an elastic energy functional which can schematically be described as the sum of stretching and bending energies separated in scale by the sheet thickness, a small parameter. The basic intuition for thin sheets is that, as the thickness decreases,

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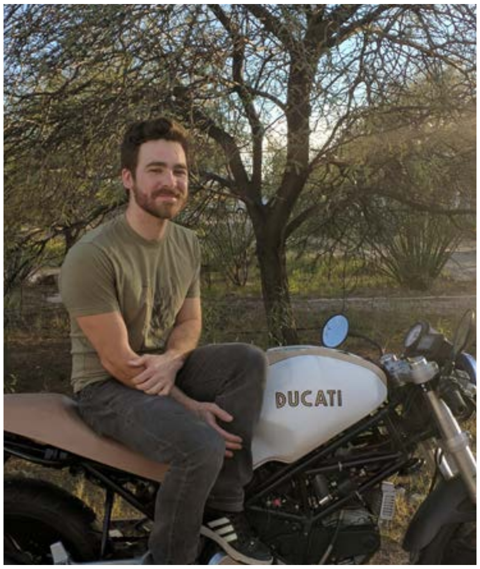
Michael Tabor Graduate Scholarship Award *(continued)*



Toby Shearman, 8th Year Student

the energy strongly penalizes stretching and drives the minimizers to states of zero stretching, i.e. isometric immersions. The study of isometric immersions of the hyperbolic plane is an old problem, one sufficiently interesting as to draw the attention of many great mathematical minds including Hilbert and Efimov.

We gained traction in the problem by developing a surgical procedure on hyperbolic surfaces: cutting and gluing to construct finite bending energy surfaces. This program is quite simple within the construct of discrete differential geometry with each cut step returning an isometric immersion with lower bending energy. Moreover, this construction produces surfaces resembling leaves with increasing wrinkling as the radius increases.

The morphology of thin elastic sheets is a long-open and complex problem. Our novel approach, borrowing techniques from many fields, has led to recent breakthroughs in the understanding of this problem from continuum mechanics. As with any interesting problem, with one answer comes ten more questions! In my final semester, I hope to finish one more contribution to our list of existing results: proof of a quantitative extension of Hilbert's embedding theorem for hyperbolic surfaces. The Michael Tabor Scholarship Award has afforded me stretches of uninterrupted time to focus on my research and will continue to do so in my upcoming final semester for which I am grateful.

Al Scott Lecture

Alex Young (6th Year Student)

This past Spring, I had the privilege of giving the Al Scott lecture which is held every year in his honor. Al, a pioneer in the field on nonlinear science, joined the Mathematics Department and Program in Applied Mathematics in 1984 after serving as the first Center Director of the CNLS. In addition to his many contributions to the study of solitons and complex systems, Al's good nature and encouragement of graduate students made him a great resource to many people in the department. He also wrote many excellent books reviewing nonlinear science -- and its connections to biology, neuroscience, consciousness, and complex systems -- which serve as a great introduction to the field.

My own research interests grew from a desire to better understand the foundations of the mathematical-biology models I was exposed to during my master's degree. These models of populations, heart tissue, and neurons often ignored the details behavior of individual people, cells, and vesicles. Instead, the systems were modeled as continua and I didn't understand the validity of this approach. During my second year at Arizona, I

Alex Young – 6th Year Student

attended a talk by Dr. Joceline Lega which discussed the emergence of collective behaviors in a system of disks which interact through inelastic collisions. In this setting, continuum models which accurately model the dynamics of the disks are difficult to construct. Joceline's curiosity in the subject mirrored my own and led me to begin working with her during my second year.

Our project, which seeks to connect properties of the collision rule to the macroscopic dynamics, utilizes molecular dynamics simulations and techniques from dynamical system and statistical mechanics. This research which comprises a portion of my dissertation, uses simulations to approximate the transport coefficients and to understand how they depend on the choice of collision rule, packing fraction, and rate of shearing.

The primary topic of my dissertation, which is a joint project with Dr. Joceline Lega and Dr. Sunder Sethuraman, pertains to the distribution of the collision times in a one-dimensional system of particles. The particles, initially distributed with random initial positions and velocities, only interact for a finite period. When the collisions are elastic, we have derived asymptotic distributions for the final collision time of an individual particle and the system which depend on moment properties of the distribution of initial positions. When the collisions are inelastic, the dynamics are much more complex and present many interesting questions which we are still investigating.

In Spring, 2017 I will be completing my PhD. As I think back on my years in Arizona, I am very thankful for the opportunities made available to me as a student of the Program in Applied Mathematics. The professors and students here have made a profound impact on my career which I intend to put to good use going forward.

New Program Affiliate Members

Katerina Aifantis Associate Professor, Civil Engineering-Engineering Mechanics Associate Professor, Materials Science and Engineering

Katerina E. Aifantis joined the University of Arizona in 2013 as faculty of the Civil Engineering Department working on nanotechnology. She received her BS at Michigan Tech, MS from the University of Cambridge and PhD from the University of Groningen. In 2008 she was the youngest recipient at 24 of the prestigious 5 year European Research Council Starting Grants.

Nanomaterials, cancer migration, biocompatible implants, next-generation Li-ion batteries, interfaces, electrodes for treating and preventing epilepsy… These are all topics I have focused on extensively through the past years, revealing an unexpected multidisciplinarity in my research, which I hadn't anticipated, and a point of view that is extremely different from when I began my PhD in Cambridge at 20. My goal at the time was to understand gradient plasticity, a popular mechanics framework developed by my father around the time I was born. I amused myself spending 16 hour days in the office - sometimes staying there overnight - trying to understand the effect that interfaces have in composites by solving nonlinear differential equations. Relating my models with experiments or any potential practical application of my work was something I never imagined. I was immersed in a theoretical world, fascinated by the harmony, logic and beauty of applied mathematics. My enthusiasm and dedication, as well as the support of my advisor John Willis - who would double check with pen and paper the solutions that my generation can only obtain with programs such as Mathematica - made it possible for me to complete the majority of my PhD work within a year. Then, as under Cambridge regulations it was not possible to defend in less than three years, I transferred to the University of Groningen at the group of Jeff De Hosson, drawn to his expertise of using novel experimental approaches for studying nanomaterials. After spending an intense few months in his lab, I was able to obtain nanoindentation experimental data, which to my great surprise, were in absolute agreement with my theoretical predictions, and allowed me to complete my PhD in less than two years at age 21.

The experimental validation of my own theory was a turning point, which completely shifted the way I viewed science. Since then I followed the approach of integrating experiment and theory in a way that they continuously complement each other. Through the years, instead of trying to solve a mathematical puzzle, which was a most exciting and personal game, I wanted to use theory to directly impact society, either through basic science contributions, or applied science advancements, which can directly improve human life or sustain the environment.

The multidisciplinary environment, which I work in is especially intriguing and unique as it requires interaction with internationally established scientists who complement my own expertise, and share the same drive of uniting our individual skill sets. Even though the areas of my research vary greatly, the common topics found in all my projects are: interfaces (between crystals or implants with tissues), the nanoscale, materials science and solid mechanics; all of which were the foundations of my PhD. Particularly, since this past July I have been able to fully reconnect with my first scientific endeavor, as I was awarded a grant from the U.S. Department of Energy, Office of Basic Energy Sciences (No. DE-SC0016306) to study The Role of Grain Boundary Structure and Chemistry in Materials Failure. This will allow me to systematically combine materials science with applied mathematics in further exploring that which I started researching as a graduate student 13 years ago. A special aspect of this grant is that it will allow me to closely work with my undergraduate mentor Stephen Hackney, who introduced me to the wonderful world of research, and acts as a co-PI to the project.

Luke McGuire (PhD 2013), Assistant Professor, Geosciences

Luke McGuire joined the faculty of the Department of Geosciences at the University of Arizona in 2016. He received his BS in mathematics from Bucknell University in 2008. After earning his PhD from the University of Arizona in 2013, he worked as a postdoctoral researcher with the U.S. Geological Survey Landslide Hazards Program.

What are the processes that shape the landscapes we live in? Can the landscape be used to infer details of past climates, the frequency of natural hazards, and tectonic history? My group seeks answers to these and similar questions by improving our understanding of the connection between different geological processes and the landscapes that they create.

We work across a wide range of temporal and spatial scales, from studying the impact that individual rainstorms have on a hillslope to examining the role of vegetation in controlling sediment transport over millions of years. A myriad of processes become inter-connected in the Earth's systems over these time scales, including feedbacks among climate, vegetation, and soil development. As such, we work with researchers in industry, academia, and the government with expertise in applied mathematics, ecology, geology, hydrology, and soil science to accomplish our goals. The interdisciplinary nature of our work is one of the more exciting aspects of what we do.

Many of our studies involve combining mathematical modeling with rigorous

New Program Affiliate Members *(continued)*

field-based analyses and remote sensing data. A great many geologic processes, however, occur either over time scales that are too long for direct observations or in response to extreme events that are unpredictable, such as earthquakes, wildfires, and severe weather. Therefore, mathematical models often provide the critical framework needed to integrate data from disparate sources through geologic time to allow us to test hypotheses.

One focus of my current work is centered on understanding the initiation of hazardous debris flows as well as how these powerful flows erode channels over hundreds of thousands of years. We collaborate with a number of researchers to monitor field sites with a high potential for debris flows, develop improved models for hazard assessments, and use these insights to inform mathematical models of landscape evolution over hundreds of thousands of years. Debris flows are particularly common in the southwestern U.S. following wildfire and we have several active field sites in the San Gabriel Mountains, CA. Immediate applications of this work include improved assessments for debris flow hazards. As we start this new lab at the University of Arizona, we look forward to continuing to develop and use mathematical models to explore mechanistic explanations for landscape evolution and are always interested in opportunities for collaboration.

Congratulations Luke McGuire (PhD 2013)

UA wins 4 of 5 prestigious Arizona Bisgrove Scholars Awards

The Science Foundation Arizona, or SFAz, recently announced its 2017 SFAz Bisgrove Scholars Awards, with **four of the five recipients from the University of Arizona**. UA researchers Michael Marty, Jiangqaing Chen, **Luke McGuire** and John Schaibley will each receive $200,000 in support of their research.

Alumni Profiles

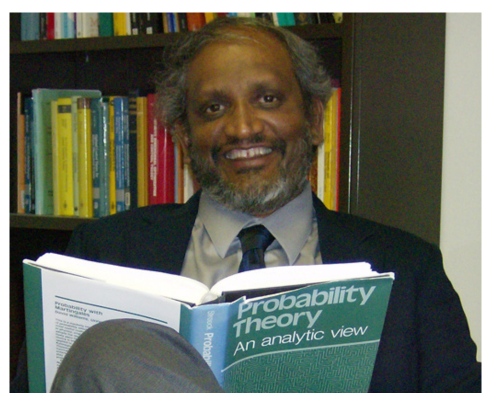
Sivaguru Sritharan (PhD 1982), Provost & Vice Chancellor,Air Force Institute of Technology, Wright Patterson Air Force Base, OH

I first met Professor Dick Seebass in 1979 at the University of Washington where I was a first year grad student in aeronautics and astronautics and expressed interest in working with him in high speed aerodynamics. After his first semester at UW, Professor Seebass who was visiting from Cornell University decided to move to the University of Arizona, so I wrote to him expressing my interest to follow him. He said UA has started a new graduate program in applied mathematics and suggested that I join this program. Dick Seebass said "you will have legendary aerodynamicist (who also moved from Cornell to Arizona) Bill Sears, K. Y. Fung and my group to learn about high speed aerodynamics, Nobel laureate W. E. Lamb, Paul Fife, Hermann Flaschka, David McLaughlin to learn about nonlinear waves and David Lovelock and Hanno Rund to learn about gauge field theory," and also added that those scholars were among the best in the world. I joined UA applied mathematics in January of 1980 and completed my PhD in August of 1982. The broad perspective I developed during this period shaped my thinking and subsequent work in a range of deeply mathematical and interdisciplinary applied mathematics covering mathematical and computational fluid dynamics, nonlinear PDEs, functional analysis, harmonic analysis, control theory and stochastic analysis. In my current position as the Provost and Vice Chancellor of the Air Force Institute of Technology, I am often called upon in national and international forums to articulate the enabling scientific underpinnings of Air Force's game changing technology areas, namely hypersonics, autonomy, directed energy weapons, nanomaterials, unmanned systems and cyber. I would certainly credit UA applied mathematics for fostering a supportive intellectual environment to help build my curiosity and interest across disciplines.

As we all know, during graduate study you learn by taking classes, attending seminars by top scholars, performing research with your thesis advisor, discussing with your classmates and learning about their interests and also by discussing and learning about what your teachers are famous for and are passionate about.

I still speak in my seminars about the masterful lectures of David Lovelock on tensors and Riemannian geometry and how he completed the semester with a beautiful theorem he proved establishing that in four dimensional Lorentzian geometry there exists only one tensor that is concomitant to the metric tensor and its first and second derivatives, depends on the second derivative linearly and that is divergence free. This is the famous Einstein tensor of general relativity and the results are now known as Einstein-Lovelock theorem. The concept of semigroups I learned from Bill Faris' lectures opened my eyes to later learn about the interconnectivity of PDEs, control theory, stochastic analysis, nonlinear monotone and accretive operators, variational inequalities and free boundary problems.

The seminars during that period were seminal with speakers such as Mark Kac, Henry P. McKean, George Batchelor, Clifford Truesdell, Eugene Trubowitz, Alan



Newell and Stephen H. Davis fostering an exciting intellectual climate every week.

We used to play volleyball Friday afternoons (volleyball court was adjacent to the math building) and among the teammates were those who later became well known scholars such as **Peter Tonellato, PhD 1985** (Harvard Medical School); **Michael Shelley, PhD 1985** (NYU); **David Kopriva, PhD 1982** (Florida State); **Larry Winter PhD 1982** (NCAR and UA); and **Stephen Hammel, PhD 1986** (US. Navy, San Diego). I will always be thankful to the vision of those UA academic scholars who created the applied mathematics program which should certainly be considered as one of the "trail blazers" to all American interdisciplinary programs.

Rosalyn Rael (PhD 2009)

As a mathematical biologist, I am currently in the glamorous business of modeling rats. As a postdoc at Tulane University I am modeling the movement of rat species across New Orleans, LA as part of an interdisciplinary study relating post-disaster recovery of ecological and societal communities with zoonotic disease risk in an urban area. The interdisciplinary nature of the applied mathematics graduate program at UA prepared me well for the research I have done since completing my PhD, and was a major draw for me from the beginning.

As an undergraduate I majored in botany, zoology, and mathematics at Western New Mexico University in my hometown of Silver City, New Mexico. WNMU is a small school where you cannot help but get to know the supportive faculty. Thanks to my undergraduate math professor Leon Arriola (now at UW Whitewater), I was introduced to the world of research in mathematical biology and worked at Los Alamos National Laboratory as a summer student. There I met faculty from the University of Arizona and ended up with the generous opportunity to take undergraduate classes at UA that would help prepare me for graduate level mathematics. I earned an NSF Graduate Research Fellowship and was accepted into the Interdisciplinary Program in Applied Mathematics, where I stayed for graduate school.

It was through the Biomathematics Seminar that I ultimately found the direction for my dissertation. There I presented a paper on an application of evolutionary game theory. It was a new topic to me, but this led me to connect with Tom Vincent, Emeritus Professor in Aerospace and Mechanical Engineering at the time, who had just written a book on the topic. Jim Cushing also came on board as my advisor, and we collaborated extensively with Bob

Costantino from EEB. For my dissertation research I got to work with this great team on modeling the changes in competitive outcomes brought about by evolution in flour beetle populations. Tom Vincent's energy and enthusiasm was always inspiring, but unfortunately he passed away shortly after I finished my PhD. His work remains very influential in evolutionary game theory, and especially in the research I do to this day.

Succeeding in the graduate program was no cake walk for me, but the environment at UA was supportive, and I take pride in my accomplishments there. I made advancements in mathematical research at the interface of evolution and ecology, taught and mentored students in math, and helped the local coffee shop economy thrive with my coffee-fueled marathon homework and dissertation-writing sessions. I think my personalized indention still remains in the bench at Epic Cafe.

Since completing the PhD program in 2009, I have had three postdoctoral positions. I worked with Annette Ostling in the Department of Ecology and Evolutionary Biology at the University of Michigan for two years. Then from 2011 to 2012, I worked as a Ford Postdoctoral Fellow at the Pacific Ecoinformatics and Computational Ecology (PEaCE) Lab in Berkeley, California with Neo Martinez, who is now an Associate Professor in Ecology and Evolutionary Biology at UA, and affiliated faculty with the Interdisciplinary Program in Applied Mathematics. I had previously collaborated with Dr. Martinez, starting in 2004, when I attended the Santa Fe Institute Complex Systems Summer School, and gained interest in studying ecosystems as complex networks of energy flow modeled as food webs. We have maintained ongoing collaborations since then.

Life then took me to New Orleans, Louisiana. Through connections with Mac Hyman (formerly of LANL, and affiliated with UA) and Ricardo Cortez at Tulane University I was able to engage with a community of researchers at the Center for Computational Science. There I came upon the opportunity to get involved in my current project with Mike Blum and Caz Taylor from the Department of Ecology and Evolutionary Biology. Though many aspects of life are unendingly excellent here in New Orleans and I have a newfound appreciation for king cake and parades, the subtropical humidity occasionally leaves me longing for the dry air and mountains of the Southwest.

During my seven plus years as a postdoc, I have found exceptional colleagues across disciplines, developed engaging research projects in mathematical biology, and I have traveled to conferences across the U.S. and in several countries. I have also engaged in events and activities that aim to enhance diversity in science and math, which will continue to be a high priority for me in whatever career I pursue. So far, the road after graduate school has been long and winding, but I look forward to seeing where the path I choose at the next fork leads.

Current Student Profiles

Brian Hong (4th Year Student)

Figure 1: Brian Hong (4th year student) and daughter Niki vacationing in Flagstaff, AZ

I was born to study applied mathematics. Of this I have no doubt. It encompasses the widest subject matter of any science. It motivates the intangible world of mathematics while untangling the secrets of the natural world. It strips away the complexity and reveals the elementary principles necessary for true comprehension. It brings the certainty of mathematics to an uncertain world, clarity to a sea of confusion. At least, that's how I see it.

I count myself among the lucky few who am able to do what I truly love: investigating the physical world by applying the vast structure of mathematics: differential equations, numerics, analysis, ... and the list goes on. Nonetheless, there are days when I am entirely lost, blindly wading through the seemingly endless abyss of literature. There are days when I feel as if I understand less than the day before and continued exploration only serves to confound further.

But, eventually, the explanations become clear. I have begun to realize that everything I encounter that is new and complicated has, at its core, a straightforward simplicity -an elegant solution that belies the complexity that surrounds it. It is there. The problem is finding it.

The cardiovascular system is one of these complicated entities. The function of the left ventricle (LV) alone incorporates solid mechanics, fluid mechanics, and electrochemical wave propagation. The intricacy of modeling the full system is overwhelming. However, by making appropriate simplifications, I believe it is possible to determine which mechanisms are of greatest importance in specific disease states.

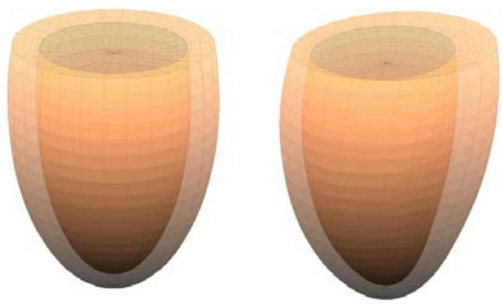


Figure 2: Models of the left ventricle. Left: axisymmetric. Right: constrained nonaxisymmetric.

I am currently focused on understanding mechanisms for heart failure with preserved ejection fraction (HFpEF). My work is part of a collaborative effort with my advisor, Dr. Timothy Secomb, and Dr. Michael Moulton, a professor and cardiothoracic surgeon at the University of Nebraska Medical Center. A typical notion of heart failure is that there is a reduced ability of the myocardium (heart muscle) to contract due to a myocardial infarct (heart attack) or other form of damage. This circumstance is often characterized by HFrEF (heart failure with reduced ejection fraction). In HFpEF, on the other hand, the heart is still able to eject more than 50% of the blood in the LV. Normal function is disrupted, instead, by diminished diastolic (filling) capacity of the LV.

Recent research has revealed that the HFpEF characterization is difficult as it encompasses multiple pathophysiologies. Some of its underlying causes are stiffening of the left ventricle, enlargement of the left atrium, remodeling of the heart, and hypertension. The intricate nature of the disease has meant that there are almost no efficacious treatments available, and survival with HFpEF is poor. My modeling approach aims to distinguish between these causes by modeling the underlying mechanisms of the LV and neighboring vasculature at targeted levels of complexity.

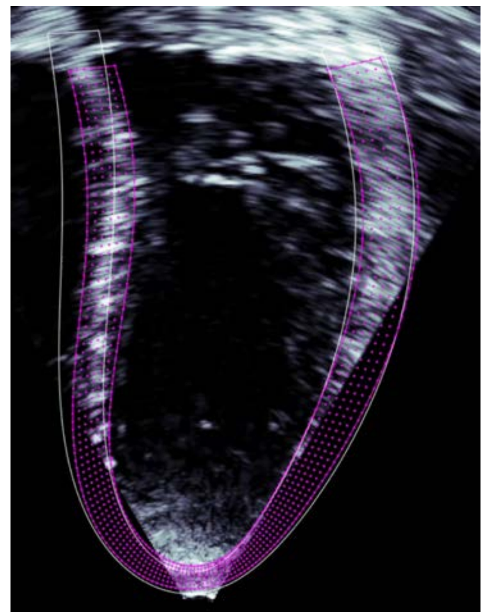
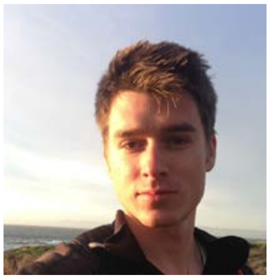


Figure 3: Image registration of echocardiogram data using non-axisymmetric modes. The overlay shows the initial model shape (white) and deformed configuration (magenta).

To this end, I have constructed models for the LV and neighboring vessels of varying intricacy under a unified framework. My hope is to distinguish, at a theoretical level, which mechanisms can reproduce the flow patterns that characterize HFpEF. I am also working on developing patient-specific models by fitting echocardiogram data. My approach continues to evolve as I compare model results to observations in patients and animal models. With time, the obscure becomes the transparent. I am confident that, like all things perplexing, the mysteries of HFpEF will be solved. My only hope is that my work will have some small contribution to the explanation that arises.

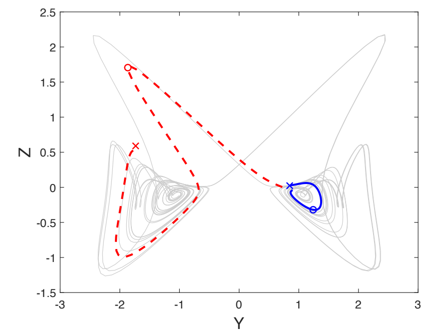
Andrew Leach (6th Year Student)



My first foray into mathematics was an introduction to proofs course, where my professor showed me with a twinkle of his eye and a dash of rigor, just how exciting the field could be. It wasn't long before I was spending late nights trying to prove conjectures on the crossing numbers of graphs, and reading through every combinatorics text book I could find. My enthusiasm for discrete math lead me to a year-long research program called "URGE to Compute" at my undergrad school, University at Buffalo. I was able to get a feel for the academic world by attending conferences and publishing my work on the computational complexity of a class of geometric set cover problems. I enjoyed the community and strived to be a part of it. Thanks to the timely introduction I had to applied math through coursework, I was steered towards applying to the Ph.D. program here at the University of Arizona. I was struck by how welcoming the faculty were when I came out to visit, and by the caliber of the students.

During my visit, I met Dr. Kevin Lin, who would later become my advisor. In my first year he instructed one of my core courses on methods in applied math, and he guided my RTG project on dimensional reduction of discrete Markov chains during the second. I took what I learned about Monte Carlo methods from the project, and stochastic differential equations (SDE) from the stochastic processes course sequence, and put it towards my comprehensive exam. Since then, I've made a point of spending a bit of each summer trying out something new. I had really positive experiences with a data science internship at SendGrid in Denver, a workshop on dynamical systems in Houston, and a systems biology workshop at MSRI in Berkeley.

Last year, Dr. Matthias Morzfeld joined the



Mathematics department, and became my co-advisor. The three of us are currently wrapping up a project for sampling from probability distributions that show up in rare event simulation and data assimilation for SDE. With Monte Carlo methods, the probability of an event is estimated as the number of times it occurs divided by the total number of samples drawn. For example, if you flip a coin 10 times and get 6 heads, you could estimate the probability of flipping heads as 6/10. If you flipped 1000 coins instead, you'd expect a more accurate answer. The events we are interested in for SDE are not as simple as landing heads on a coin flip, and the likelihood of seeing them in a simulation can be very small, even when a large number of samples is drawn. We utilize importance sampling methods to run simulations where seeing the event becomes very likely, and add a correction for the bias that this introduces. I'll be presenting the work in a poster at the American Geophysical Union Fall Meeting (nearly 24,000 attendees last year!) as part of our recently formed uncertainty quantification cohort.

I'm finishing up my last year here in the program, and defending my dissertation this Spring. It has been quite the journey, and I've really enjoyed it along the way. I've made friends from many of the university's other departments, rock climbed and hiked the accessible outdoors, and indulged in some of the fantastic coffee and Mexican fare that the city of Tucson has to offer. Above all though, the students and faculty have really made this place home.

News from Members and Affiliates

Jim Cushing (Math) I was Amy Veprauskas' adviser; she defended her dissertation and graduated from the Applied Program May 2016. I co-edited two books: 1. Applied Analysis in Biological and Physical Sciences, Springer Proceedings in Mathematics & Statistics, Volume 186. 2. Discrete Dynamical Systems and Applications, Springer Proceedings in Mathematics & Statistics, Volume 180. I was author/co-author of 5 journal articles that appeared so far this year. I was a plenary speaker at five conferences: 1.Biology and Medicine through Mathematics Conf., Virginia Commonwealth Univ., Richmond, VA, May 2016; 2. Natural Resource Modeling Conf., NAU, Flagstaff, AZ, June 2016; 3. Canadian SIAM Symposium on Recent Advances in Dynamical Systems & Mathematical Biology, Univ. of Alberta, Edmonton, CA, June 2016; 4. Intl. Conf. on Difference Equations and Applications, Osaka Prefecture Univ. Osaka, Japan, July, 2016; 5. ICDEA2016 Pre-conf., Okayama Univ. of Science, Okayama, Japan, July 2016.

Moshe Dror (MIS) Patents: Dror, M. and K., Carl, (December 2015). US Patent 9,217,649, 2015. Systems and methods for providing topographical graphs and travel routes based on perceived exertion.

Ozan Koyluoglu (ECE) Grants: August 2016: NSF CNS (Computer and Network Systems) grant on cloud computing and cybersecurity. February 2016: NSF CCF (Computing and Communication Foundations) grant on information and coding theory. Papers: O. O. Koyluoglu, Y.

News from Members and Affiliates *(continued)*

Pertzov, S. Manohar, M. Husain, I. R. Fiete, "Fundamental bound on the persistence and capacity of short-term memory stored as graded persistent activity," Oct. 2016: B. Akgun, O. O. Koyluoglu, and M. Krunz, "Pilot Contamination Attack in Massive MIMO," Jul. 2016; G. Calis O. O. Koyluoglu, "Architecture-aware coding for distributed storage: Repairable block failure resilient codes," May 2016; B. Akgun, O. O. Koyluoglu, M. Krunz, "Exploiting full-duplex receivers for achieving secret communications in multiuser MISO networks, Apr. 2016; A. S. Rawat, O. O. Koyluoglu, S. Vishwanath, "Centralized repair of multiple node failures with applications to communication efficient secret sharing," Mar. 2016.

Mathias Morzfeld (Math) Awards: Alfred P. Sloan Research Fellowship. Grants: PI. NSF, "Feature-Based Data Assimilation and Uncertainty Quantification for Complex Systems in Science and Engineering". PI. DOE/Nevada National Security Site, "Bayesian inversion for high-powered X-ray imaging systems", 2016–2017. PI. Simons Foundation, Mathematics and Physical Sciences-Collaboration Grants for Mathematicians (declined due to Sloan award). PI. International Research Development Grants, Univ. of AZ, 2016. Papers: M. Morzfeld, A. Fournier, G. Hulot, "Coarse predictions of dipole reversals by low-dimensional modeling and data assimilation", Physics of Earth and Planetary Interiors, in press (2016); D. Hodyss, C.H. Bishop, M. Morzfeld, "To what extent is your data assimilation scheme designed to find the posterior mean, the posterior mode or something else?", Tellus A 68 (2016); A.J. Chorin, F. Lu, R.N. Miller, M. Morzfeld, X. Tu, "Sampling, feasibility, and priors in data assimilation", Discrete and Continuous Dynamical Systems 36(8), special issue dedicated to Peter D. Lax for his 90th birthday, (2016); A.T. Lorenzo, M. Morzfeld, W.F. Holmgren, A.D. Cornin, "Optimal interpolation of satellite derived irradiance and ground data", Photovoltaics Specialist Conference (PVSC), 2016 IEEE 43rd, Portland, OR, 2016.

Shlomo Neuman, (Hydrology & Atmospheric Sciences) retired formally from the UA in June 2015, and is now serving as Regents' Professor Emeritus in Hydrology & Atmospheric Sciences. He continues doing research on scalable random variations in space-time with emphasis on subsurface media (soils and rocks) and fluids (chiefly water).

Walter Piegorsch (Statistics GIDP) Journal Article: Schissler, A.G, Li, Q., Chen, J.L., Kenost, C., Achour, I., Billheimer, D.D., Li, H., Piegorsch, W.W., Lussier, Y.A. (2016). Analysis of aggregated cell-cell statistical distances within pathways unveils therapeutic resistance mechanisms in circulating tumor cells. Bioinformatics 32, i80-i89. doi:10.1093/bioinformatics/btw248 Research Grant: NIH Project #ES027394: "Translational mixed-factor benchmark-dose risk assessment." (2016-2018).

Calvin Zhang (Math): Papers: C Zhang, TJ Lewis (2016) Robust phase-waves in chains of half-center oscillators. Journal of Mathematical Biology DOI:10.1007/s00285-016-1066-5 (pp. 1-30); CS Peskin, C Zhang (2016) Mathematical Aspects of Synaptic Vesicle Release and its Optimal Filtering. (in prep), Fall, 2016: (1) A talk at the Motor System Symposium at the Salk Institute for Biological Studies about my research in the mathematical modeling, analysis and simulation of crustacean swimming. (2) A talk in an emphasis workshop at the Mathematical Biosciences Institute about my research in the mathematical modeling and analysis of synaptic vesicle release.

News from Alumni

Alejandro Aceves (PhD 1988) is reaching the mid-point of his term as Dept. Chair at SMU. He still manages to work on research and enjoy summer visits overseas to continue old collaborations. Last summer he was a Visiting Professor at INSA-Rouen, France where he worked with Jean Guy Caputo who is well known in Arizona.

Julia Arciero (PhD 2008) is the PI for a 3-year NSF REU grant to support 8 undergraduate research students for 8 weeks each summer at Indiana University-Purdue University Indianapolis (IUPUI). Please encourage your undergraduate students to apply to this summer research opportunity! She is the Co-PI of an NSF Conference grant to support the 5th Annual Midwest Women in Mathematics Symposium that she is co-organizing at IUPUI on February 25, 2017. If you are located in the midwest, please consider attending this conference! All details can be found at: wims.math.iupui.edu

Jared Barber (PhD 2009) became a tenure-track assistant professor in the IUPUI Dept. of Mathematics in the Fall, 2016. While still becoming familiar with the position, he has already had the opportunity to teach Numerical Analysis and help co-lead an Applied Mathematics Seminar and has begun pursuit of research opportunities in the area of vascular remodeling and cancer cell translocation.

Serina Diniega (PhD 2010) continues working at the Jet Propulsion Laboratory (JPL), splitting her time between the NASA Mars Program Office, the Europa Clipper mission, and science research. In 2016, she worked with 5 undergraduate student interns on her NASA-funded research investigating active surface processes within the North Polar region of Mars. This work was presented at the 2nd International Martian Gully Workshop (held in London, UK), the 6th International Mars Polar Science and Exploration Conference (Reykjavik, Iceland), and the Division for Planetary Sciences/European Planetary Science Congress annual meeting (Pasadena, CA); and the first conclusions are now being written up. Her paper exploring how science advancements are made within Planetary Dune Studies was recently published (http://www.sciencedirect.com/science/article/pii/S1875963716300623), along with an editorial on how senior science community members are needed in the fight against harassment (https://eos.org/opinions/senior-scientists-must-engage-in-the-fight-against-harassment). An

News from Alumni (*continued*)

additional paper that compares terrestrial and martian tumuli (an inflated lava flow feature) characteristics and measurements is in-review. Outside of work, Serina "relaxes" with long-distance running, and she ran her first ultra-marathon in December 2015, 31 lovely, mountainous, Malibu miles in 7.5hrs.

Brendan Fry (PhD 2013) is now an Assistant Professor of Mathematics at Metropolitan State University of Denver.

Scott Hottovy (PhD 2013) just became an assistant professor at the United States Naval Academy, Annapolis, MD and is continuing to do work on limits of stochastic processes (with Prof. Janek Wehr at UA) and developing stochastic models of the tropical atmosphere.

Quintina Jones (MS 2010) in March 2016, was selected for the second cohort of the Raytheon Women in Engineering, Science and Technology (RWEST) Technical Development Program. In April 2016 she became Technical Lead for a Facility Upgrade program. In August, 2017 she is expected to complete the doctoral program in Systems and Industrial Engineering with a minor in Applied Mathematics from the University of AZ.

William Johnson (PhD 1978) is presently a visiting professor of mathematics at New Mexico Institute of Mining and Technology in Socorro, NM. He has a paper "Evaluation of 4-D Reaction Integrals in the Method of Moments: Co-planar Element Case", D. R. Wilton, F. Vipiana, W. A. Johnson, in the review process at IEEE transactions on Antennas and Propagation.

Dmitry Kondrashov (PhD 2005) continues as a senior lecturer at the University of Chicago, teaching mathematical and computational modeling for biologists, has developed a broad course, required for first-year biology majors, introducing a variety of mathematical concepts through learning basic programming in R. This course resulted in a textbook called Quantifying Life: A Symbiosis of Computation, Mathematics, and Biology (University of Chicago Press, 2016). The homepage for the book: https://dkon.uchicago.edu/page/quantifying-life and MAA review: http://www.maa.org/press/maa-reviews/quantifying-life

Regan Murray (PhD 1999) started a new position at the U.S. Environmental Protection Agency's Office of Research and Development as the Chief of the Drinking Water Treatment and Distribution Branch, leading a team of scientists and engineers who are tackling some of the nation's most challenging water infrastructure issues.

Louis Rossi (PhD 1993) has had the pleasure and privilege to serve as Chair of the Dept of Mathematical Sciences at the Univ of Delaware for the last year and half. One of several professional highlights this year was to organize a mini-symposium on the Mathematics of Plankton and spend a day with an interdisciplinary collection of the experts to discuss the great questions and challenges in understanding plankton ecology which has a fundamental impact on the planetary climate.

Michael Shelley (PhD 1985) recently moved part time to the Simons Foundation for the next few years (it's in lower midtown, about a 20-minute walk from Courant), where he is leading a research group "Biophysical Modeling Group", part of the Center for Computational Biology, which is itself part of the new Flatiron Institute. His group works mostly on cellular biomechanics problems, active matter, and fluid-structure interactions.

Peter J. Tonellato, (PhD 1985) is on sabbatical from his 50% position at the Univ. of Wisconsin, Milwaukee School of Public Health (Prof of Bioinformatics) and spending time at the Univ. of Pavia and Medical College of Wisconsin establishing whole genome next generation sequencing clinical lab testing systems. In each case, he is using the optimized models and computational platform developed by his lab at Harvard Medical School, Dept. of Biomed Informatics, where he holds his other 50% appointment. Lots of travel and great road biking in the Po Valley of Central Italy.

Guillermo Uribe (PhD 1993) after a 20+ year career in academic support and institutional analysis, has returned to the Univ. of AZ Math department as a data analyst and lecturer in August 2016. He will be performing studies on student performance in math classes, placement, test item analysis and others; developing applications that use institutional data to facilitate departmental processes; and will be teaching Mathematics courses as needed.

Current Student Achievements

Luke Edwards (3rd Year) was awarded a GPSC travel grant for travel to AIAA Aviation in June 2016. He gave a talk: "Real gas effects on receptivity to kinetic fluctuations" at APS DFD 2016. He co-authored two papers jointly with Anatoli Tumin accepted for presentation at AIAA January 2017: "Real gas effects on receptivity to kinetic fluctuations", and "Analysis of receptivity to kinetic fluctuations in the Reenty-F flight experiment".

Patrick Greene (6th Year) went to the SIAM Conference on the Life Sciences in July 2016 where he gave a talk "Spatial Localization of Neurons via Extracellular Recordings." Funding to go to the conference was provided by the Don Wilson Fund and a SIAM travel grant.

Travis Harty (3rd Year) was awarded the "Distinguished Poster Award," from the Arizona Student Energy Conference for his poster titled, "Improving satellite-derived irradiance estimates using sparse rooftop solar data and optimal interpolation". This work is co-authored by Antonio Lorenzo (Optical Science), William Homgren (Hydrology and Atmospheric Science) and Matthias Morzfeld (Mathematics).

Nick Henscheid (5th Year) presented an invited talk at the SIAM Conference on Image Science in May, 2016. Presented a poster at the Gordon Conference on Image Science in June, 2016- Received an ARCS scholarship for 2016-17 and was awarded a Galileo Circle Award for 2015-2016.

Isak Kilen (5th Year) was invited to talk at Photonics West 2016 OPTO - Integrated Optoelectronic Devices, February 2016, San Francisco, CA "Modeling of ultra-

Current Student Achievements *(continued)*

short pulse generation in mode-locked VECSELs". Also wrote a small conference paper with the same title: published at http://spie.org/Publications/Proceedings/Paper/10.1117/12.2217147

Emily Meissen (6th Year) published a paper titled, "A global bifurcation theorem for Darwinian matrix models", E. P. Meissen, K.R. Salau, J.M. Cushing, Journal of Difference Equations and Applications link:http://www.tandfonline.com/doi/full/10.1080/10236198.2016.1177522

Aaron Ragsdale (PhD 2016) published a paper in Genetics in May, 2016 titled,"Triallelic Population Genomics for inferring Correlated Fitness Effects of Same Site Nonsynonymous Mutations." He graduated in December 2016, and is starting a postdoc at McGill Univ. in Montreal with Simon Gravel in March 2017.

Ammon Washburn (3rd Year) published a paper in Numerical Algorithms by Springer, "A shooting like method for non-Darcian seepage flow problems", S. Chow, A. Washburn (this work was done with his undergrad advisor). He received support from the Don Wilson travel fund, Herbert E Carter travel fund, and SISBID scholarship to travel to the Summer Institute in Statistics for Big Data (SISBID) at the Univ. of Washington, July 2016. He also received support from Don Wilson travel fund to travel to the 2016 annual INFORMS conference in Nashville, TN, November 2016 and presented a talk: "Sparse Support Vector Machines with Data Uncertainty".

Zhuocheng Xiao (1st Year) based on his undergraduate years at Peking University, has one paper under review and another just submitted, the titles are: 1. A Fokker-Planck approach to graded information propagation in pulse-gated feedforward neuronal networks. Being reviewed by Biological Cybernetics 2. Cusps enable line attractors in neural information processing. Submitted to Physical Review Letter.

Alex Young (6th Year) received the following awards: Program in Applied Math Al Scott Prize recipient, May 2016; Galileo Circle scholarship recipient, Spring 2016; selected as the Mathematics Department Outstanding Graduate Teaching Assistant, Fall 2016. He attended the First Workshop on Interdisciplinary Statistics at CIMAT, June 2016. and presented a talk titled "Distribution of collisions times of interacting particles in one-dimension with random initial positions and velocities."

Recent Graduates

Ben Holman (PhD 2016), Currently working for Raytheon Missile Systems as Senior Systems engineer I, Signal Processing Center, Tucson, AZ.

Katherine Williams (PhD 2016), Currently working as Senior Scientist at Applied BioMath, LLC, a biotech start-up in the greater Boston area that develops quantitative systems pharmacology models to facilitate better drug development.

Amy Veprauskas (PhD 2016), Postdoctoral research associate at the University of Louisiana, Lafayette. Her postdoc is focused on using mathematical models to understand how oil spills in the Gulf of Mexico affect its whale populations.

Jackson Burton (PhD 2016), Currently working for Fractal Therapeutics as a Senior Scientist. His work involves analyzing and modeling techniques for cancer diagnostics, pharmacokinetic modeling, and managing teams of student analysts.

Aaron Ragsdale (PhD 2016), Postdoc at McGill University, Department of Human Genetics, Montreal, Quebec, CA He will be continuing research with Simon Gravel in population genetics starting in March 2017.

Jeff Walter (MS 2016), currently teaching at Sheridan College in Wyoming.

The Don Wilson Applied Mathematics Endowed Fund for Excellence

The Don Wilson Applied Mathematics Endowed Fund for Excellence *was established to honor the memory of Don Wilson, a University of Arizona Research Professor in the College of Optical Sciences, with the purpose of providing support for the professional development of graduate students in the Program in Applied Mathematics. Dr. Wilson worked very closely with Harry Barrett's renowned medical imaging group and helped train many of the Applied Mathematics students who worked in that group. One of those students,* ***Jack Hoppin (PhD 2003)****, and his wife Janna Murgia, made a generous gift to the Program that enabled the fund to be established.*

2016 Don Wilson Fund Recipients:

Jackson Burton (PhD 2016) was awarded $500 in February 2016 to attend the World ADC Conference in Berlin, Germany where he gave a talk about mathematical modeling of ADC (antibody drug conjugates) delivery to tumors.

Patrick Greene (6th year student) was awarded $500 In July 2016 to attend the SIAM Conference on Life Sciences in Boston, MA where he gave a talk titled, "Triangulating neurons: spatial localization via extracellular recordings".

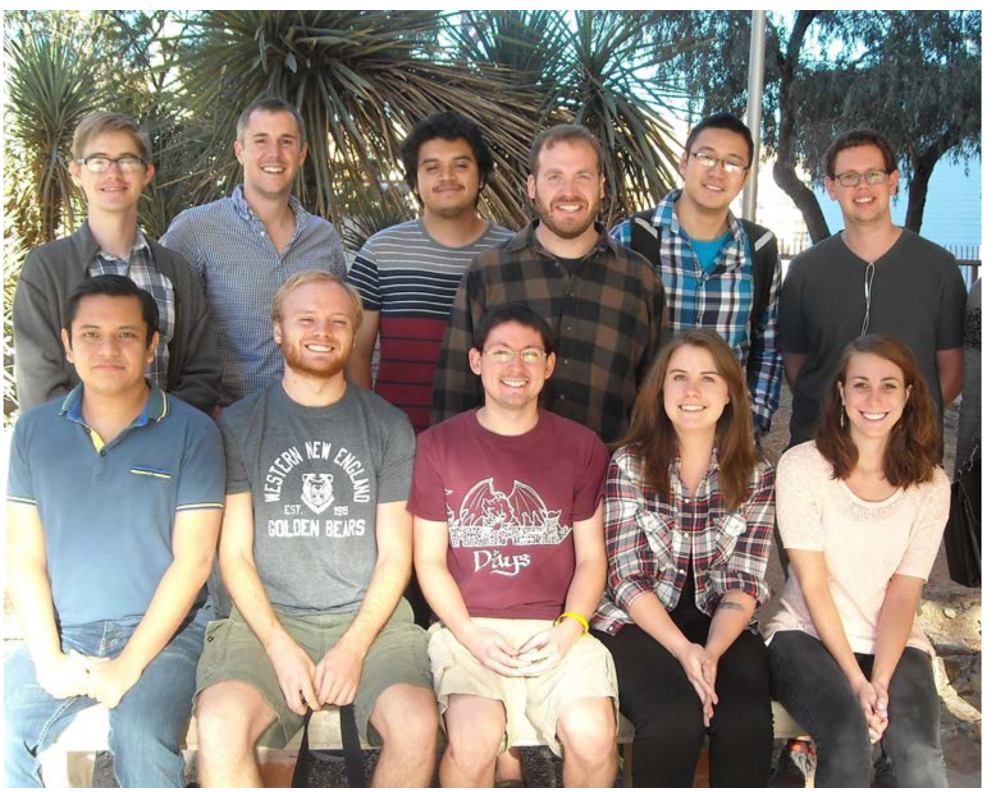
Nick Henscheid (5th year student) was awarded $500 in May 2016 to attend the SIAM Conference on Imaging Science in Albuquerque, NM where he gave a talk titled, "Multi-GPU Strategies for Computing Frame Based 3D Reconstructions in Cone-Beam CT".

Andrew Leach (6th year student) was awarded $500 in July 2016 to attend the 11th AIMS Conference on Dynamical Systems, Differential Equations, and Applications in Orlando, FL. Andrew gave a talk at a special session on Modern Applications of Mathematical and Computational Sciences regarding his work with Kevin Lin and Matthias Morzfeld in rare event simulation. Andrew was also awarded $500 in December, 2016 to present a poster at the American Geophysical Union Fall meeting in San Francisco, CA.

Ammon Washburn (3rd year student) was awarded $500 in July 2016 to attend the Summer Institute in Statistics for Big Data at the University of Washington, Seattle. Ammon was also awarded $500 in November 2016 to attend the INFORMS 2016 Annual Conference in Nashville, TN where he presented a paper titled, ""Sparse Support Vector Machines with Data Uncertainty".

If you would like to donate to the Don Wilson fund, please visit the following link:
http://appliedmath.arizona.edu/donate-program-applied-mathematics

New Students Fall 2016



Incoming class, August 2016 from top left: Jared McBride, Brigham Young University; Kyle Gwirtz, University of Kansas; Kevin Luna, Northern Arizona University; Stan Swierczek, Washington State University; Zhuocheng Xiao, Peking University; Justin Crum, Northern Arizona University.

Front Row from left: Armando Albornoz, University of Autonoma de Yucatan; Sam McLaren, Western New England University Greg Johnson, Colorado School of Mines; Jessica Pillow, Rhodes College; Hannah Kravitz, Ohio State University. Not pictured: Chelsey Hoff, Florida Atlantic University.

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Program in Applied Mathematics
The University of Arizona
PO Box 210089
Tucson, AZ 85721-0089

appliedmath.arizona.edu

Phone: 520-621-2016
Fax: 520-626-5048

Moysey Brio
Interim Chair

Stacey LaBorde
Program Coordinator, Sr.

Keri Oligmueller
Graduate Coordinator

To submit articles or news
items, contact:
appliedmath@math.arizona.edu

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