The University of Arizona
Program in Applied Mathematics

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Greetings from the Program in Applied Mathematics Steering Committee

Tim Secomb
Leadership of the Program

Applied Mathematics at the University of Arizona has a new Chair. Dr. Michael (Misha) Chertkov, currently at Los Alamos National Laboratory, recently accepted the positions of Program Chair and Professor of Mathematics and will start in January, 2019. For an initial period, he will retain an appointment at Los Alamos and spend a part of his time there. Dr. Chertkov's expertise covers a number of fields, including hydrodynamics, statistical physics, machine learning, and modeling of power grids. He is a highly productive researcher, with multiple publications in journals and conference proceedings and a strong record of attracting external funding to his institution. In his research presentation to the Program as a candidate for the Chair position, he laid out a vision for "science-application-informed machine learning." This combination of modern developments in machine learning with applied mathematics approaches addresses some of the current limitations of machine learning, and has great potential for future growth.

During the long interim since Michael Tabor stepped down, the Program in Applied Mathematics has continued to function smoothly and productively. For most of that time, Moysey Brio has served as Interim Chair, ably assisted by the administrative staff, Stacey LaBorde and Keri Oligmueller. During the spring semester of 2018, Dr. Brio took sabbatical leave, and Janek Wehr took over the leadership of the Program. On behalf of all involved in the Program, I would like to express our great appreciation to both Dr. Brio and Dr. Wehr for their excellent service.

This is an exciting time for the Program. We are well established as one of the leading applied mathematics programs in the country, with a history going back more than 40 years. Demand for our students and for our graduates is strong. Misha Chertkov is an energetic new leader with fresh ideas about many aspects of the Program, and we are very pleased to welcome him.

I thank all students, faculty, staff, donors and friends of the Program, past and present, for your work and support. Please visit our website at http://appliedmath.arizona.edu/ and enjoy reading the rest of this Newsletter.

Best wishes,

Tim Secomb
Chair, Applied Mathematics Steering Committee

CONTENTS

Greetings from the Chair, Program in Applied Mathematics

Dear students, alumni, colleagues and friends,

I am ready to open a new chapter in my life and grateful to the applied math community for its overwhelming support, to my predecessors for creating and maintaining this extraordinary program, and to the Chair search committee and UA leadership for giving me the opportunity of a lifetime.

I am excited and humbled to lead a program with such an extraordinary history of achievement. Working together, we can extend the boundaries of what modern applied math is, both in terms of education and research.

Strategically, I plan to collaborate with all of you on

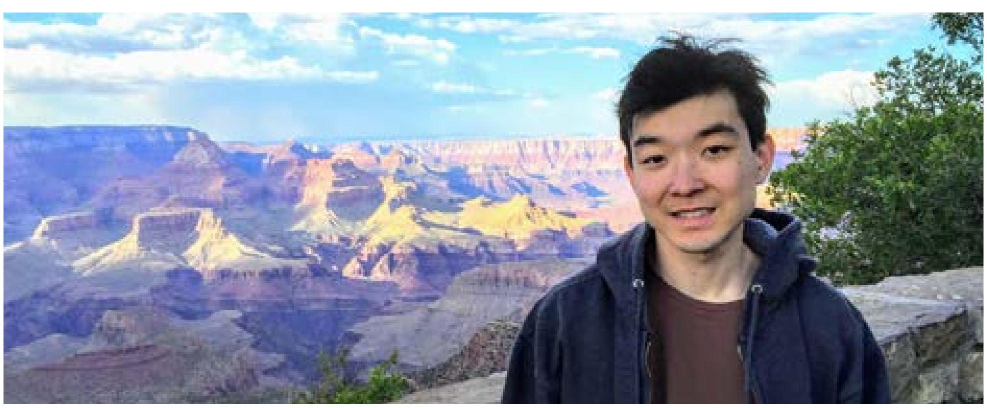
- attracting a new cohort of students with strong mathematical skills, interest in other disciplines and in applications of mathematics;
- engaging students in research early, giving them plenty of options and flexibility;
- creating new internship and collaboration opportunities for the students;
- extending the interdisciplinary nature of the program across the campus and globally;
- exploring new formats of interaction with industry and national labs.

Upon my arrival in January, my immediate focus will be on the admission of new students to the program, coordinating the work of the committee working on modernization of the program's core courses in the spring of 2019 and then implementing the upgraded courses starting in the fall of 2019. I will be seeking community input and suggestions towards new elective classes, especially those which are in high demand but missing across the UA campus. I also plan to contribute to campus-wide efforts to bring new talent and ideas in emerging areas of science and engineering dependent on mathematics.

On a personal note, I anticipate to focus in my research on statistical inference, optimization, and learning integrated with domain-specific modeling in science, e.g., hydrodynamics, and engineering, e.g., energy systems. I am open to new collaborations across campus and beyond, especially those involving our students. Thank you everyone associated with the program for all your work and support. Please stop by the 4th floor to chat (after January 21) and enjoy reading this newsletter. My best wishes, Misha.

Michael Tabor Graduate Scholarship Award

Ken Yamamoto (4th Year Student)



Having transitioned into my fourth year in the Program, it is hard to believe how time flies but also how much I have grown. I can emphatically say that I could not be more content with my journey so far. I reflect often about how very fortunate I have been to be a part of a lively and challenging program, to work with Dr. Shankar Venkataramani, to present and meet experts in my field, and to now benefit from all the additional opportunities that the Michael Tabor Graduate Scholarship Award has and will continue to enable for me. With how incredible an honor it is, I fondly recall the deeply joyous moment of receiving the news of being selected for the award.

As we students know, the first year in graduate school is rough. It was even more so for me. I needed a second try to get through the qualifying exam. However, these struggles have ultimately strengthened me, kept me humble, and bolstered my resolve to work hard, just in time as I began to focus more on research. To all the first- and second-year students reading this: Don't be discouraged; keep fearlessly forging on!

After attending talks by both of them during my first year, I found myself drawn to Dr. Shankar Venkataramani and his research on non-Euclidean elastic sheets with Toby Shearman, another student in the Program who has since graduated. I was fascinated by how they were combining calculus of variations with discrete differential geometry (DDG) to explain the

FIGURE 1. *Examples of naturally occurring non-Euclidean elastic sheets.*

intricate wrinkled patterns of thin elastic sheets. In the end, it is very important to pick a problem that excites you and to find an advisor that you mesh well with by going to seminars, knocking on doors, and talking to people about their research.

Thin sheets are omnipresent in nature, technology, and everyday life. They buckle easily and create striking examples of periodic, self-similar patterns along the edges of growing leaves, flowers, marine invertebrates, and torn plastic sheets (Figure 1). Recently, these extreme properties have been investigated and exploited for stimuli-responsive nano-structures, shape memory materials, and furthering the understanding of biological processes, e.g., biomechanics and mechanically induced cell differentiation.

Together with Shankar, I am investigating novel insights into the shaping mechanism of these thin structures. We argue that non-Euclidean elastic sheets (like lettuce, flowers, and sea slugs) exhibit an inherent floppiness, which is governed by and may, in turn, be quantified by non-smooth geometric defects. The presence and interaction of these localized defects in hyperbolic sheets may be modelled and explored with rough solutions via DDG based on taking a singular limit that assumes a no-stretching constraint.

So far, we have developed a novel DDG software framework for simulating the mechanics and dynamics of thin objects which has tremendous potential as a predictive modeling tool. Numerical simulations using this novel DDG framework reveal the significant impact of non-smooth geometric defects on elastic energy as well as the non-negligible role of weak

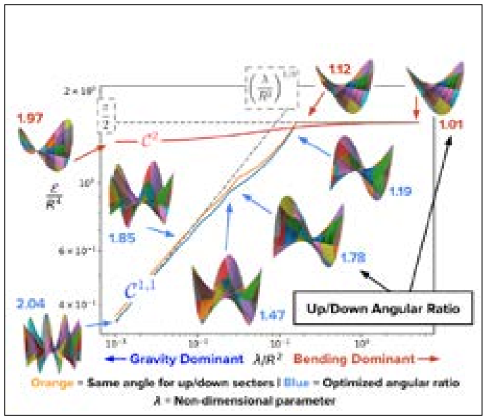


FIGURE 2. *There is a significant energy gap between C1,1 vs C2 surfaces in the gravity-dominant regime. C1,1 geometric defects allow for dramatic decreases in gravity energy.*

forces, i.e., effects other than stretching or bending, and associated scaling laws (Figure 2). Ultimately, we seek to elucidate how forces and stresses over thin membranes may play an important role in the morphogenesis of naturally growing biological tissue (e.g., leaves and flowers) as well as the biomechanics of marine invertebrates (e.g., sea slugs) (Figure 3). Potential applications include soft robotics.

For the month of January 2019, I will work with physicists in Dr. Eran Sharon's laboratory at the Hebrew University of Jerusalem to compare experimental insights into the wrinkling of thin sheets with my theoretical findings. As applied mathematicians, we all know how essential it is that we interact with experimentalists to substantiate and inform our theoretical approaches. In particular, our collaborative work will ensure that my theoretical work describing the geometry and mechanics of thin elastic objects remains both relevant and useful to the broader physics and scientific community.

Among many other benefits, the Michael Tabor Graduate Scholarship Award has directly enabled this significant work in Israel by allowing me to be out of the country without the need to teach. I am very excited about this trip, which is just a few weeks away as I write this! I cannot express how deeply grateful I am for the opportunities I can take advantage of thanks to this very generous scholarship.

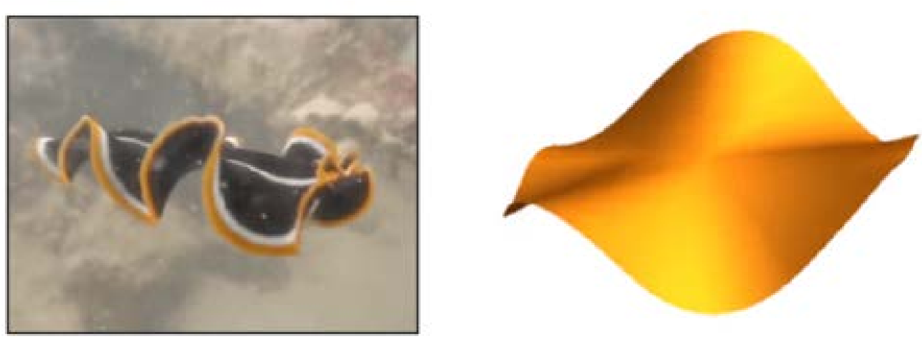


FIGURE 3. *A "mathematical" sea slug (right) with merging and splitting C1,1 geometric defects is a cartoon for the motion of a true sea slug (left).*

Al Scott Lecture

Nick Henscheid (PhD 2018), Postdoctoral Research Associate, Medical Imaging, UA

It was a delight to have the opportunity to give the Al Scott prize lecture for the Program last May. Al Scott joined the Mathematics Department and the Program in Applied Mathematics in 1984 after serving as the first director of the Center for Nonlinear Studies at Los Alamos National Lab. He was a prolific scientific contributor in the field of nonlinear science, a mentor and a friend to many in the Department.

In my talk, I spoke about the use of imaging data and stochastic models in precision cancer medicine. The prospect of employing mathematically rigorous approaches to making optimal personalized treatment decisions under uncertainty is perhaps closer to reality than it may seem, and my research seeks to advance the mathematical and computational techniques necessary to make this strategy practical.

Complex problems with real-world consequences have always provided a deep motivation for my work, and the general approach to such Grand Challenges offered by mathematical and computational science seems to allow me to have my Math and eat it too. It didn't occur to me until I began working with Harrison Barrett that one could apply rigorous mathematical techniques to medical decision-making, but I now see that a rich set of scientific (and philosophical!) problems arises if one seeks to mathematize medicine.

In my dissertation, I laid out a framework for mathematical medical decision-making that attempts to account for inter- and intra-patient heterogeneity and allow for uncertainty about the patient's current and future state. I also suggest a risk-averse treatment selection strategy that maximizes the probability (or perhaps expected utility) of a successful treatment, and provide a set of mathematical strategies for computing these objective functions. Modeling a patient as a realization of a vector-valued random field accounts for both spatiotemporal heterogeneity and uncertainty. Then, I define successful treatment in terms of quantitative biomarkers, which are patient-specific numerical quantities that can be measured in the clinic. In the language of UQ, a biomarker is simply a quantity of interest: it is a functional of the current or future state of the patient. Medical imaging data can be used to form a patient-specific posterior, with which a Virtual Clinical Trial can be performed to compute and optimize probability of successful treatment. More colloquially, each real patient gives rise to a population of virtual "stunt doubles," on which we test the proposed treatment and choose the one that works the best.

After defending my dissertation in April, and taking a short break to climb and get married, I returned to the Department of Medical Imaging at Arizona to complete work on an NIH-funded grant titled Parallel Computing and Emission Computed Tomography, which seeks to advance computational techniques in molecular imaging and precision medicine. I am also participating remotely in a yearlong SAMSI program in precision medicine, collaborating with a group at NC State on mathematical models for tumor heterogeneity and optimal control of immunotherapy.

New Program Affiliate Members

Matthias Poloczek, Assistant Professor, Systems and Industrial Engineering

Matthias Poloczek joined the faculty of the Department of Systems and Industrial Engineering at the University of Arizona in Fall 2017. He is also an affiliate member of the Program in Applied Mathematics GIDP. Before joining the University of Arizona, he worked as a postdoctoral researcher with David P. Williamson and Peter I. Frazier at the Cornell University in Ithaca, NY. His research was partially supported by a Feodor Lynen Research Fellowship of the Alexander von Humboldt Foundation. Poloczek obtained his PhD in Computer Science with highest honors from the Goethe University Frankfurt am Main in Germany in 2013, advised by Georg Schnitger. Since October 2018, Poloczek has been on leave to lead the Bayesian optimization team at Uber's AI Labs in San Francisco, CA.

My research interests lie at the intersection of machine learning and optimization. Specifically, I develop algorithms for sequential decision-making under uncertainty and combinatorial optimization that achieve excellent results in practical applications and to also provide provable performance guarantees. The design of algorithms relies on ideas from probabilistic modeling, non-convex optimization, and combinatorial optimization, whereas their analysis involves techniques from probability, stochastics, and theoretical computer science. I

also enjoy interdisciplinary work and have applied my methods in materials discovery, aerospace engineering, and biochemistry. But more on that later.

In sequential decision-making under uncertainty, my research focuses on Bayesian optimization that aims at optimizing an objective function that is expensive to evaluate. Moreover, the objective has no closed form and hence is a "black-box". Prominent examples are multi-armed bandits, automated tuning of machine learning algorithms (AutoML), and sequential design of experiments, where we acquire information about the problem instance while making decisions that earn rewards or inflict costs. Hence, we have to carefully decide what information to collect, trading off exploration and exploitation. For example, when tuning machine learning algorithms, the unknown function maps tunable parameters —the learning rate and mini-batch size of stochastic gradient descent and the regularization penalty— to test performance. Another example is the search for a solar cell material, where the objective could be the power conversion efficiency as a function of the composition and process parameters. When sparsifying a probabilistic model, the objective function could be the Kullback-Leibler divergence between the output distribution of the reference model and that of the proposed model, plus a sparsification penalty.

Following the Bayesian paradigm, we model our uncertainty about the objective function by a probability distribution, often a Gaussian process. Starting from a prior probability distribution informed by a few initial samples and possibly experts' knowledge, we refine our belief when we observe the evaluations of the function and thus compute the posterior distribution via Bayes' theorem. The decision of what data to acquire next can in principle be made optimally via a technique called dynamic programming. In practice, however, the curse of dimensionality typically renders this approach infeasible, giving rise to a variety of efficient myopic strategies. A popular approach is to select a candidate that offers maximum improvement over the current best solution in expectation.

Recent work with Ricardo Baptista (MIT) links Bayesian optimization to combinatorial optimization. This work pioneers the optimization of expensive black-box functions over combinatorial structures. Such problems are ubiquitous in academia and industry, including the placement of docking stations for new mobilities, simplification of graphical models, model sparsification of computational systems, and automated configuration of algorithms. However, the lack of a closed form and costly function evaluations pose a challenge for most optimization techniques, whereas the large combinatorial domain prohibits a direct application of common Bayesian optimization. Our work that appeared at ICML 2018 proposes the Bayesian optimization of combinatorial structures (BOCS) algorithm. It combines a tailored probabilistic model, that efficiently learns interactions of elements, with semidefinite programming to scale to combinatorial domains. We have applied the BOCS algorithm successfully in aerospace engineering where we removed expensive feedback couplings from a multi-component airfoil model while preserving its input-output behavior.

Interdisciplinary projects often require new algorithmic solutions that lead to exciting basic research problems. An example is the search for a solar cell material of maximum power conversion efficiency that fulfills certain robustness criteria, which is a joint undertaking with the Clancy group (Johns Hopkins) and the Choi group (University of Virginia). Since determining the feasibility of a candidate material requires the evaluation under expensive black boxes, we face an interesting constrained problem over a large combinatorial search space. The method will also be valuable for other domains, for example, when we optimize aerospace designs under safety requirements, or when we develop deep neural nets that meet the requirements of mobile devices. Another exciting project is the sample-efficient design of controllers with the Jiang group (University of Pittsburgh) that combines ideas from Bayesian optimization and reinforcement learning. Thus, I look forward to collaborations at the University of Arizona, in particular in materials science and space situational awareness, as well as with the data science institute and the new center for risk and reliability.

In regards to teaching, I have developed two new courses for a wide audience interested in machine learning and optimization, including, but not limited to, learners from SIE, ECE, AME, BME, applied math, and computer science.

SIE 575 offers a graduate-level introduction to Bayesian machine learning with an emphasis on Bayesian optimization of expensive black-box functions. The course combines a rigorous theoretical treatment with practical applications on problems from robot control, materials discovery, simulation optimization, computer science, and engineering. A project allows students to apply the presented techniques on a research topic of their choice. SIE 474/574 provides an introduction to Bayesian statistics and Bayesian decision-making under uncertainty. After formalizing the concept of the value of information, students develop an algorithmic framework for optimal sequential decision-making. The course closes with a discussion of chances and potential pitfalls of data-driven decision-making, specifically when agents observe each other's decisions, such as user ratings on Yelp or Google Maps, and in competitive settings with private information, including auctions on Ebay.

Eleonora Tubaldi, Assistant Professor, Aerospace and Mechanical Engineering

Eleonora Tubaldi joined the faculty of the Department of Aerospace and Mechanical Engineering at the University of Arizona in 2018. She is also an affiliate member of the Program in Applied Mathematics GIDP. She received her BS in Aerospace Engineering from Politecnico di Milano in 2010. In 2013, she earned two MS in Aerospace Engineering and Aeronautical Engineering from Politecnico di Milano and Ecole Polytechnique de Montreal, respectively. She earned her PhD in Mechanical Engineering from McGill University in 2017.

My research agenda addresses open problems of fluid-structure interaction and nonlinear dynamics applied to structures made of traditional and advanced materials for industrial and biomedical applications. The numerical and analytical research approach I use is based on very accurate reduced-order models that can be fully studied by using bifurcation analysis. This type of approach is now considered the future frontier in the nonlinear analysis that is for the moment too demanding from a computational point of view. By applying accurate reduced-order models with a limited number of degrees-of-freedom, the study of nonlinear vibrations can be included in the design of systems in a wide range of engineering structures such as aerospace, biomedical, marine applications and energy infrastructures. The reduction of security coefficients commonly used in current designs to balance the risk of using a linear theory will be achievable. As a consequence, higher performing and lightweight structures can be designed without compromising safety, while also reducing raw material costs.

My research operates also at the interface between nonlinear flow-induced vibrations and cardiovascular solid mechanics with the objective to expand the knowledge about physiology and pathophysiology of the vasculature, and to improve the requisite diagnostic and therapeutic capabilities. It is well known that vascular diseases are associated with changes in the mechanical properties of the arterial wall; however, some disorders such as aortic dissection and rupture have no biomechanical explanation yet. The investigation of a shell-like buckling phenomenon as a potential contributing cause of aortic dissection is a fascinating mathematical open problem she loves to tackle.

New Program Affiliate Members *(continued)*

My aspiration is to develop a theoretical framework that will help to predict the conditions of an incipient aortic dissection, which is considered one of the most undiagnosed serious conditions and one of the most challenging clinical emergencies.

A crucial issue in vascular surgery is the dynamic behavior of artificial vessels used in the treatment of vascular maladies requiring replacements of components of the cardiovascular system (i.e. vessel patches for aneurysms). Currently used vascular prostheses, once implanted in open surgery repair, last on average ten years and they have an impact on concomitant diseases (i.e. valve disease, heart failure, ischemic heart disease). My long-term objective is to design, based on mathematical modeling, the next generation prosthesis able to mimic the dynamic behavior of the native vessels.

I am currently also addressing another challenging topic in cardiovascular biomechanics. In patients with dialysis, the ability to be connected to the dialysis machine relies on the presence of a functional vascular access. However, vascular access points used to draw and return a patient's blood often wear out. With the study, titled "MRI-to-CFD Pipeline for Hemodynamic Profiling of Murine Arteriovenous Fistula," the goal is to develop an open-source software application that provides analysis of MRI data. Doctors can use the data to determine the best way to make the vascular access points last longer, thus reducing patient morbidity and mortality. This project has been recently founded by the BIO5 Team Scholars Program Project and I am working alongside BIO5 researchers Dr. Prabir Roy-Chaudhury and Dr. Diego Celdrán Bonafonte.

My research interests also address the study of innovative nonlinear mechanical metamaterials. Metamaterials are materials whose properties emerge from structure rather than composition. I do not modify any material at the molecular level, but assemble reasonably simple building blocks in a more complicated fashion to obtain some specific and unusual behaviors. These behaviors and properties can be obtained by using several nonlinear mechanical phenomena like snap-through instability (limit point) and buckling instability (bifurcation). Thanks to my collaboration with Prof. Katia Bertoldi at Harvard University, I is working on engineering bistable elements that store elastic energy in their deformed configuration. The stored energy will be released when a single external stimulus is provided by creating a controllable and tunable chain reaction. This research will open new promising paths because controlling waves capability can be exploited in mechanical signal transmissions, mechanical diodes, objects detection, switcher designs and logic gates.

Alumni Profiles

Jose Oliverio Alvarez-Sierra (PhD 2005) Senior Geoscientist, Microwave Research Leader, Aramco Research Center, Houston TX

"Caminante no hay camino, se hace camino al andar" is an old Spanish proverb that accurately describes my overall career experience. In short, it means, "there is no set path to follow, rather one forges one's own way." My route has meandered through a variety of science and engineering areas, in some cases directed by personal choice and in others by work needs.

Entering college twenty-five years ago in Guatemala City, I did not know what the future would bring nor where my path would lead. In a country where one is encouraged to study traditional (i.e., money making) careers, I only knew that I loved learning and mastering mathematical concepts and that the future could not be too intimidating if I was doing exciting things every day. In my fourth year at the Universidad del Valle de Guatemala, I attended different workshops by professors from France and the United States. I was fortunate to meet professor Geraldo de Souza, who not only encouraged me to continue my studies, but opened important doors for me.

After completing my undergraduate degree, I was awarded a UNESCO scholarship to study a one-year diploma program in mathematics at the Abdus Salam International Center for Theoretical Physics (ICTP) in Trieste, Italy. There, I was exposed to a much higher level of mathematics. Up until that point, I had seen myself as a pure mathematician but after taking courses at the ICTP, I decided to pursue a PhD in Applied Mathematics and felt that the PhD programs in the United States were more suitable for me than the European system.

When researching graduate programs, the University of Arizona's Applied Mathematics program stood out as a well-structured, interdisciplinary option, and the outstanding faculty and truly collaborative environment amongst students caught my attention.

Joining the program was one of the best decisions I have ever made.

The first year went by quickly, revolving between coding, linearizing and "massaging" equations, and represented a year of considerable personal growth. I was living on my own for the first time, working as a teaching assistant, taking core courses and making new friends. I warmly remember older and wiser students helping us selflessly and engaging in scientific conversations… a true collaborative environment.

Once the qualifying exams were over, I was ready to start exploring different topics. The brown bag and applied math seminars offered my first exposure to the research that was actively happening both within the program as well as elsewhere. I also took courses in Celestial Mechanics, Fluid Mechanics and Control Theory, and did a summer internship at Los Alamos National Laboratory where I worked with Aric Hagberg. I also learned a lot from Mac Hyman.

After one year of exposing myself to the many options, I decided to study aeroacoustics with Edward Kerschen in the Aerospace and Mechanical Engineering Department (AME). This is another one of my best decisions. We worked on the modeling of acoustic resonance in cavities under subsonic flow, and ultimately developed a first principles model for cavity resonances. Prior to our work, the resonant frequencies were determined by a semi-empirical formula (Rossiter). We were able to create a model based on solid mathematical grounds. As an added bonus, we were sponsored by the Air Force Office of Scientific Research (AFOSR) and I enjoyed two years of focused research. During my final year, we extended our work to determine the effect of wind tunnel walls on cavity acoustic resonances, producing novel results. To this day, both of these publications have been cited over sixty times.

As I reflect on what I would have done differently over the course of my graduate studies, I would suggest to all graduate students that they think about where they want to go after graduation two years in advance and find job listings for their dream jobs (dream jobs >>1). This anticipation will allow them to review those job requirements with time and enable them to look for course or independent study opportunities that may ultimately offer them a competitive advantage going forward.

When I graduated, job opportunities in aeronautics had been greatly diminished by government budget reductions. After a few months, I started with ExxonMobil Upstream Research Company, where I remained for almost eight years… I could never have imagined the complex science involved in digging a hole in the ground!

My first five years at ExxonMobil were spent working in the engineering function on a variety of problems including sand transport along pipes in the ocean floor, detonation theory to model expansion waves in a wellbore, and CFD modeling of acid injection in limestone reservoirs (acid reacting with rock) through 3 Km long horizontal wells. Two of my ideas are now granted patents, and I am proud of the wide array of research topics I was able to comprehensively investigate over time.

In my fourth year at ExxonMobil, I pushed to move into the geosciences function, as it was more exciting to me. Towards this end-goal, I took advantage of the education reimbursement program offered by the company, and entered the Digital Signal Processing Graduate Certificate program at Purdue University. Yes, I went back to take 5 courses after a PhD! My son was one year old when I started, and my first daughter was born during that time period - there was a lot of time management required on my side, and support and patience from my wife.

The following year I was moved to geosciences, a much needed change. I was in charge of looking for better ways to acoustically measure the quality of the cement behind pipe, since the Deepwater Horizon tragedy had been caused by a poor cement job and human error. Unfortunately, the required resources never materialized, but a new and exciting job opportunity arrived.

I was fortunate to join the newly opened Aramco Research Center in Houston, as a scientist on the Sensors Development Team. I was given the opportunity to apply electromagnetics in downhole measurements, and decided to focus on electromagnetic wave propagation in

geomaterials (rocks, oil, water). Not only is there still a lot to be done in this field, but it has allowed me to continue doing research in the area of wave theory. My field of research transitioned from Navier-Stokes to Maxwell's equations. I quickly realized that there is a tremendous dearth of electromagnetic data for geomaterials, and inevitably, I have become an experimentalist (another new path). I am grateful that I took MATH 697B, the Applied Mathematics Laboratory course with Dr. Tabor! This, in turn, has lead me to create first-in-class equipment for specific measurements both on my own and with collaborators.

Currently, I am the leader in microwave research and my current focus is on microwave characterization of geochemical properties of geomaterials. I look for correlations between the complex permittivity spectra and a particular property of interest. Before even starting a measurement, a lot of questions need to be answered: What is the frequency range I need? What is the final application? What kind of accuracy is needed? Broadband measurement? Do we need temperature control? Does a fixture exist that can perform such measurements? What are the main sources of uncertainty? What is the expected uncertainty? Answering all these questions in advance allows for good quality data and avoids the need for redoing experiments. Microwave measurements take a few seconds to perform, but hours to prepare.

Microwave analysis shows promise of being a useful method for characterizing properties of rocks and produced fluids and has shown to be a viable option for monitoring changes in hydrocarbon composition that can occur during production. Some of our recent results suggest that the dielectric constant (real part) for liquid hydrocarbons is proportional to the density. In addition, at higher frequencies, the content of aromatic components such as toluene and xylenes can be characterized through the loss term (imaginary part). I am currently working on an apparatus to perform highly accurate permittivity measurements on pressurized gases.

In unconventional resources, such as shale reservoirs, it is extremely important to know the maturity of the shale, its mechanical properties and its total organic content (TOC). The values of these parameters usually take a long time to obtain from core samples in laboratory settings. Moreover, if the core sample is not properly preserved, the measurements are not representative of what a downhole logging tool may sense. In our research, we are trying to identify signatures in the microwave spectra of rocks that will allow for a quick determination of any of the important parameters mentioned above from a downhole tool.

My research cannot be done in isolation. Arriving at useful interpretations of carefully performed experiments requires an interdisciplinary approach. I have been very fortunate to work with very smart and supportive geochemists, geologists and engineers. Through them, I have gained enough knowledge and insight of the problems to contribute to the research.

I am fortunate and grateful for the research opportunities I have had thus far, the people I have crossed paths with, and the places I have been. No one knows what his or her road is going to be and if it will ever remain straight to the end. But, if you enjoy what you are doing and making contributions, you will have a great time forging your way.

John Gemmer (PhD 2012) Assistant Professor, Department of Mathematics, Wake Forest University, Winston-Salem, NC

As an undergraduate at Millersville State University of Pennsylvania I initially pursued a degree in mathematics secondary education. I had always enjoyed mathematics and science and through my experience as a baseball coach, camp counselor, and a youth mentor I knew I was passionate about teaching and mentoring. While in college, I was pushed - one might say gently shoved - by professors Ron Umble, Bob Buchanan, and Michael Nolan to pursue a PhD with the goal of becoming a professor. Under their guidance, I changed to a double math and physics major, took part in an REU in computational mathematics at Florida State University, and conducted original research as part of an honors thesis.

When deciding on graduate schools, I was completely unsure of what type of research I wanted to pursue. Given my career goals, I was also looking for a program that not only allowed students to teach but encouraged it. The Program in Applied Mathematics' large number of faculty from various departments across campus, its close connection with the Mathematics Department, and its requirement to teach made Arizona a natural fit for me. I greatly enjoyed my time in Tucson and I cherish all of my memories from this time in my life.

The first couple of years in the program were very challenging for me. I had very little exposure to the topics covered in the core courses and I remember spending many stressful late nights mastering this material. One of the unique aspects about the program is its requirement for students to be involved in various semester long research projects during the first two years. These projects allowed me to determine not only what areas of research I enjoyed but more importantly what areas did not align with my interests. During my second semester, I particularly en-

joyed a project in nonlinear geometric control theory I conducted under the supervision of Prof. Shankar Venkataramani.

Eventually, after some wanderings and missteps, I began officially working with Shankar during my third year of graduate school. The problem we worked on combined techniques from nonlinear analysis, differential geometry, and calculus of variations to study the fractal-like patterns that emerge in swelling thin elastic sheets, think of leaves, flowers etc. This was a fantastic project for me as it combined ideas from many areas of mathematics while being firmly grounded in the real world. It took me a long time to understand the necessary physics and mathematics underpinning this problem and Shankar's patience with me during this time was extraordinary. Through our work, we were able to construct explicit geometries that qualitatively match experimental results and additionally we provided quantitative explanations for why such patterns emerge. I am very happy with this work and I am very pleased that this area of research is ongoing and has been taken up by Shankar's past and current students.

One strength of the Program in Applied Mathematics is that you are given a lot of freedom after the first year of courses. I took advantage of this freedom to not only explore different research areas but to grow as an educator. In addition to serving as a traditional instructor, I was also a "Super TA" for Principles of Analysis, ran the qualifying exam summer study sessions, was an active participant in the Tucson Math Circle, ran the University of Arizona Calculus Workshop, and was a mentor for the mathematical modeling course. However, one of my most rewarding experiences was when I taught for the New Start Summer Program. This program focused on introducing first-generation and minority students to college life. I still keep in touch with many of these students and one of them is about to finish her PhD in Environmental Health at the University of Arizona. While my role as an instructor is but a minor part of their success, I am immensely proud of the impact I have had on their lives.

After graduation, I took a research postdoc at the Arizona Center for Mathematical Sciences (ACMS) under the direction of Prof. Jerry Moloney and Shankar. I worked on mathematically modeling the remote propagation of high intensity laser beams over a one kilometer range. The challenging aspect of this problem was to learn how to counteract the natural diffraction of light over such long ranges. We developed an algorithm which optimized over the spatially vary input phase profile allowing us to construct the desired solution at target.

During my time at the ACMS I realized that while I enjoy research, half of me still wanted to be in the classroom. To this end, after one year in the ACMS I took another postdoctoral position at Brown University under the mentorship of Govind Menon and Bjorn Sandstede as part of their Research Tutorial Group (RTG) on "Integrating Dynamics and Stochastics". This position was an excellent fit for me as I had the opportunity to teach one course a semester, organize workshops and research seminars, mentor undergraduate and graduate students and help run a successful REU. I was also heavily involved in improving the diversity of the department including helping start the Association for Women (AWM) chapter at Brown.

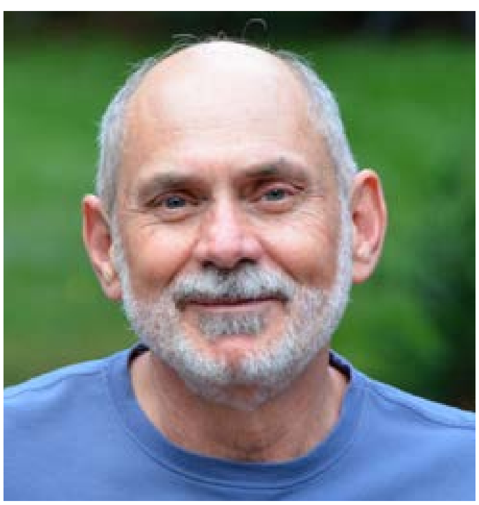
While at Brown I also grew as a researcher. One of the projects I pursued came from a conversation I had with a Shai Sabbah, a postdoctoral researcher in the neuroscience department. He was interested in understanding how during motion the head and eyes coordinate their movements to stabilize an image on the retina. In particular there are two reflexes that stabilize the image: the vestibule-ocular reflex fed by the inner ear semicircular canals and the optokinetic nystagmus driven by direction-selective ganglion cells on the retina. The problem Shai had was that he could collect data for how the ganglion cells responded to motion but needed more advanced mathematical tools to create a sufficient model for testing his theories. Moreover, all of Shai's data came from flattened retinas which differed from their natural geometry, i.e. spherical. In collaboration with Shai we created a mathematical model that used differential geometry, projective geometry, and elasticity to recreate the optical flow which the ganglion cells responded to. To our amazement the preferred directions of the various subtypes of ganglion cells varied topographically so as to align with specific translatory optic flow fields, creating a neural ensemble tuned for specific direction of motion through space. One subtype maximizes its output when the mouse advances, others when it retreats, rises or falls. By considering the interaction between the left and right retinas we also showed that each subtype ensemble is also tuned for rotation.

Since the Fall Semester of 2016, I have been an assistant professor at Wake Forest University within the Department of Mathematics and Statistics. Wake Forest is a unique university in that it is a liberal arts university that is also research active. The university takes particular pride in having a "teacher/scholar" ideal which essentially means that faculty are expected to be excellent teachers and researchers. While this is a very high bar, the expectation dovetails nicely with my own professional interests and I greatly enjoy my job. During my time at Wake, I have created a new B.S. degree in applied mathematics which started this fall, introduced a new mathematical modeling course, I mentor several first generation students, mentored one master's student who is now in her first year at Arizona, mentored one undergraduate thesis, and this semester I have started an applied math research group consisting of three master's students and five undergraduate students.

At Wake I have also remained active in research. Following up on some of the work I have done at Brown, I have been collaborating with Mary Silber at the University of Chicago and my former student Jessica Zanetell. We are studying noise induced transitions in non-autonomous and piecewise smooth dynamical systems. This work is partly motivated by conceptual models for the dynamics of Arctic sea ice. Specifically, we want to understand how fast random fluctuations in greenhouse gas levels can cause the current perennially ice covered state of the Arctic Ocean to permanently transition to a seasonally or perennially ice-free state. We are largely using tools from dynamical systems, the calculus of variations, and the theory of large deviations to understand the most probable scenario in which Arctic sea ice will melt. Within the context of this simple model, this work is key to our understanding of early warning signs for so-called tipping events.

In writing this article, I have had the opportunity to reflect on the choices I have made to lead me to a tenure track position at a university that I love. First, I think persistence and dedication were the most important skills I learned during my graduate school. In the beginning, the core courses were so challenging that I thought I would never be able to complete the degree. By the end of my PhD I learned that academia is not a sprint but a long marathon in which you slowly better yourself. Second, I learned to be very focused on projects that would train me for the career path I wanted. To this end I took advantage of the many opportunities at Arizona to not only better myself as a researcher but as an educator. Arizona is unique in that its applied mathematics students can be very active teachers and mentors. This is not the case for many applied math programs and it greatly helped me when I was on the job market for tenure track positions. Finally, the unique training in rigorous mathematics and mathematical modeling I received at Arizona has allowed me to easily transition between research projects in elasticity, optics, computational biology, and stochastic differential equations.

C. Dave Pruett (PhD, 1986) Emeritus Professor, Mathematics & Statistics, James Madison University, Harrisonburg, VA



My career path has been anything but direct. Then again, "Not all those who wander are lost." Following an undergraduate degree in mechanical engineering from Virginia Tech and a stint in the Air Force, I taught high school mathematics for three years in Richmond, Virginia. I then went to work for an aerospace contractor (Analytical Mechanics Associates) at NASA Langley Research Center (LaRC), where I helped develop the algorithm for SEADS, the Shuttle Entry Air Data System, the brainchild of NASA engineer Paul Siemers. (My mentor during this period was company founder Henry Wolf, a Jew who fled Nazi Germany just ahead of the Holocaust. Henry, a nurturing father figure, told me he'd never seen anyone grow professionally like I did during my time at AMA). SEADS eventually flew in the late 1980's as a successful experiment on Columbia and morphed decades later into MADS, the Mars Air Data System on the aeroshell of one of the relatively recent Mars landers. During this period, I earned an M.S. in applied mathematics from the University of Virginia. Originally I thought I'd continue there for a PhD, perhaps working under renown numerical analyst James Ortega, with whom I'd taken an independent study. However, while at UVA during the spring semester of 1982, I learned of a NASA traineeship in computational fluid dynamics (CFD) at the University of Arizona. It was both intellectually and geographically appealing. I applied, was accepted, and began my studies at UA in August 1982. Having grown up in West Virginia and having stayed close to home (mostly Virginia), I'd lived a relatively sheltered existence. Four years in Arizona changed that. Like the vast vistas from the summits of Mt. Lemmon and Mt. Wrightson, my world and worldview opened up. I made friends of many persuasions and nationalities among colleagues in the applied mathematics program and its sister disciplines.
I fell in love with the desert Southwest and left few stones unturned among Arizona's natural and cultural gems.
I traveled for the first time to Mexico and gained an appreciation for other cultures. I spent the summer of 1984 in Stuttgart, Germany, thanks to my

doctoral advisor, Hermann Fasel, who had ties with a world-class CFD group there. International friendships and collaborations formed there—and love for that underappreciated gem of a city—continue to this day. In the summer of 1985, I participated in the first Supercomputing Workshop, in Seattle, the Emerald City, jointly sponsored by NSF and Boeing Computer Services. And at a Halloween party that fall, I met the woman who would become my wife, Suzanne Fiederlein, a doctoral student in political science. My four years at UA hold many of the richest experiences of a lifetime.

I graduated from UA in summer 1986, bid fond farewell to the Old Pueblo, and took up a tenure-track position in the Department of Mathematical Sciences at Virginia Commonwealth University. I loved VCU, but the department in that era had problems. In the summer of 1989, I returned to NASA LaRC, this time as a post-doc, to work on numerical simulations of hydrodynamic stability of high-speed flows with luminaries Tom Zang, Craig Street, and Gordon Erlebacher, among others. (That work would eventually garner the 1996 Robert T. Knapp Award of ASME International.) ICASE, the Institute for Computer Applications in Science and Engineering, just next door, afforded a constant stream of visiting computational scientists of world-class caliber: Peter Lax, Heinz-Otto Kreiss, David Gottlieb, and Nick Trefethen among them. I also began adjunct teaching at William & Mary, first with undergrads in the Mathematics Department and later with graduate students of the Program in Applied Science.

In early 1996, four months after our daughter Elena was born, I returned to full-time academia at James Madison University, a large "public comprehensive" (i.e., primarily undergraduate) institution in Virginia's beautiful Shenandoah Valley. JMU became the academic home I'd longed for: kind and supportive colleagues, freedom to experiment, interdisciplinary. Amazingly, the appreciation has been mutual. I received our college's Distinguished Teacher Award in 2004, the first Provost's Award for Excellence in Honor's Teaching in 2008, and became the first recipient of the University's Mengebier Endowed Professorship, also in 2008. And in 2015, the generosity of the Brown family (whose daughter Katherine, a JMU valedictorian, I taught) created the department's Dave Pruett Faculty Support Endowment for Excellence in Teaching. I retired as full professor in 2012, but have continued to teach each spring semester since, with the exception of spring 2018, when I traveled to ETH in Zurich and Uni Stuttgart to lecture on recent research interests: temporal large-eddy simulation and the uses of time-domain regularization for fluid-flow simulations.

For better or worse, my interests range beyond mathematics and fluid mechanics into metaphysics. In 2012, my alter-ego's 12-year labor of love, Reason and Wonder: A Copernican Revolution in Science and Spirit, was published by Praeger. The offspring of an award-winning "science-religion" honors course, the book earned CHOICE's Outstanding Academic Title distinction in late 2012. In 2016, I self-published an affordable paperback version. Surprisingly, that feat needed only software resident on my trusty laptop. (What hath the digital age wrought?) And I've just been invited by a former JMU honors student, now with a doctorate, to a science-religion conference in Bern in the second half of 2019.

There you have it: a convoluted, unconventional career path that in retrospect has granted more than its share of satisfaction. Thank you UA Applied Math. Just the right place at just the right time.

Current Student Profiles

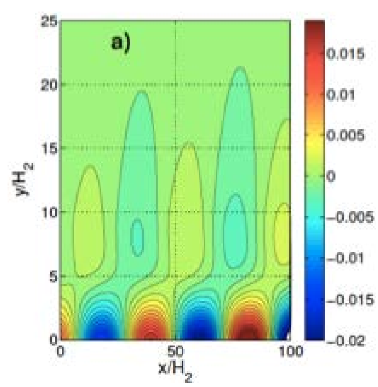
Luke Edwards (5th Year Student)

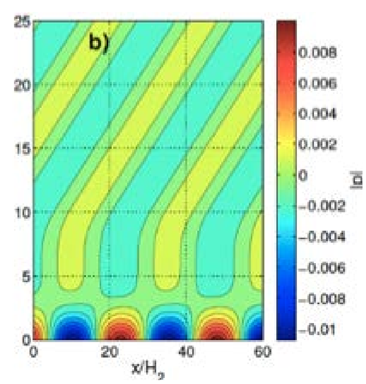
My research is focused on the millimeters-thick flow field immediately adjacent to the surface of an aircraft hurdling hypersonically through the atmosphere. I'm interested in how random microscopic fluctuations in this thin region can trigger a fundamental transition of the flow from nice and smooth, or laminar, to chaotic and disordered, or turbulent. The question of so-called laminar-turbulent transition is a fascinating one to work on. An understanding of the phenomenon is critical for a variety of modern commercial and defense related institutions and yet it is surprisingly far from being well understood.

More broadly speaking, I work in the area of fluid mechanics, a field I've always been particularly attracted to. The problems it offers are incredibly diverse, complex and often niche, yet they are ultimately unified by common roots in the powerful Navier-Stokes equations. This lends an incredible connectedness to the field that allows the practitioner to move freely through a space of innumerable interesting questions. I hope to leverage that flexibility throughout my career as mathematician to continually find problems that fascinate me.

As an undergraduate, I selected my major in mathematics somewhat arbitrarily, knowing it was among the paths likely to serve me well in the future. It didn't take long for me to realize that math was something that brought me a lot of joy. By the time I graduated, my vision for a career wasn't exactly clear but my interest in math was. Graduate school seemed like the right choice and, luckily, Arizona quickly revealed itself to be a perfect fit.

Calling my impending graduation and departure from Tucson bitter-sweet would under-emphasize how much I've enjoyed my experience here as a graduate student. Like most students in the Program, it took me a while to find the right balance between work and everything else, but once I did, everything really fell into place. I loved the Sonoran Desert from the moment I got off the plane for a visit in the Spring of 2014, and my appreciation for everything it has to offer has only grown. I'll never forget escaping to the Dragoons for a camping trip on a Friday or the rejuvenating feeling of running the rocky trails though the Tucson mountains. And, luckily, the enjoyment I've derived from my research has usually been enough to make returning to work on Mondays much more of a delight than a chore.





Jesse Adams (6th Year Student)

As I entered my final undergrad year as a computer engineering student, I came to the conclusion that I assume most people do: I just do not have enough math in my life! This led me to pursue a masters degree in math, which in turn brought me to the Applied Math PhD Program at Arizona. I have always had a love for learning, and this path has allowed me plenty. Although this certainly has not been the path of least resistance, it has been a worthwhile one.

After surviving a grueling first year and a challenging second, my hard work paid off as I obtained a summer internship at the Nevada National Security Site (NNSS) in Las Vegas. This is, of course, the perfect place to spend a summer, getting away from the desert heat in Tucson. My position was in the Signal Processing and Applied Math group, where I was first introduced to Uncertainty Quantification. I specifically began working on computational inverse problems in X-ray radiography. The combination of mathematics, statistics, and computational difficulties brought me to a new realm which I

Current Student Profiles *(continued)*

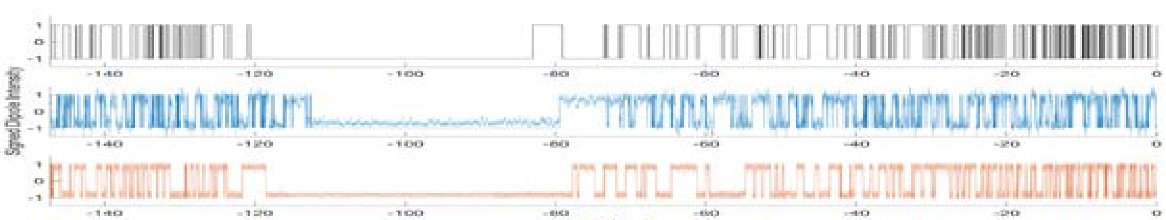
have no intent on leaving. My boss, Dr. Aaron Luttman, at the NNSS was happy to hear this and offered partial funding for the rest of my time at Arizona.

With this offer in hand, I had the task of finding a professor in the department who would become my co-advisor with Dr. Luttman. I was immensely fortunate that a new hire, Dr. Matthias Morzfeld, had just arrived on campus, and had yet to fill his plate with students. Upon our first meeting, his passion and knowledge in the field were evident, and the deal was done. Dr. Morzfeld became my advisor. Without both Dr. Luttman and Dr. Morzfeld, I most surely would not be where I am today.

Along with the projects from the NNSS, during my 3rd and 4th year I worked on a problem with Dr. Morzfeld stochastically modeling the geomagnetic dipole of the Earth's magnetic field. Previous models were characterized by two components: a deterministic drift term modeling resolved dynamics, and the stochastic term for turbulent fluid motion in the Earth's core. These models performed well over "short" time periods (on the order of 2 million years), but were suspect over longer time periods (150 million years), as they lacked the ability to produce superchrons: periods of time in excess of 10 million years where no pole reversals occurred. We were able to extend two models to better match the data by using data assimilation techniques, as shown in the figure. These results, along with work from Math graduate student Spence Lunderman and undergraduate Math student Rafael Orozco, was published in Nonlinear Processes in Geophysics under the title Feature-based data assimilation in geophysics.

At the same time, and over the summers, I continued working with the NNSS on several problems involved in X-ray imaging. At the NNSS, hydrodynamic materials experiments are performed, and the primary source of data for these are X-ray images. One part of maximizing the information gleaned from these images is to remove the blur caused by the system, while not amplifying the noise in the image. We also aim to quantify the uncertainty in the images. In my thesis work we have implemented an algorithm capable of deblurring large images, while avoiding artifacts inherent in Fourier methods.

As my time at Arizona comes to a close, I know there is much I will miss. As an outdoorsy-type from Montana, I was initially wary of the desert life. But I quickly came to love the backpacking, mountain biking, and climbing ventures available surrounding Tucson. Luckily for me, I get to continue living the desert life as a postdoc at the NNSS. And I will finally get to experience Las Vegas during a time of the year when the air does not feel like it is roasting my lungs! I will forever be grateful for the friends I have made, my amazing advisors, and the outstanding professors I have had while at Arizona. With all their help, I am excited to finally start my career as a mathematician.



News from Members and Affiliates

Cushing, Jim (Mathematics) gave 3 talks at the Joint Math Meetings in San Diego, January, 2018. Also gave invited talks at: International Conference on Difference Equations and Applications, Technische Universitat Dresdent, Germany, Institute for Mathematics and its Applications (IMA), U of Minnesota, American Mathematical Society (AMS) meetings a U of Portland and San Francisco State. Authored & co-authored research articles that appeared this year in the Journal of Mathematical Biology and Natural Resource Modeling, co-organized a special session on Mathematical Biology at the AMS regional meeting held a San Francisco State University last October.

Kunyansky, Leonid (Mathematics) was awarded an NSF grant as PI, "Inverse Problems Arising in Novel Modalities of Biomedical Imaging". He also published two papers: N. Do and L. Kunyansky, "Theoretically exact photoacoustic reconstruction from spatially and temporally reduced data", Inverse Problems, 34(9), 2018, p. 094004 and F. Terzioglu, P. Kuchment, and L. Kunyansky, "Theoretically exact photoacoustic reconstruction from Compton camera imaging and the cone transform: a brief overview" Inverse Problems, 34(5), 2018, p. 054002.

Poloczek, Matthias (SIE) is the lead of the research team for Bayesian optimization at Uber AI Labs, San Francisco. Papers published: Bayesian Optimization of Combinatorial Structures. With Ricardo Baptista. In the Proc. of the Thirty-fifth International Conference on Machine Learning http://www.sie.arizona.edu/poloczek (ICML), 2018.

Sethuraman, Sunder (Mathematics) became a fellow of the IMS (Institute of Mathematical Statistics) 2018, and became a Simons fellow 2018 as a result of being awarded a sabbatical grant. He also received a JSPS fellowship 2018 (Japan Society for the Promotion of Science) which allowed me to visit universities in Japan, primarily Waseda University.

Wehr, Janek (Mathematics) published six papers (see below). In the Spring of 2018, he served as the Applied Mathematics Program Interim Chair. In July, he co-organized (with J. Miekisz and D. Stein) a summer school "Mathematical Physics of Non-periodic Structures" in Bedlewo, Poland.

2018 publications: (1.) J. Birrell, J. Wehr: Phase Space Homogenization of Noisy Hamiltonian Dynamics. Annales Henri Poincar e 19, Issue 4, pp 1081-1114 (2018). (2.) S.H. Lim, J. Wehr, A. Lampo, M.A. Garc a-March, M. Lewenstein: On the Small Mass Limit of Quantum Brownian Motion with Inhomogeneous Damping and Di usion. J. Stat. Phys. 170, Issue 2, pp 351-377 (2018) (3.) S. Hottovy, A. McDaniel, J. Wehr: A small delay and correlation time limit of stochastic di erentialdelay equations with state-dependent colored noise. arXiv:1510.05065 (to appear in J. Stat. Phys., 2018) (4.) J. Birrell, J. Wehr: A homogenization theorem for Langevin systems with an application to Hamiltonian dynamics. arXiv: 1707.02884, to appear in Charles Newman Festschrift volume, Springer (2018) (5.) S. H. Lim, J. Wehr: Homogenization for a Class of Generalized Langevin Equations with an Application to Thermophoresis, to appear in J. Stat. Phys. (2018) (6.) M. Leyman, F. Oggemark, J. Wehr, G. Volpe: Phototactic Robot Tunable by Sensorial Delay, to appear in Phys. Rev. E (2018) The last paper was selected as Editor's Suggestion https://journals.aps.org/pre

Witte, Russell (Medical Imaging) recently founded a start-up company, ElectroSonix LC, to commercialize acoustoelectric imaging technology. In September, the company was awarded a Phase 1 NIH SBIR, "4D Acoustoelectric Cardiac Imaging for Fast and Accurate Mapping of Arrhythmias." (Contact Russell for the abstract). BME Graduate Student Chet Preston also just published a paper on selective mapping of current generated by deep brain stimulator using acoustoelectric imaging. We also applied for a patent based on this application of the technology. https://www.umbjournal.org/article/S0301-5629(18)30276-X/abstract

Zhang, Calvin – Mathematics: Calvin Zhang (Math): Papers: C Zhang, CS Peskin / Analysis, simulation, and optimization of stochastic vesicle dynamics in synaptic transmission / Communications on Pure and Applied Mathematics, 60 pages, accepted (2018). C Zhang, L Schlaeger, CR Smarandache-Wellmann / Intermittent synchronous activities in the crustacean neural cord / in prep, 2018. S Granzier-Nakajima, RD Guy, C Zhang / Metachronal propulsion at low to intermediate Reynolds numbers / in prep, 2018. Invited talk: Mathematics Colloquium at the University of Queensland, July 2018.

2018 Graduates

Nick Henscheid, PhD is a Postdoctoral Research Associate with the Medical Imaging Department at the University of Arizona.

Nick Kappler, PhD

Soon Hoe Lim, PhD is a Postdoctoral Research Fellow at NORDITA (Nordic Institute for Theoretical Physics), Stockholm Sweden.

Patrik Nabelek, PhD

Ammon Washburn, PhD accepted a position at Goldman Sachs, Salt Lake City, UT

News from Alumni

Alvarez-Sierra, Jose Oliverio (PhD 2005) published the paper titled "Theory, Design, Realization, and Field Results of an Inductive Casing Collar Locator" at the IEEE Transactions on Instrumentation and Measurement. Presented two papers at the International Geoscience and Remote Sensing Symposium (IGARSS); the papers were titled: "Feasibility of a Microwave Meter for Water-Cut Measurements and Permittivity Profile" and "Multi-Frequency Microwave Resonance Cavity for Nondestructive Core Plug Measurements". Presented the paper "Spot-Probe Reflectometer Measurements of Geological Core Slab Samples" at the Antenna Measurement and Technique Association Conference (AMTA).

Beauregard, Matthew (PhD 2008) was promoted to full professor at Austin State University, and received a NSF Math Bio grant in the previous year which started funding in 2018. Also, received a Distinguished Grant Award from our university (basically this award recognizes sum total of grants received over a rolling three year window and goes to one member of the faculty from each college).

Blayneh, Kbenesh, (PhD 1996) was promoted to a full professor position in 2018 at Florida A&M University, Department of Mathematics, Tallahassee, FL.

Burton, Jackson (PhD 2016) is an Associate Program Director in quantitative medicine at the Critical Path Institute in Tucson, AZ. He leads collaborative efforts in Huntington's disease, Alzheimer's disease, and type-1 diabetes focused on quantitative solutions for drug development. These include disease progression modeling, parametric time-to-event models, and clinical trial simulation platforms. A primary focus of his work is to guide the quantitative efforts through formal regulatory review processes at both the FDA and the EMA (European Medicines Agencies) for which such tools receive endorsement from the respective agencies. Once endorsed, these tools become publicly available to sponsors for use in drug development.

Coombs, Daniel (PhD 2001) is currently on sabbatical in the Biology Department at Emory University, Atlanta, GA. He says his goals for this year are to "fully embrace Bayesian approaches to data fitting, eat healthy, and be more patient with students. I'll be happy with two out of three."

Garcia-Naranjo, Luis (PhD 2007) will be starting a 10-month research visit at TU Berlin, Germany, working on the geometric discretisation of nonholonomic systems. The stay will be funded by the Georg Forster Research Fellowship for Experienced Researchers, awarded by the Alexander Von Humboldt Foundation.

Hottovy, Scott (PhD 2013) was awarded an NSF grant in Applied Mathematics in Spring, 2018: https://www.nsf.gov/awardsearch/showAward?AWD_ID=1815061

Hoppin, Jack (PhD 2003) gave a generous donation to the School of Mathematical Sciences to provide significant funding to advance research and teaching. The funds are quite flexible and are meant to be used strategically to allow faculty to take their work to a higher level. Possible uses include funding (or partial funding) for: visitors for a mini-conference to bring a research group up to speed on a hot topic, seed money for a major research conference, travel to semester-long programs at national/international, research institutes, specialized equipment, teaching buyout or postdoc/RA support to accelerate a major project, graduate student or post-doc support to enable development of new courses.

Jones, Quintina (MS 2018) is currently working as a Technical Lead/Principal Systems Engineer at Raytheon Missile Systems and recently completed her PhD in Systems and Industrial Engineering from UA (Fall 2018).

Kopriva, David (PhD 1982) retired from FSU and is holding emeritus status and working as an itinerant mathematician and adjunct professor with the Computational Science Research Center at San Diego State University. Enjoying his freedom, he has since retirement taught a graduate seminar on spectral methods at SDSU and hosted three PhD students there, one from Imperial College in London and two from the Polytechnic University of Madrid. With his Simons Foundation grant he has attended conferences, and had research stays at the University of Cologne, Florida State University, and UT Austin. He visited UT Austin as a J.T. Oden fellow at the Institute for Computational Engineering and Sciences working with Tan Bui on moving nonconforming spectral element methods. With Guus Jacobs, David is now organizing the first North American High Order Methods Conference (NAHOMCon) to be held in June, 2019 at SDSU, https://www.nahomcon19.sdsu.edu. David stopped by the UA math department on his drive from Florida to California, but sadly most everyone was out for the fourth of July holiday.

Love, David (PhD 2013) is a Senior Data Scientist at American Express. He received the "President's Award of the Global Consumer Services Group". The official description of the GCSG Presidents award is "Presented to employees who have made significant contributions to our company and demonstrate an ongoing commitment to collaborate across the Blue Box, grow our business, and most importantly, deliver exceptional value to our customers" He received it for his work on software systems to identify problems in data quality, and for rapidly discovering new predictive features for our machine learning models.

News from Alumni *(continued)*

McEvoy, Erica (PhD 2017) finished her Fellowship with Insight Data Science in San Francisco in Spring, 2018, and started a new job with MITRE Corporation in the Washington, DC area as a "Multi-disciplinary Sensors and Systems Analyst". She will be doing work involving Machine Learning, Operations Research, and Artificial Intelligence.

Russell, David (PhD 1983) has been a faculty member at three universities, a research scientist at Lockheed Missiles and Space Corporation, and the founder of several technical software companies in Silicon Valley. He is currently developing artificial intelligence for automating the engineering design process and for improving systems engineering. His current company, Intelligent Portal Systems, Inc., is actively developing a new software product in this area and has contract work with several engineering companies. He is also working on applying variational methods in classical and quantum field theory, particularly gravitational theory, and intend to complete writing a book on this subject this next year.

Soares, Edward (PhD 1994) along with his research collaborator (Prof. Amber Hupp, Department of Chemistry, College of the Holy Cross) has been invited to contribute a research article to a special issue of the journal Separations titled Chromatography and Chemometrics. The article is titled, "Balancing resolution and run time for biodiesel fuel separations: A study of GC column conditions using PCA and the Mahalanobis distance."

He has also been invited to give a talk at the 4th annual Optics and Photonics Winter School and Workshop, hosted by the College of Optical Sciences at the University of Arizona from Jan 4-7, 2019. The Winter School will introduce students to foundational areas of optical science and their role in optics and photonics research, in hopes of encouraging them to pursue a career in the field. The Workshop targets faculty from both research universities (RUs) and primarily undergraduate institutions (PUIs). The workshop will allow RU and PUI faculty to share results, approaches, and methodologies in optics & photonics research and education, and at the same time showcase some of the exciting opportunities that await students beyond the undergraduate level.

Sritharan, Sivaguru (PhD 1982) is the Provost and Vice Chancellor of Air Force Institute of Technology. He and his former National Research Council postdoctoral fellows Dr. Manil T. Mohan and Dr. Sakthivel Kumarasamy will publish a breakthrough advance in the theory of turbulence phenomena in aerodynamics in a soon to appear article in the prestigious mathematics journal Mathematische Nachrichten.

Modern perspective on turbulence

started with the 1893 paper by Osborn Reynolds and also the papers of A. Kolmogorov in the 1940s. These works assume that the turbulence phenomena can be characterized by a concept called ergodicity which in essence says that statistical time averages converge to averages in the state space and also that there is a well-defined statistically stationary state of the aerodynamic fields. It was conjectured by A. Kolmogorov that subject to suitable noise, the statistically stationary state would be unique and this situation is called ergodicity in mathematics.

In an extensive paper titled "Ergodicity of three dimensional stochastic Navier-Stokes equation subject to Levy noise", Dr. Sritharan and his postdoctoral fellows prove rigorously that the Kolmogorov conjecture for turbulence is indeed true for a general class of jump noise called Levy noise. Many of the turbulence closure models used today in the simulation of turbulent flow rely on this conjecture and the soon to appear paper by Sritharan and his colleagues will resolve this issue decisively, laying a pathway for future research in controlling aerodynamic flows, machine learning of statistically stationary states of turbulent fields, etc.

Stover, Joseph (PhD 2008) was a tenure-track assistant professor of mathematics at Lyon College in Batesville, AR for 5 years and is now a tenure-track assistant professor of mathematics at Gonzaga University in Spokane, WA. His recent publications include: Kendall, B.E., Publications Fox, G.A. & Stover, J.P. (2018), Boldness-aggression syndromes can reduce population density: behavior and demographic heterogeneity, Behavioral Ecology, Volume 29, Issue 1, 13 January 2018, Pages 31–41, https://doi.org/10.1093/beheco/arx068

Tonellato, Peter (PhD 1985) retired from his positions at Harvard Medical School and the School of Public Health, University of Wisconsin in December 2018. In addition, he completed a year-long gig of re-engineering the sequencing facility and bioinformatics group at the Medical College of Wisconsin in summer of 2018. In January, 2018 he accepted and started a new appointment as Professor of Bioinformatics and Founding Director of the Center for Biomedical Informatics in the School of Medicine at the University of Missouri (Mizzou) to lead efforts in the translational precision medicine initiative recently approved at MU. His best opportunity to move discovery to best practice medical care in the era of 'omic science, technology and analysis.

Williams, Katie (PhD 2016) was selected as Chair of the Raleigh-Durham Chapter of Women in Bio. WIB is a national organization committed to promoting careers and leadership of women in the life sciences. She and **Alex Young (PhD 2017)** fellow program graduate, got engaged to be married and are both very excited!

Current Student Achievements

Abrams, Ruby (2nd Year) was nominated as the SIAM official chapter representative, which includes a travel award up to $500 to attend the Siam CSE conference in 2019.

Acevedo, Alberto (2nd Year) received a GPSC travel Award in October, and will be traveling to Brussels for the Solvay conference on Quantum simulation February 2019.

Crum, Justin (3rd Year) received funding to attend the ICERM Fractional PDE's: Theory, Algorithms, and Applications workshop in June and also presented a poster talk there on Fractional Laplacian Smoothing.

Dib, Soleh (4th Year) continued his internship at Raytheon, received his MS and will be going on a leave of absence to work full-time in 2019.

Edwards, Luke (5th Year) had an Internship at Los Alamos National Labs, working with the Shock and Detonation Physics group. He worked on problems related to the effects of the compaction of an inert porous confiner on the propagation of detonation waves in high explosives.

Gershuny, Victoria (5th Year) attended 3 conferences and received 2 travel awards: (1). "Quantifying immune effects of FOLFOX therapy with mathematical models" October 2018 American Conference on Pharmacometrics 9, San Diego, CA. (2.) "The role of Natural Killer cells in the development of a primary tumor mass and metastasis formation" July 2018 SMB Annual Meetings 2018 Sydney, Australia (3.) "Mathematical models for expansion of the adaptive immune system on re-exposure to antigen" March 2018 Frontiers in Immunobiology and Immunopathogenesis Symposium 2018 Tucson, AZ. Travel Awards: Carter Travel Grant and Don Wilson Travel Grant.

Gomez, Kevin (5th Year) was selected as one of seven recipients chosen from 54 applicants for the prestigious Centennial Achievement award. Each year, the Dean of Students Office administers the Centennial Achievement Awards to commemorate the achievements of outstanding graduate students. We congratulate Kevin on being recognized for his passion, determination and leadership. He will be honored at the 2018 Centennial Achievement Awards Dinner.

Gwirtz, Kyle (3rd Year) was awarded a NASA Fellowship and summer internship at NASA-GSFC. The summer internship was 11 weeks at NASA's Goddard Space Flight Center and Kyle worked under Andy Tangborn on geomagnetic data assimilation. He also attended an AGU fall meeting in Washington, DC and presented a poster titled "Localization and bias correction in geomagnetic data assimilation: systematic numerical experiments with reduced-scale models."

Harty, Travis (5th Year) was awarded an ARCS scholarship for 2018-2019, and gave two presentations: SIAM Conference on Uncertainty Quantification 2018 Title of Talk: "Data Assimilation for Irradiance Forecasting," and American Meteorological Society 2018 Annual Meeting Title of Poster: "Irradiance Forecasting Using the Local Ensemble Transform Kalman Filter, Satellite Images, and Ground Sensors." He also attended the Unidata Users Workshop: Reducing Time to Science: Evolving Workflows for Geoscience Research and Education. In the summer he visited the National Center for Atmospheric Research for 6 weeks. He was awarded travel support from Herbert E. Carter Travel Award.

Luna, Kevin (3rd Year) gave a talk titled "Receptivity of high-speed boundary layers in binary mixture of gases to kinetic fluctuations" at the 71st Annual Meeting of the APS Division of Fluid Dynamics in Atlanta, GA on November 18–20, 2018. He also received two travel awards; The Don Wilson Award for $500 and the Graduate and Professional Student Council (GPSC) travel grant for $500.

McLaren, Samuel (3rd Year) presented a poster with recent applied math graduate Isak Kilen (PhD 2017), at the ACMS30: Mathematical Modeling and Computational Methods for Multiscale Problems in Science & Engineering workshop on the UA campus, November 29-30, 2018. The poster was titled: "Microscopic Many-Body Model for Mode-Locked Vertical External Cavity Surface-Emitting Lasers."

Washburn, Ammon (PhD 2018) presented a talk titled, "Online Active Set: Hyper-parameter Optimization" at the annual INFORMS conference in Phoenix, AZ on November 4th, 2018. Graduated Fall of 2018 and is working at Goldman Sachs, in Salt Lake City, UT.

Yamamoto, Kenneth (4th Year) was awarded the 2018-19 Michael Tabor Graduate Scholarship Award and also received a Don Wilson Fund travel award to present at the 2018 APS March Meeting (American Physical Society) in Los Angeles, CA, titled, "The role of weak forces in the self-similar buckling of non-Euclidean elastic sheets." He presented at the SIAM Conference on Mathematical Aspects of Materials Science in Portland, OR in July 2018, "The role of weak forces in the self-similar buckling of non-Euclidean elastic sheets." He also represented our SIAM Student Chapter at Student Days events at the 2018 SIAM Annual Meeting held jointly. There he met with SIAM Leadership and members of student chapters around the world to develop ideas for how to further the mission and activities of our SIAM Student Chapter. He won second-place prize for poster presentation at the ACMS Workshop (Arizona Center for Mathematical Sciences) in November 2018 with a poster titled, "Geometry, mechanics, and dynamics of leaves, flowers, and sea slugs." He also presented this poster at the 2018 GIDP Student Research Showcase in December 2018. He received a second Don Wilson Fund travel award to work with researchers at the Hebrew University of Jerusalem during January 2019.

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.*

2018 Don Wilson Fund Recipients:

Nikki Holtzer (4th year student) was awarded $500 to attend the 34th Pacific Coast Gravity Meeting at Caltech in the spring, 2018.

Victoria Gershuny (5th year student) was awarded $500 to give a talk at the Society of Math Biology Annual Meetings in Sydney, Australia in summer, 2018.

Ammon Washburn (PhD 2018) was awarded $500 to give a talk at the 2018 INFORMS Optimization Society Conference in Denver, CO in the spring, 2018.

Ken Yamamoto (4th year student) was awarded $500 to give a talk at the APS March Meeting in Los Angeles, CA in the spring, 2018.

Luke Edwards (5th year student) was awarded $500 to give a talk at the 18th US National Congress for Theoretical and Applied Mechanics in Chicago, IL, summer, 2018.

Zhuocheng Xiao (3rd year student) was awarded $500 to present a poster at the Annual Conference of Computational Neuroscience in the summer, 2018.

Kevin Luna (3rd year student) was awarded $500 to give a talk at the 71st Annual Meeting of the APS Division of Fluid Dynamics in Atlanta, GA in the Fall, 2018.

New Students Fall 2018

Top row from left:

John McKinnon, University of Akron

Jesse Friedbaum, Brigham Young University

Michael Woodward, Northern Arizona University

Alexander Norman, Rensselaer Polytechnic Institute

Caleb Dahlke, University of Northern Colorado

Front row from left:

Dan Li, Tsinghua University

Jessica Zanetell, Wake Forest University

Alexa Aucoin, Montclair State University

William Fries, Wake Forest University.

Added to group picture: **Elizabeth Parsons**, University of Colorado, Boulder.

For more information about donating to the Don Wilson fund, the Michael Tabor Fellowship Endowment, or the Applied Mathematics General Fund, please visit the following link:

http://appliedmath.arizona.edu/donate-program-applied-mathematics

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Graduate Coordinator

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