The University of Arizona
Program in Applied Mathematics

January 2020 Number XX

Greetings from the Chair, Program in Applied Mathematics

Dear Students, Alumni, Professors and Friends of the Applied Math program at UA,

It is exactly one year since I moved to Tucson, and the year has been eventful.

I am extremely grateful to Dr. Moysey Brio and Dr. Tim Secomb, for making the program leadership transition smooth, and, of course, to the program staff Stacey LaBorde and Keri Oligmueller for keeping the program running smoothly. Hard work by many program affiliates, members of the steering committee, the qualifying exam committee, and the admissions committee paved the way for our many accomplishments this year.

This report will be long -- reflecting upon many events and changes to the program:

Core Classes: We are halfway through the first year of the core class curriculum upgrade. The traditional structure of the three core classes – Math 527 (Theory), Math 583 (Methods) and Math 575 (Numerics) has been kept, however the material offered in the core classes of the program underwent a significant change. We have complemented the traditional applied math curriculum (complex and Fourier analysis, ODE and PDE) with contemporary applied mathematics subjects in optimization, control, elements of statistics, probability and data science. These changes are team efforts by Dr. Shankar Venkataramani (Math 527), Dr. Mikhail Stepanov (Math 575), yours truly (Math 583), and Dr. Colin Clark – a program postdoc who is helping with inter-class coordination and recitations. Needless to say that participation of our amazing first year (2019-2020) class in these efforts, which are still very much a work in progress, was and continues to be critical for a smooth and efficient transition. Check https://appliedmath.arizona.edu/students/new-core-courses for more info.

Qualifying Exam: The Qualifying Process of the program underwent significant modification this year. The changes were recently approved by the program steering committee which was acting in response to a recommendation from the qualifying committee. Qualification is now decided based on student performance within the core classes. (See revised program handbook for details https://appliedmath.arizona.edu/students/handbook)

Program Affiliates: The steering committee has approved 30 new faculty affiliates, which brought the total number of faculty members and affiliates of the program to 101. (For a complete list see https://appliedmath.arizona.edu/people/faculty). We are lucky to have all of our great experts in mathematics applied to a broad range of research disciplines from 25 departments across 8 colleges at the University available to supervise our students towards a successful PhD. Our affiliates are also active participants of the 4 weekly seminars run by the program.

Arizona-Los Alamos Days: (https://appliedmath.arizona.edu/events/arizona-los-alamos-days) took place at the Biosphere 2 in April of 2019. The event followed the tradition set more than 20 years ago by Dr. Michael Tabor and Dr. Mac Hyman but was on hold for the last 15 years. We are planning the next event (tentatively in mid-May, 2020 immediately after finals) at the Center of Nonlinear Studies (CNLS) at the Los Alamos National Laboratory. Tucson participants will drive to Los Alamos, NM to participate in two days of exciting discussions of the ongoing and emerging collaborations between the program and CNLS in many areas of science and engineering, including multi-physics, astronomy, earth sciences, theoretical biology and energy systems. Many of our students are offered internships and other collaboration opportunities at LANL as follow up on the events.

Applied Mathematics Laboratory and Open Space will soon open its doors for students and faculty. The facility is located on the fifth floor of the Physics building and will be available for small (table-top) experimentation and also social events and gathering of the members of the program. We are planning an open house in late February, 2020 and everyone is invited.

Hiking: Applied Math Student Hikes are now a regular occurrence. Lead by Brian Bell (program student representative), interested students, faculty and staff continue to explore the amazing natural beauty of Arizona. Last year included a Rim-to-Rim hike of the Grand Canyon. Many more interesting hikes are planned – please follow e-mails from Brian.

Promotional Video: We were filmed! Courtesy of COX Media, which did it as a part of the company's service to the Tucson community, the video (available at https://appliedmath.arizona.edu/) offers a brief description of the program to prospective students. Special thanks to the film producer Ray Frieders who was extremely professional and super-patient with us.

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, Michael Chertkov, Chair of the Program in Applied Mathematics, University of Arizona Tucson.

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Michael Tabor Graduate Scholarship Award

Dustin Keys (5th Year Student)

As members of the applied mathematics community, our goal is to apply the cornucopia of ideas offered by the study of mathematics to interesting problems. Often, this means working in fields like biology or engineering but mathematics can also be a tool for understanding philosophy. The study of the things that exist in the world is called ontology and if we want to have an ontology which agrees with our observations, from the most basic to the most sophisticated, our theory of ontology should be guided by physics, whose intrinsic language is mathematics.

The ontology of physics comes from the standard model which says the universe is composed of 'quarks', 'leptons', and 'bosons', all of which are excitations in quantum fields, and from the fields we get the 'state' of a quantum system. Justifiably, we might be lead to conclude that everything is made up of quantum fields and it would be of paramount importance that we understand how these fields behave. The problem is that, while we can say how any experiment using these fields will turn out one way or another with a certain probability, it is evident that we don't have a coherent explanation for how these fields evolve.

In nonrelativistic quantum mechanics, we are given essentially two types of evolutions. One is given by the famous Schrödinger equation, which tends to produce systems in superpositions of different states, as in the famous thought experiment of Schrödinger's cat - which can be both alive and dead at the same time. We don't observe these superpositions in our everyday experience, so to allow for the fact that the results of experiments are of a singular nature, a second evolution is added which projects the system state into a single possible outcome with a certain probability. This assumption is called the 'projection postulate'. There is nothing wrong with doing this, except that we can't say when or how these projections occur with the degree of specificity we should expect of a physical theory, other than that they happen at some point during measurement. This problem is known as the 'measurement problem' and it needs to be addressed if we want to have a complete ontology of the physical world.

There are a few popular ways to think about this problem, though none are universally accepted. These include the 'many worlds theory', whose ontological implications include adding the existence of a continuously unfolding plethora of parallel universes; 'pilot-wave theory' which adds a real trajectory of the universe to be guided by the quantum state; and 'stochastic collapse models' which I am working on and which posit a new random dynamics that projects the quantum state independently of any measurement. These theories are illustrated in figure 1. Through a formalism known as 'quantum stochastic calculus' we are able to shed new light on stochastic collapse theories and derive some new implications, including the description of a new kind of quantum field.

Thanks to the Michael Tabor Fellowship, I'll be able to spend all my time developing the ideas that my advisor, Janek Wehr, and I have formulated about stochastic collapse theories at a level of focus which we are hoping will allow us to provide the essential details about what our work has uncovered. It's an amazing opportunity and I'm exceedingly grateful for it.

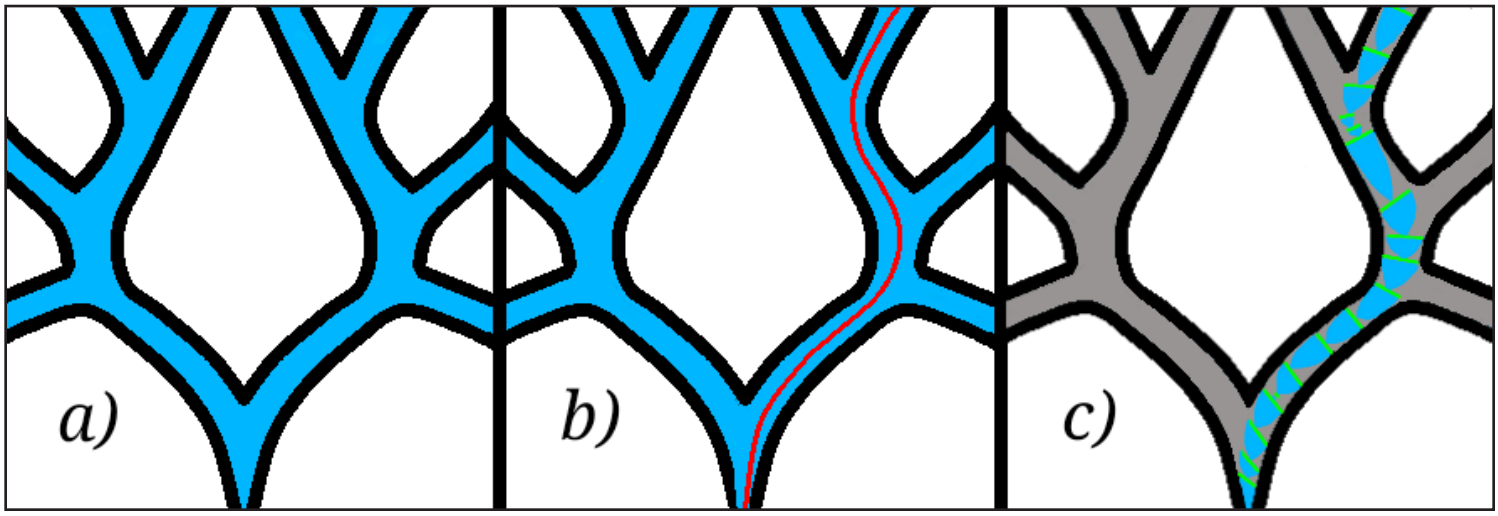


Figure 1: Shown are a few different ways the quantum state (blue) can evolve. a) In the many worlds interpretation we have only the quantum state and it splits according to different possible outcomes. b) In pilot-wave theory the quantum state behaves exactly the same but the universe follows a single trajectory (red) which is guided by the quantum state. c) In stochastic collapse models the quantum state has a new dynamical law which includes projections (green) ensuring a single outcome.

Al Scott Lecture

Jesse Adams (PhD 2019), Postdoctoral Researcher, Nevada National Security Site

This past spring, I was given the honor of presenting the Al Scott prize lecture as part of the applied math colloquia series. This prize and lecture are given in remembrance of the University of Arizona Professor Al Scott, who was also the founding director of the Center for Nonlinear Studies at Los Alamos National Lab, the editor of the Encyclopedia of Nonlinear Science, and a founding editor of Elsevier's Nonlinear Phenomena Journal. I did my best to pay homage to this titan in nonlinearity while presenting my research that focused entirely on a linear model. In my talk I introduced a dimension-robust algorithm for image deblurring within a Bayesian framework. Several hurdles were in place that made this a difficult problem. Firstly, Markov chain Monte Carlo (MCMC) methods used to generate samples from a posterior distribution in a Bayesian formulation generally scale very poorly with the problem dimension. In the case of image deblurring, the problem dimension is the number of pixels in the image, and I was tasked with deblurring images of size up to 4096 by 4096 (or about 16 megapixels). Secondly, standard Fourier-based image deblurring techniques require specifying boundary conditions, which are often non-physical and un-reasonable choices in images. But non-Fourier based methods can be computationally intractable due to the size of the system. I presented a method that was dimension-robust, i.e. produced image samples that were nearly independent regardless of image size, and was applicable to large images without requiring unreasonable boundary condition assumptions. I demonstrated the applicability of this approach by deblurring radiographs of size 4096 4096 pixels taken at the Cygnus Dual Beam X-ray Radiography Facility at the U.S. Department of Energy's Nevada National Security Site (NNSS).

My defense followed shortly after the Al Scott prize lecture, and though it may not have been quite as early in my time at Arizona as I would have liked, it was a success. After completion, I took a celebratory solo tour around the world, visiting friends in Germany, Thailand, and Mexico, which made the subsequent move from Tucson to Las Vegas feel relatively short. At the tail end of May, I began a postdoctoral position at the NNSS in the signal processing and applied math group. The beginning of my postdoc was not quite as expected due to the fact that my external PhD advisor, Dr. Aaron Luttman, left the NNSS for a position at Pacific Northwest National Lab (PNNL) shortly before my arrival. I was left in good hands, however, as my postdoctoral advisor, Dr. Marylesa Howard, was a Presidential Early Career Award in Science and Engineering (PECASE) recipient this year, an award that is given to only 100 people a year. Under her excellent advisement, I have been able to expand my knowledge in radiography and data analysis. As part of the data analysis team, my work has been a mix of continued research, system modeling, and getting my hands dirty with actual experimentation and data. This position has also provided multiple opportunities to coordinate and collaborate on various projects with scientists and mathematicians at both Los Alamos, Livermore, and Pacific Northwest National Labs. I have even had the opportunity to help in mentoring interns and another current graduate student, Jessica Pillow, in her dissertation research.

Although I do not yet know whether I will stay at the NNSS after my postdoctoral position is complete, I am confident that skills and knowledge that I am acquiring here are a foundation for future success. In the meantime, I'm just trying to make sure I enjoy the world class climbing and entertainment that sin city provides on my days off.

This work was done by Mission Support and Test Services, LLC, under Contract No. DE-NA0003624 with the U.S. Department of Energy. DOE/NV/03624--0669.

New Program Affiliate Profile

Paul Reverdy, Assistant Professor, Aerospace and Industrial Engineering

My research interests lie at the intersection of dynamical systems, robotics, and decision theory. This is a broad area and reflects my training in both physical and social sciences. Simply put, I study how humans and automated machines make decisions to achieve physical goals. I develop models of human decision-making behavior and design and implement algorithms that allow robots to take meaningful action in the world. My goal is to integrate these models and algorithms to develop systems that seamlessly interface between human supervisors and automated machines. The key challenges here are representation (how do I gather the data that is relevant to a particular decision and provide it to a model or algorithm?) and implementation (once a decision is made, how do I implement it in terms of a physical action?). I tackle these challenges using a variety of tools from applied mathematics, including machine learning and dynamical systems theory.

The core representation that I use in my algorithms and models consists of value functions. When confronted with a decision, one must choose among a set of possible actions. A fruitful way to quantify decision-making behavior is to associate a value, i.e., a real number, to each action and choose the action with the maximal value. Viewed through this lens, decision making is clearly connected to optimization. For any given decision-making problem, the challenge of representation becomes a challenge of computing values. A number of approaches for computing values are useful. Often these values are functions of the information available to the decision maker, such as in the classic explore-exploit tension in decision making under uncertainty. In this case, value functions can be derived in a principled way using heuristics. In economics, value functions are often referred to as utility functions, and can be constructed indirectly by observing a decision maker's preferences as revealed by their choices. In the revealed preference paradigm, one observes a sequence of decisions and records the choices made by the decision maker. Assuming that the decision maker chooses actions that maximize their value function, the observed data define a partial order over the set of actions. Seminal work in economics by Debreu defines the conditions under which this partial order can be represented by a value function.

Once a decision-making problem is represented and a choice is made, it must be implemented. Often in machine learning, decision implementation is straightforward: an advertisement is shown to a user or a financial transaction is made. For the engineering systems I study, decisions must be implemented in the physical world, which places significant constraints on the possibilities for action, e.g., from a robot's mechanical dynamics. A particularly effective way to work within the constraints of physical systems is to encode actions in terms of vector fields. In this representation, vectors represent desired velocities for the system states, which can be smoothly translated into commands to the actuators which produce motion. Smoothness of control inputs is particularly important for physical systems, where discontinuities in control inputs can cause wear, instability, and other undesired behavior.

A significant portion of my current research seeks to extend the notion of implementing decisions in terms of vector fields. In the standard paradigm in robotics, vector fields represent motion plans, i.e., actions that a robot can take. Decisions among actions are made in a discrete framework and are implemented using vector fields, yielding a hybrid dynamical system. In contrast, I have pioneered a framework which I term motivation dynamics, which seeks to make decisions using vector fields. The key observation is that since the possible actions are implemented in terms of vector fields, decisions can be encoded in terms of a linear combination of the individual action vector fields. Decisions, then get made by varying the weights of the linear combination, which I refer to as the motivation state; my motivation dynamics defines vector fields that evolve the weights as functions of the underlying action values. My system can represent a much richer set of behaviors than is possible in a standard hybrid system. For example, if two actions are both important but neither one is a clear priority, the system can put equal weight on both until one action wins out. In developing motivation dynamics, I have been lead to consider many fascinating questions in bifurcation theory, since the fundamental decision-making mechanism can be thought of as a pitchfork bifurcation which is unfolded by the action values.

My long-term goal for motivation dynamics is to connect formal, logic-based methods for specifying system behavior and vector field methods for control. The dream outcome for me is to develop a system that can take a formal specification given in terms of a temporal logic and "compile" a continuous dynamical system whose trajectories satisfy that specification. An alternative specification method would come from a human supervisor's value function, which could be inferred by presenting the human with a series of possible behaviors of the automated system and asking them to express a preference among them.

In parallel with the theoretical work, I am developing applications of motivation dynamics. In one application, I have modified the motivation system to react to external stimuli. In collaboration with Robert Wilson (Psychology), I am developing connections between the motivation system and models of human behavior. In another application, I am collaborating with Hoshin Gupta and Eric Betterton (Hydrology and Atmospheric Sciences) to develop robotic systems that automate field measurements for monitoring the local desert.

I appreciate the Applied Mathematics program for offering a venue to have rigorous mathematical conversations about applied problems. The connections I have made through the program have been an integral part of my experience at the University.

Alumni Profiles

Jackson Burton (PhD 2016), Scientific Director of Mathematical and Statistical Medicine, Critical Path Institute

If you have ever spent some time thinking about how you arrived at the current season of life you are in, you will likely come to the realization that it was dependent on some sort of social-type butterfly effect. In other words, seemingly small variations in everyday life result in huge shifts in future trajectories. That was indeed my case in my journey to becoming a 'quantitative scientist'. While a PhD in applied math may indicate that one is a mathematician, my current career trajectory is much more multifaceted. And much of my journey has taught me several life lessons, some of which shaped what paths I took.

My collegiate start might be considered blasphemy by some, as my first major was fine art. Somehow, finishing up high school with several art classes under my belt, I had decided that computer animation was the path for me, a path that my AP calculus teacher at the time had a frustrating and puzzling response to. Perhaps it was playing too many online computer games at the time that swayed me, a habit which was thankfully kicked at the start of college. I learned an important lesson during high school regarding computer games: play them if you want low grades.

I began my undergraduate at the junior college County College of Morris. Looking back, while not entering a 4-year school may have seemed detrimental, I can't help but be grateful for entering such a strong 2-year school. The circumstances around that choice were financial, as my mother worked there which bypassed tuition. There, I declared a major in fine art and found myself drawing baskets, towels, bowls of fruit, and very charismatic humans for my drawing class. While I don't need to describe the multitude of oddities in my other art classes, I will share a brief conversation with a 2-D art design professor. I asked one day, "So, what exactly is the definition of art?" He replied, "There is no definition, that's why it's so beautiful." I changed my major the next day.

It was not until my calculus 2 professor said to me in office hours, "You should be a teacher, you've got the personality for it." Not being particularly picky with major life decisions, I said, "Yeah, that sounds good, I'll do that." That led me to Montclair State University on a general honors scholarship that waived all tuition. At Montclair, I was a mathematics major, and found myself having an immediate love / hate relationship with proofs. However, in time, I learned to appreciate the aesthetics of math, and grew a deep passion for theory. I finished Montclair in 2006 having far more mathematics courses under my belt then needed. I was, first and foremost though, a certified high school teacher for the state of New Jersey. During teaching, I was told that I could take graduate math courses and have that count towards teaching pay raises. That was a no brainer, so I enrolled in a time-permitting graduate complex analysis course at Montclair. I was not a fan of a night class, but I was happy to engage with math beyond logs and polynomials.

After that course, I left teaching in 2009, and entered the master's program at Montclair State in pure and applied math. I was awarded an RA position under the advisement of Dr. Lora Billings. I will always mark August of 2009 as the start of my professional career. I spent two years with Dr. Billings doing mathematical epidemiology focused on casting deterministic models in a stochastic frameworks to capture spontaneous die-out of infection diseases. I learned many valuable lessons during that time, most of which is that discipline sometimes has to step in when desire is lacking. While coursework came easy, research required a different mindset, one of which I had not properly cultivated. If not for Dr. Billings providing some hard conversations about the reality of graduate school, I would not be writing this piece now. While at Montclair, newly appointed professor and former U of A applied math alumni, Dr. Eric Forgoston (2006), first brought up Arizona as a good trajectory for a PhD, which after a close decision between U of A and the University of Colorado, brought me to Tucson in the fall of 2011.

The early years of the program focused on core courses and the stress that comes along with them. I learned an invaluable lesson though, namely that I can learn something from everyone. That rang true with my classmates especially who helped me wrestle through contour integrals, singular value decompositions, and decoding Runge-Kutta methods in Matlab. In my third semester, I had the opportunity to work with Tim Secomb on 2D Stokes flow in the presence of obstructions. The motivation was based on malaria-infected red blood cells which become rigid and adhesive to blood vessel endothelium causing severe and often deadly complications. At the time, I was deeply motivated to tackle biological problems related to quality of health for individuals, which lead to a focus on modeling structural mechanics of malaria-infected red blood cells. Tim become my advisor as we sought to develop a comprehensive project.

The biggest trajectory change came in early 2014, when I attended a SIAM

event. There, a speaker named Stacey Tannenbaum, a former applied math master's graduate, spoke on role she had in the pharmaceutical industry related to pharmacokinetic modeling, i.e. modeling how the human body absorbs, distributes, metabolizes, and eliminates a drug. My then classmate, Katie Williams, was able to secure an internship in Boston at Takeda pharmaceuticals through a contact of Stacey's. Highly interested by Stacey's talk, I reached out to the same contact, and was able to secure an internship of my own at the same location. The internship was transformational, as it introduced me to the field of pharmacometrics, the discipline I learned in the modeling and simulation group at Takeda. There, I was exposed to a fast-paced forward-thinking methodology focused on critical questions in the drug development process for cancer. One project stood out above the others. It involved spatial-temporal modeling of antibody-drug conjugates (ADCs) in solid tumors. ADCs are, simply put, an antibody lined to highly toxic small drugs for which the antibody binds to cells, gets internalized by the cell and releases the toxic drug to kill the cell. The work was highly interesting and had numerous open questions around the transport and kinetics of ADCs on which multimillion-dollar decisions hinged. I ended up closing the work on Malaria with Tim and engaged new work in drug transport in solid tumors. I maintained my employment with Takeda the remaining years during my PhD with a small number of hours.

In December of 2016, I graduated with my PhD having developed a body of work around drug transport and kinetics in solid tumors. I immediately joined a start-up that spun out from the modeling and simulation group at Takeda, where I was exposed to a multitude of fascinating problems, ranging from optimization of drug portfolio pipelines, to engineering problems for miniature mass spectrometry devices. However, startups can be uncertain, and at the season of my life being married, having just bought a house, I wanted something more certain. In a chance encounter with my now boss, Klaus Romero MD at the BIO5 Student Industry Networking Event, I learned of an amazing institute just up the street from the U of A called the Critical Path Institute. In an hour exchange between Klaus and myself at that event, I learned of a job that sounded like it was made for me.

I joined the Critical Path Institute (C-Path for short) in April of 2017, and quickly learned that it is truly a one-of-a-kind organization on the planet. C-Path seeks to accelerate the development of novel treatments for unmet medical needs through open science. As a nonprofit, C-Path forms formal collaborations with

pharmaceutical companies, universities, drug regulatory agencies (FDA and EMA), and other nonprofits. In such collaborations, data from pharma industry and academics are shared with C-Path for which novel statistical and mathematical tools are developed to address particular drug development questions. A good example is a clinical trial simulator for Alzheimer's disease that allows companies to simulate different clinical trial scenarios and identify the most optimal structure. Given the hundreds of billions of dollars spent on Alzheimer's drug development (with zero successes) such a tool is of critical importance. The Alzheimer's example is one of many active tools in development. We are currently developing similar tools for Parkinson's disease, Huntington's disease, Duchenne Muscular Dystrophy, Type-1 Diabetes, and Kidney Transplantation with several other disease areas following suit.

What sets C-Path apart, is that we put these quantitative tools through formal regulatory review, both at FDA and EMA. Yes, you can get a mathematical model 'approved' just like a drug can get approved (more or less), and the tool becomes open source for anyone to use to help design and optimize trials in a certain disease.

I was hired as an associate program director in the Quantitative Medicine group at C-Path. Since that time, I have taken on the role of Scientific Director of Mathematical and Statistical Medicine, in which I focus on innovate quantitative methodologies to build new tools for existing problems. The role has been very rewarding, as I now lead a team of scientists each with different skillsets to tackle the ever-evolving field of drug development. I can say that I am truly within an interdisciplinary team, having a mathematician, statistician, chemical engineer, an artificial intelligence specialist, an electrical engineer, and a pharmacometrician. On a given day, I get the privilege of providing oversight on a variety of projects some of which include building accelerometers to measure movement changes in Parkinson's disease, developing time-to-event models to predict kidney transplant failure, coding neural networks to process MRI images in Alzheimer's patients, building models to describe disease progression in Huntington's disease, and developing graphical user interfaces for the models generated.

I am deeply grateful for my time in the applied math program, which trained me not just to be a mathematician, but to think about problems systematically. I am approached by leadership consistently, both within C-Path and outside in our extensive pharma and academic network, about how to tackle quantitative problems in drug development, not because I'm brilliant (which I assure you, I'm not) but because I spent five and a half valuable years being trained to think about the big picture and the tools I need to paint it.

Alumni Profiles (*continued*)

Ben Berman (PhD 2015), MITRE Corporation

Since graduating from the Program in Applied Mathematics, it is safe to say that Arizona connections have played a big part of my career. But that comes as no surprise when I think about the friends and faculty I have had the pleasure to work with.

To understand my trajectory after graduation, I should first mention that my dissertation was on new techniques for magnetic resonance imaging (MRI) optimization. My advisors Ali Bilgin and Maria Altbach helped me to not only find challenging research to work on, but also to understand current limitations in medical imaging practice. We used compressed sensing to push the MRI acquisition/reconstruction process as far as we could – opening some new applications in dynamic imaging. I remember volunteering for hours-long scans, so that we could have the best ground-truth reference data possible. We used such datasets to demonstrate our new techniques which were extremely fast and robust to motion.

It was through an Arizona lab connection that I learned about a postdoctoral research opportunity at the US Food & Drug Administration (FDA) Division of Imaging, Diagnostics, and Software Reliability – Christian Graff (PhD 2009). Do you know that FDA regulates more than food and drugs? In fact, the FDA imaging research group is lead by an Arizona alum and image science pioneer, Kyle Myers (PhD 1985). In the winter of 2015, I moved to Washington DC, and started life in the federal government – joining a project on quantitative computed tomography of the lungs and liver.

Quantitative imaging is the extraction of quantifiable features from images. In comparison to conventional qualitative image interpretation, quantitative imaging promises more consistent, reliable, and accurate imaging results across platforms, clinics, and time. For example, a micro-hemorrhage in the brain may go unseen by radiologists, but the derived magnetic susceptibility in the corresponding pixels may be significantly elevated. At FDA, I helped to improve the value of quantitative imaging by developing phantoms (imaging test objects) and calculating the repeatability and reproducibility of various estimation methods. This was a very collaborative effort involving the Radiological Society of North America, the National Institutes of Health, multiple universities including Columbia and Duke, as well as Children's National Hospital.

After nearly two years as a postdoc in the lab, I had a decision to make. On one hand, I could join the research staff and continue on several projects, including an investigation of reader variability in histopathology lead by Brandon Gallas (PhD 2001). On the other hand, I had an opportunity to join the regulatory staff at FDA and use sound science to help safe & effective medical devices find their way to market. Ultimately, I decided to step away from research, try something new, and become a lead reviewer in the Division of Radiological Health.

Working as an FDA reviewer was highly gratifying – every device submission that came across my desk presented unique challenges and learning opportunities. The devices ranged from flat panel x-ray detectors, to ultrasound transducers, to computer-aided diagnostic software. As lead, I had the task of organizing the clinical and technical experts on each review team, and of communicating the primary scientific and regulatory concerns. Our goal was to find the least burdensome pathway for each device to market, without compromising safety, quality, or statistical validity. Aside from reviewing unique devices, working as a regulator offered unique opportunities to become directly involved on various public health initiatives including FDA's Digital Health policies, and a draft guidance document on quantitative imaging.

Earlier this year, I left FDA to join the MITRE Corporation – a not-for-profit organization that manages federally funded research and development centers (FFRDC). We act as independent and objective technical consultants for many different parts of the federal government. I am able to work in a unique position that utilizes all of my experiences in applied math, imaging science, and government service; and I continue to work with fellow Wildcats including Joseph Dagher (PhD 2006).

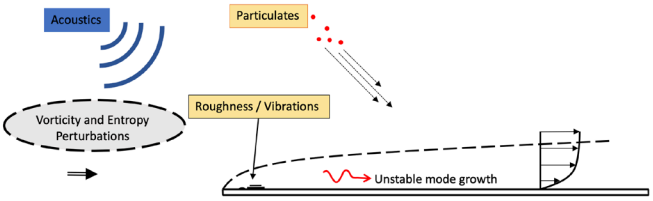
My coursework and research in the Program in Applied Mathematics were invaluable to prepare me for a career in imaging technology. I was fortunate to receive support from the ARCS Foundation, where I was able to hone the skill of communicating complicated research with genuinely interested but nontechnical people. Beyond that, it was the connections made with my cohort, my labmates, and my professors that have had a lasting impact on me.

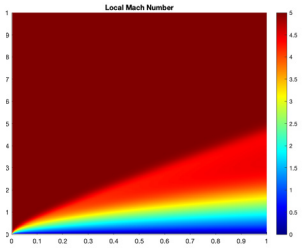
This summer, several friends from Tucson came all the way to Maryland and attended my wedding. I met my wife, also a mathematician, three years ago in DC – but perhaps our paths crossed before in Arizona! It just happens that she attended the Math Department recruitment weekend in 2011 (but decided to study elsewhere, closer to home).

In writing this, I am filled with so many good memories from my time in the Program. To current students: enjoy working late in Math 224, and grading homework. Enjoy playing bridge at Time Market, and eating scones from Raging Sage. Enjoy going on weekend trips to the mountains, and spending time with friends. Bear down!!

Current Student Profiles

Kevin Luna (4th Year Student)





During my time in the program, my work has focused on studying the stability of thin fluid structures that form at fluid-solid interfaces. These structures are called "boundary layers". In fluid dynamics, boundary layers are small and thin regions near a physical boundary where viscous forces dominate the flow. The dynamics of these thin (think millimeters!) boundary layers can have dramatic effects on the rest of the fluid flow in the domain. In many applications there is a particular interest in modeling the environmental disturbances that can enter the boundary layer and predicting the transition of this region from a smooth-ordered state to a turbulent state. For example, in the context of hypersonic flight, a turbulent boundary layer can cause heat fluxes to increase significantly on an aircraft (which is not what you want in an object that needs to move fast and stay light!). To put this speed in context, an aircraft moving this fast can reach any point on the globe within two hours. In these conditions, chemical reactions become unavoidable. My work has involved incorporating the effect of chemical reactions to a particular boundary layer stability problem. In particular, I have been researching how unavoidable fluctuations from the molecular nature of fluids can destabilize these boundary layers.

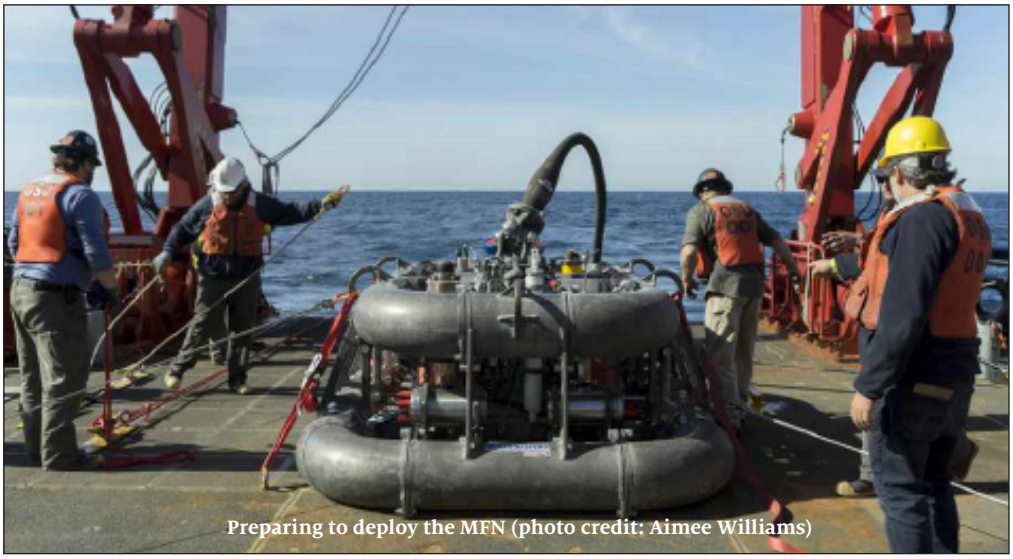
While I may be enthusiastic about applied mathematics now, it took time to realize my research direction. As an undergraduate, I was interested in mathematics and computation; however, I aimed to pursue a PhD in physics. Fortunately, I came to realize that what I truly enjoyed was the use of mathematics and computers to solve problems in the sciences. When the time came to search for applied mathematics PhD programs, the University of Arizona stood out to me in particular because of its interdisciplinary structure. On top of that, the opportunity to explore research beyond the mathematics department seemed like a great opportunity to explore my interests. I ultimately did not do much exploring and instead found my advisor during the recruitment workshop. Working with my advisor Dr. Anatoli Tumin has been a great experience. To date I've had the opportunity to present my research at various conferences, publish some work, and participate in a wonderful summer internship at the Center for Computational Sciences and Engineering at Lawrence Berkeley National Lab where I had the opportunity to apply the skills I've gained from my research. On Tucson itself, I always assumed living in triple degree temperatures would be the price I pay for being in an ideal graduate program. However, during the time I've spent in Tucson, my opinion of the desert has completely changed and now I love the climate and landscape. Tucson has definitely been kind to me as a graduate student, and I look forward to making the most of my time remaining in the program.

Stan Swierczek (4th Year Student)

In early October, I traveled to Newport, Oregon to participate in the Coastal Endurance Fall 2019 Deployment. The Ocean Observatories Initiative (OOI) is a large, long-term NSF project to operate a number of mooring arrays in crucial waters. Oregon State University has an entire group of 17 scientists, engineers, and technicians working under the OOI grant operating Coastal Endurance, which is the name for a pair of mooring arrays, one off the coast of Washington and the other off the coast of Oregon. The team deploys new or refurbished moorings every six months, and in between salvages and rebuilds the next moorings from the old.

I am working with Joellen Russell in the Geosciences department, Matti Morzfeld in the Mathematics department, and Matt Mazloff at Scripps Institution of Oceanography to develop a regional biogeochemical ocean model in the Argentine Basin. As part of my model validation, I have used data from a now-defunct OOI mooring that had been deployed in the South Atlantic. This encounter and the common rite of passage for oceanographic students to spend some time at sea compelled me to investigate cruise opportunities. This is how I came to be in Newport for the first leg of the deployment. Our ship was the R/V Sikuliaq, a state of the art $200 million NSF research vessel built in 2014 and operated by the University of Alaska, Fairbanks. We started by loading five moorings on to the rear deck intended for three locations (inshore, shelf, and offshore) outside Gray's Harbor, Washington. We left at high tide around midnight, and made our way north.
We began deploying the new moorings early the next day. This was coordinated technical work requiring the ship's crane and A-frame, a heavy lift winch, and many people. Some of the pieces weighed over 10,000 lbs and had to be moved across the deck and lowered to the sea-floor very carefully while the ship rocked in the waves. Because of limited space on deck, the moorings had to be assembled as we deployed them, and the recovered moorings had to be disassembled as the components were brought up. Parts of the recovered moorings were covered in biofouling, which had to be removed with paint scrapers. The deployment took five days to complete. I spent five years in my 20s working in the mining industry as a technician and equipment operator, and

Current Student Profiles (*continued*)



Preparing to deploy the MFN (photo credit: Aimee Williams)

the work at sea was very reminiscent of my old career. The hard hats, vests, steel-toed boots, heavy equipment, hand signals, team dynamic, physical work in adverse outdoor conditions, etc., were all similar. In the end, I enjoyed the experience. We worked long hours to finish before bad weather was predicted to roll in, but the weather was great while we were out. I got a cabin to myself and the bed was more comfortable than my own. It was nice to have physical work to do where you can see the results. My ship duties all had very tangible objectives - ratchet strap equipment to the deck so it wouldn't roll overboard, scrape off the goose barnacles from recovered equipment, hold onto this rope to stabilize an anchor that is being lowered, etc. In contrast, my research at the UofA consists of staring at a screen through bloodshot eyes for 30 hours a week, trying to debug and repurpose code that had obviously been written by a moron who didn't annotate anything and used unhelpful variable names like "temp_7", and also the moron was me three weeks ago. Perhaps this episode is a sign for me to quit school and become a pirate.

News from Members and Affiliates

Barnard, Kobus (Computer Science) Two affiliates, myself an d Mihai Surdeanu, are part of a recently awarded DARPA grant. More information is here: http://ivilab.org/news.html#ToMCAT **ToMCAT**. A collaboration between the Information School (INFO), Computer Science (CS), and Family Studies and Human Development (FSHD) has been awarded a large grant to develop a theory of mind-based cognitive architecture for teams (ToMCAT). The grant ($7.5M, for 48 months) is part of the DARPA Artificial Social Intelligence for Successful Teams (ASIST) program. The PI/Co-PIs collaborating on this project are: Adarsh Pyarelal (PI), Kobus Barnard, Emily Butler, Clayton Morrison, Rebecca Sharp, Mihai Surdeanu, and Marco Antonio Valenzuela-Escarcega. Data collection for the project will take place in the Lang Laboratory, housed in the Frances McClelland Institute for Children, Youth and Families in the Norton School of Family & Consumer Science. Further information is available on the project web site https://ml4ai.github.io/tomcat/

Canales, Robert (Community, Environment & Policy): Published 6 papers and presented at 4 conferences: Publications: Canales RA, Reynolds KA, Wilson AM, Fankem SL, Weir MH, Rose JB, Abd-El-maksoud S, Gerba CP (2019). Modeling the Role of Fomites in a Norovirus Outbreak. Journal of Occupational and Environmental Hygiene. Feb 2:1-1. Wilson AM, Reynolds KA, Verhougstraete MP, Canales RA (2019). Validation of a Stochastic Discrete Event Model Predicting Virus Concentration on Nurse Hands. Risk Analysis. Feb 13. Muñoz-Gutierrez KM, Canales RA, Reynolds KA, Verhougstraete MP (2019). Floor and Environmental Contamination during Glove Disposal. Journal of Hospital Infection. Mar 1;101(3):347-53. Canales RA, Wilson AM, Sinclair RG, Soto-Beltran M, Pearce-Walker J, Molina M, Penny M, Reynolds KA (2019). Microbial Study of Household Hygiene Conditions and Associated Listeria monocytogenes Infection Risks for Peruvian Women. Tropical Medicine & International Health. May 7, 2019. Wilson AM, Reynolds KA, Sexton JD, Canales RA (2019). Estimating the Effect of Hand Hygiene Compliance and Surface Cleaning Timing on Infection Risk Reduction with a Mathematical Modeling Approach. American Journal of Infection Control Jul 19, 2019.Contreras RD, Wilson AM, Garavito F, Renolds KA, Canales RA (in press). Assessing Virus Infection Probability in an Office Setting using Stochastic Simulation. Journal of Occupational & Environmental Hygiene. Conference Presentations Hadeed S, O'Rourke MK, Alshammari M, Blohm J, Canales RA, Paukgana P, Olivas G, Carl A, Lugo-Lerma V, Gonzalez-Figueroa E (2019). The Hopi Environmental Health Project (HEHP)- Measuring Concentrations of PM2.5 in Households on Hopi Lands. International Society of Exposure Science

Conference. Lopez-Galvez N, Wagoner R, Canales RA, de Zapien J, Rosales C, Beamer P (2019). Imidacloprid Exposure in Grape Workers. International Society of Exposure Science Conference. Van Horne YO, Chief K, Canales RA, Begay M, Beamer P (2019). A Community-Based Probabilistic Risk Assessment for the Diné People Impacted by the Gold King Mine Spill. International Society of Exposure Science Conference. Lopez-Galvez N, Wagoner R, Canales RA, Beamer P (2019). Characterizing Environmental and Occupational Exposures Associated to Kidney Function among Migrant Farmworkers in Mexico: A Study Protocol. International Society for Environmental Epidemiology Conference.

Chan ,Chi-kwan (Astronomy & Steward Observatory): Published 9 papers, 2 white papers; gave 2 invited talks, 2 public talks. "The Growing Importance of a Tech Savvy Astronomy and Astrophysics Workforce" Norman, D., Cruz, K., Desai, V., et al. 2019, arXiv e-prints, arXiv:1910.08376 "EHT-HOPS Pipeline for Millimeter VLBI Data Reduction" Blackburn, L., Chan, C.K., Crew, G.B., et al. 2019, ApJ, 882, 23 "Prospects for Wideband VLBI Correlation in the Cloud" Gill, A., Blackburn, L., Roshanineshat, A., et al. 2019, arXiv e-prints, arXiv:1908.03991 "The Event Horizon General Relativistic Magnetohydrodynamic Code Comparison Project" Porth, O., Chatterjee, K., Narayan, R., et al. 2019, ApJS, 243, 26 "Astro2020 APC White Paper: Elevating the Role of Software as a Product of the Research Enterprise" Smith, A.M., Norman, D., Cruz, K., et al. 2019, arXiv e-prints, arXiv:1907.06981 "First M87 Event Horizon Telescope Results. VI. The Shadow and Mass of the Central Black Hole" Event Horizon Telescope Collaboration, et al. 2019, ApJL, 875, L6 "First M87 Event Horizon Telescope Results. V. Physical Origin of the Asymmetric Ring" Event Horizon Telescope Collaboration, et al. 2019, ApJL, 875, L5 "First M87 Event Horizon Telescope Results. IV. Imaging the Central Supermassive Black Hole" Event Horizon Telescope Collaboration, et al. 2019, ApJL, 875, L4 "First M87 Event Horizon Telescope Results. III. Data Processing and Calibration" Event Horizon Telescope Collaboration, et al. 2019, Ap JL, 875, L3 "First M87 Event Horizon Telescope Results. II. Array and Instrumentation" Event Horizon Telescope Collaboration, et al. 2019, Ap JL, 875, L2 "First M87 Event Horizon Telescope Results. I. The Shadow of the Supermassive Black Hole" Event Horizon Telescope Collaboration, et al. 2019, Ap JL, 875, L1.

Cushing, Jim (Mathematics): A lecture tour in China: Plenary speaker, Department of Mathematics, Xi'an Jiaotong University, Xi'an, China and Plenary speaker, Department of Mathematics, Sichuan University, Chengdu, China and Invited speaker, Guangzhou Mathematics-Tianyuan Workshop on Mathematical Modeling & Analysis of Population Dynamics , University of Guangzhou, China. **Other invited talks:** Special session on Global Dynamics: Persistence and Extinction in Mathematical Models from Ecology and Epidemiology, annual meeting of the Society of Mathematical Biology, Montreal. International Conference on Difference Equations and Applications, University College London. Special Session on Delay, partial differential and difference models of population ecology, Computational and Mathematical Population Dynamics 5, Ft. Lauderdale, Florida. Special Session on Bifurcations of Difference Equations and Discrete Dynamical Systems with Applications, Joint Mathematical Meetings, San Diego. Special Session on Mathematical Models in Ecology, Epidemiology and Medicine, Joint Mathematical Meetings, San Diego. Invited speaker, Special Session on Modeling Natural Resources, Joint Mathematical Meetings, San Diego. **2019 Publications** J. M. Cushing, Discrete time Darwinian dynamics and semelparity versus iteroparity, Mathematical Biosciences and Engineering, 16(4) (2019), 1815-1835, DOI 10.3934/mbe.20190882. J. M. Cushing, Stability and the Geometry of Bifurcation Graphs for a Class of Nonlinear Leslie Models, to appear in Difference Equations and Discrete Dynamical Systems with Applications, Springer Proceedings in Mathematics &Statistics (M. Bohner, S. Siegmund, R. Hilscher and P. Stehlik, eds), 20193. J. M. Cushing, Difference Equations as Models of Evolutionary Population Dynamics,Journal of Biological Dynamics 13 (No. 1), 2019, DOI1 0.1080/17513758.2019.1574034

Gutenkunst, Ryan (Molecular & Cellular Biology): New NIH R01 grant, entitled "Joint Inferences of Natural Selection Between Sites and Populations" (NIH R01 GM127348, https://projectreporter.nih.gov/project_info_description.cfm?aid=9659095). This 5-year ~$1.5M grant supports my group's efforts to develop new computational tools for inferring natural selection from population genomic data. In particular, we'll be building off the work of my former Applied Math PhD student, Aaron Ragsdale, to develop new ways of understanding how selection acts on nearby interacting sites in the genome. We'll be applying our new methods to public data from humans, Drosophila, and other model organisms.

Gupta, Hoshin (Hydrology & Atmospheric Sciences): Named on the Clarivate "Highly Cited Researchers List" for 2018 under the category of "cross-field" (influential in 2 or more fields) as one of 6,000 persons who rank in the top 1% most-cited in their respective fields over the 11-year period 2006-2016; https://clarivate.com, based on publications in Web of Science. Elected Fellow of American Meteorological Society (July 2019 – present) for the Class of 2020. Published 11 papers in peer-reviewed journals. Gave two invited/keynote talks and 6 contributed talks. Serving as Guest Editor for the Special Issue on Big Data & Machine Learning in Water Sciences: Recent Progress and Their Use in Advancing Science, Water Resources Research (2018-2020). Co-organized 6 conference sessions at professional meetings. Co-organized the SITES: Summer School on Information Theory in the Earth Sciences (Santander, Spain, June 3-8); hosted by the University of Santander; with Allison Goodwell, Ben Ruddell, Cristina Prieto, Florian Wellman, Grey Nearing, Praveen Kumar, Rui Perdigao, Steven Weijs and Uwe Ehret.

Piegorsch. Walter (Statistics, Mathematics): Invited Talks: 1) Model uncertainty in environmental risk assessment. University of Nevada Department of Mathematics & Statistics, Reno, Nevada; 2 May 2019. 2) Special invited introductory overview lecture – Environmental risk assessment. Joint Statistical Meetings; Denver, Colorado; 30 July 2019. Publication: Wheeler, M.W., Piegorsch, W.W., and Bailer, A.J. (2019). Quantal Risk Assessment Database: a database for exploring patterns in quantal dose-response data in risk assessment and its application to develop priors for Bayesian dose-response analysis. Risk Analysis 39, 616-629. doi:10.1111/risa.13218.

Witte, Russell (Medical Imaging): New NIH award: Title: 4D Transcranial Acoustoelectric Imaging for High Resolution Functional Mapping of Neuronal Currents (NIMH, NIBIB) Duration: 9/30/19 - 9/29/20 (1 year) PI: Russell Witte, Total Cost: $428,307, Goal: Optimize sensitivity of acoustoelectric imaging for detecting neuronal currents through human skull. Co-Is: Jennifer Becker, Nan-kuei Chen, Martin Weinand, Stephen Cowen, Kati Gothard, Ying-hui Chou. In

News from Members and Affiliates (*continued*)

case you missed it, my company (ElectroSonix) was also featured in Sunday's Arizona Daily Star (12-16-19): https://tucson.com/business/tucson-tech-ua-startup-perfecting-new-imaging-tool-to-guide/article_6f6b3f-dc-b8e0-590f-8fc7-bc257f7a17c4.html

Zakharov, Vladimir (Mathematics): Awarded the Bogoliubov Medal of the Russian Academy of Sciences for outstanding achievements in Mathematics (both pure and applied) and Theoretical Physics. The prize, one of the highest honors bestowed by the Russian Academy, is awarded only every five years, and he is the fifth recipient.

Zeng, Xubin (Hydrology & Atmospheric Sciences): 1) New Grants: "Aerosol Cloud meTeorology Interactions over the western ATlantic Experiment (ACTIVATE)" NASA EVS-3, $29.9M (UA portion: $1.310M), 1/2019 - 12/2023 Deputy PI "Assessing and improving the numerical solution of deterministic and stochastic physics and dynamics in the ACME atmosphere model" DOE SciDAC, Grant $300,000 (Subcontract amount from PNNL) 2/2020 – 7/2022, Principal Investigator Preliminary data analysis for the planetary boundary layer incubation study team" NASA PBL, Grant $98,155 1/2020 – 12/2020, Principal Investigator "Evaluation and Improvement of the West-WRF Forecasts" Army Corps of Engineers, grant $90,492 (Subcontract amount from SIO/CW3E) 11/2019-9/2020, Principal Investigator 2) Leadership: Chair, NOAA OSSE White Paper (submitted to NOAA leadership and U.S. Congress), 2018-2019; Co-Chair, University Strategic Planning and Budget Advisory Committee, 2018-2019; Member, University President's Cabinet, 2018-2019; Member, UA COS Dean Search Advisory Committee, 2019-2020, Member, UA COS Transition Committee, 2019-2020 3) **News:** At the invitation of NASA, did an audio interview as part of the AGU Narratives, a project initiated as part of AGU's Centennial celebration. The interview will be added to the AGU Narratives Community on StoryCorps and archived in the American Folklife Center at the Library of Congress.

Retirement Celebration for Professor Edward Kerschen

Ed Kerschen joined the University of Arizona faculty in 1981 and advised several students, both from the Program in Applied Mathematics and the AME department. On **May 6, 2019**, we celebrated Ed's retirement from the AME department. Oliverio Alvarez (PhD 2002) organized a series of talks given by many of Ed's former students. The talks took place in the morning at the Math building then a reception for faculty and alumni was held in the afternoon at the AME Building. The celebration also involved hiking Wasson's peak and socializing at 1702 (Wayne Hacker's favorite hangout).

From left to right: Meelan Choudhari; Bill Schuster; Oliverio Alvarez; Robert Jacobi; Ed Envia; Roland Heinrich; Edward Kerschen; Matt Myers; Ying Fang and Ramons Reba. *Not pictured:* Wayne Hacker

Recent Graduates

Jesse Adams, PhD is a Postdoctoral Researcher, Nevada National Security Site (NNSS), Las Vegas, NV.

Colin Clark, PhD is a Postdoctoral Research Associate I, Department of Mathematics, Program in Applied Mathematics, University of Arizona.

Robert Crandall, PhD is a Research Scientist at AmazonGo, Seattle, WA.

Luke Edwards, PhD is a Senior Systems Engineer I, Aerodynamics group of the Guidance, Navigation and Control division, Raytheon Missile Systems, Tucson, AZ.

Victoria Gershuny, PhD is an ORISE Fellow, Center for Drug Evaluation and Research, FDA in Washington, DC.

Patrick Greene, PhD is Postdoctoral Fellow, Institute for Computational Medicine, Johns Hopkins University.

Andrew Hofstrand, PhD is a Postdoctoral Research Associate, Optical Sciences, University of Arizona.

Brian Hong, PhD is a Postdoctoral Researcher, University of Nebraska Medical Center.

Guangyu Hui, PhD is a Quantitative Associate at Wells Fargo Securities in Charlotte, North Carolina.

News from Alumni

Aceves, Alejandro (PhD 1988) Let me start by sending best wishes to all Applied Math alumni. Seeing some of you at the 30th year celebration of the ACMS held at the end of November 2018 was a pleasant reminder of the outstanding people that has passed through Arizona, many leaving a mark in the Program. Speaking of the Program, it was good to see Moysey keeping things in order while the search of new Director was taking place; now with Misha at the helm, the future looks good.

On my end while 2018 ended on a sad note with the passing of my colleague and friend Rich Haberman (more on this below), we had for the most part a very successful 2019. Fall of 2020 marks the start my last (6th year) as SMU Math Department Chair; the picture reflects well my state of mind on this. I am eager to spend a sabbatical year 2021-22, traveling a bit, but primarily settled in NYC to be close to our daughter Ale. Returning to 2019, we have been working hard on strengthening our Applied Math graduate program and got a big boost with the award of a 3.2M dollars NSF Research training groups (RTG) grant that will allow us to sponsor graduate students and postdocs to work on research center in three thematic areas: "Computation-enabled investigations into circuits and cognition", "Nonlinear dynamics and the modeling of large systems", "Modeling complex transport processes in nanoscale manufacturing". So a bit of advertisement and a request for my fellow alumni to recommend undergrad and PhD students to apply to our fellowships. In addition, the Haberman family gave the Department a very generous gift to create a fellowship for our PhD students. Altogether, I see our SMU-PhD program turning the corner to become nationally recognized. Adding to our efforts to gain visibility, this past November we hosted a sectional (Texas/Louisiana) SIAM conference with an attendance of around 250 participants. I'm certain it is a record number for a sectional conference. Along the way, I was trying my best to keep my research going and attend a few conferences in the US and Europe. Nonlinear optics is a "generous" research field in that it keeps bringing up new ways of looking at more general scientific questions in a realizable setting. More recently with a PhD student we have been studying the fractional nonlinear Schrödinger equation as a viable model in nonlinear optics both in a particular laser cavity and in globally coupled resonator arrays.

Finally, Rocio and I try to keep up staying in touch with kids and grandkids with visits to San Diego, NYC and frequent weekend drives to Austin, piling up miles in our Mazda CX5, or as Alan Newell would say our post-BMW driving experience. We do this to visit son Andy, daughter in law Chelsea and grandkids Mason and Camila. The drive never gets boring and this old couple always returns exhausted but happy back to Dallas on many Sunday nights.

Alvarez, Oliverio (PhD 2005) Was elevated to Senior IEEE member, got a third granted patent and published two journal papers : 1) Permittivity Spectrum of Low-Loss Liquid and Powder Geomaterials Using Multipoint Reentrant Cavities in the IEEE Transactions on Geoscience and Remote Sensing; 2) Dielectric Properties of Aromatic Components of Crude Oil in Energy & Fuels (American Chemical Society). Presented, for the first time in 20 years in Spanish at Converciencia 2019 in Guatemala City.

Beauregard, Matthew (PhD 2008) was the recipient of the 2019 Teaching Excellence Award for Stephen F. Austin State University.

Borghese, Michael (PhD 2017) Working at Fabfitfun since April, 2019 and now has the title of Senior Data Scientist.

Calini, Annalisa (PhD 1994) Started a rotation as Program Director in Applied Mathematics, in the Division of Mathematical Sciences at the National Science Foundation.

Graff, Christian (PhD 2009) Now a Senior Machine Learning Engineer at Micrima, a startup company developing microwave-based medical imaging technology in Bristol, England.

Hallmark, Brian (MS 2006) Received PhD (2018) in Statistics at UofA with Dr. Joseph Watkins and is now an Assistant Research Professor with the Bio5 Institute at the University of Arizona.

Halpern, David (PhD 1989) Since 2015, director of graduate programs for the Department of Mathematics at the University of Alabama.

Hariprasad, Daniel (PhD 2014) Left UNM in 2016, currently at the Biotechnology HPC Software Applications Institute in Ft. Detrick, MD as a Research Scientist II doing research involving trauma-induced blood coagulation and pulmonary health.

Johnson, William A (PhD 1978) Retired but doing some consulting and also work with a small group of researchers at the University of Houston and Politecnico de Torino. Recent publications include: J. Rivero, F. Vipiana, D. R. Wilton, W. A. Johnson," Hybrid Integration Scheme for the Evaluation of Strongly Singular and Near-Singular Integrals in Surface Integral Equations", IEEE Transactions on Antennas and Propagation (Volume: 67 , Issue: 10 , Oct. 2019) B. A. Freno, W. A. Johnson, B. F. Zinser, S. Campione" Symmetric Traingle Quadrature Rules for Arbitrary Functions", accepted subject to revisions, Computers & Mathematics with Applications. B. A. Freno, W. A. Johnson, B. F. Zinser, D. R. Wilton, F. Vipiana, and S. Campione," Symmetric Numerical Integration Techniques for Singular Integrals in the Method-of-Moments Implementation of the Electric-Field Integral Equation", submitted for publication in IEEE Trans. on Antennas and Propagat. The paper by J. Rivero, F. Vipiana,D. R. Wilton, W. A. Johnson "Reducing the Dimensionality of 6-D MOM Integrals Applying Twice the Divergence Theorem" has been accepted for EuCap (Copenhagen Denmark, 15-20 March 2020) D. R. Wilton, J. Rivero, F. Vipiana, W. A. Johnson,

News from Alumni (*continued*)

"Evaluation of static potential integrals on triangular domains", submitted for publication in the International Journal for Numerical Methods in Engineering. D. R. Wilton, J. Rivero, F. Vipiana, W. A. Johnson, "New Representations for Static Potentials and their Gradients for Linear Sources on Planar Triangles", submitted to 2020 International Symposium on Antennas and Propagation and North Americal Radio Science Meeting, Montreal , Quebec, Canada, 5-10 July 2020.

Jones, Quintina (MS 2010) Received second Raytheon Missile Systems (RMS) Technical Honors Award (Principal Engineer with Honors); 3 submissions for consideration for Raytheon IP (Intellectual Property) and working on getting my Texas P.E. License. Personal: I have Kindergartner and a 5th grader, so I'm extremely thankful that I don't have to pay for daycare anymore. First year having both boys in Football with the Sahuarita Green Valley 49ers (Flag & 11U) My friend, Tricia Elliott, and I (better known as Team White Chalkolate) got 2nd place at Old Pueblo CrossFit's annual Crossfit Competition (Battle of the Boxes III) and tied for 2nd place at Green Valley CrossFit's annual CrossFit Competition (2019 Arizona Clash of the Fittest) in our division. I'm hoping to get into competitive Olympic weightlifting in 2020.

Kim, Sangil (PhD 2005) Assistant professor, Department of Mathematics, Pusan National University, Korea.

Kopriva, David (PhD 1982) Retired. With Guus Jacobs of San Diego State University, co-organized the first North American High Order Methods Conference (NAHOMCon) in San Diego held at SDSU in June, 2019. Plans are to hold it every other year with next one at the University of Colorado, Boulder in early June, 2021. We hope to see folks from U of A there! Travel has also been big part of this year, with three stays at the Polytechnic University of Madrid (UPM), one in Tallahassee at FSU, and a quick trip to the University of Utah. He also still hosts graduate students, who come to work with him at SDSU on spectral element methods for stays of varying lengths. Two came from UPM and one came from Imperial College of London, as part of their Ph.D. research. One is from the University of Stuttgart completing his Masters thesis work. Helped by one of his visiting students, bought a guitar, and started taking lessons a year ago. He is now playing solos along with Petrucci, Syu and Malmsteen, made possible only by a slow-downer app.

John Pate and Family

Pate, John (MS 2008) I got my MS in applied math where I studied numerical solutions to non-linear laser propagation. I have been with Raytheon Missile Systems (RMS) since Summer 2009 where I was an intern and decided to join industry instead of getting my PhD. At RMS my masters work let me easily jump into radar modeling (longer wavelength but still EM. I've spent the last 10 years working many different missile programs with a wide variety of radars and radar applications - air to air electronic warefare scenarios, air to ground high resolution imaging, air to dynamic ocean surface engagements, and others. I'm also a section head where I am in charge of 10 people, making sure they are executing their modeling tasks on their programs and have the support they need. I have 3 boys from 3 to 8 years old and am still married to my wife Tiffany. I spend my time volunteering for youth sports, church activities, cub scouts, and if lucky playing in the outdoors: camping, hiking, hunting.

Shelley, Michael (PhD 1985) Recently became Director of the Computational Biology Center at the Flatiron Institute of the Simons Foundation, and, still a Math Professor at the Courant Institute.

Soterwood, Jeanine (PhD 2005) Continuing to grow her software consulting business in the San Francisco Bay Area. Through her involvement with a research program at the University of South Carolina, she recently co-authored a paper entitled "Predicting Contextual Informativeness for Vocabulary Learning" published in IEEE Transactions on Learning Technologies. Last year she tied the knot with her wife Monica, who is a critical care veterinarian. She is also actively involved with her local chapter of Women Who Code and is enjoying mentoring new developers.

Stark, Donald (PhD 1995) Left the National Center for Atmospheric research and is now working with research computing at the University of Colorado, Boulder. Working on developing online learning modules for HPC and on the development of a new DOE multiphase fluid dynamics code.

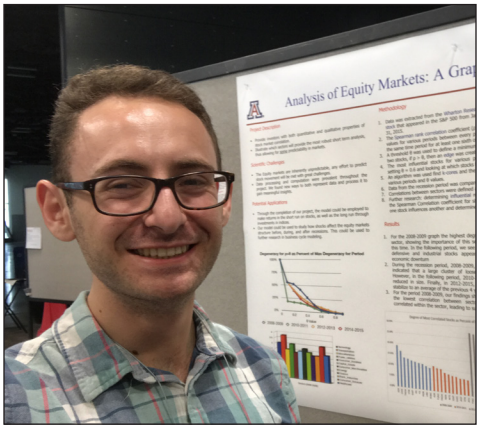
Uribe, Guillermo (PhD 1993) During 2019, co-authored 2 research papers that showed a positive impact of active learning techniques on academic performance in STEM courses. One for the UofA Math Department and the other for the UofA College of Engineering (both have been submitted for publication).

Washburn, Ammon (PhD 2018) My wife had a little girl in May. Her name is Lily and she is doing well.

Williams, Katie (PhD 2016) Was promoted to Associate Director of Business Development at Applied BioMath this year. Most of my time is spent in conversation with pharmaceutical and biotech companies about how modeling may improve decision-making at all stages in the discovery/development pipeline.

Young, Alex (PhD 2017) Accepted a position as College Fellow in Statistics at Harvard University which began in Fall 2019. To date, I have developed (and recently taught) a new course in Dimension Reduction for upper level students and continued research work started during my previous post-doctoral appointment.

Current Student Achievements



Abrams, J. Ruby (3rd Year) I was part of the G-RIPS (Graduate Research Internship Program) based out of UCLA in Berlin, Germany. I worked at the Zuse Institute of Berlin and was there for 2 months. We studied the underdeveloped Inspector Scheduling Problem. The Deutsche Bahn want to maximize the number of passenger tickets inspected given already set train schedules with their limited resources, the passenger ticket inspectors. We formulated this problem as a network flow and implemented this as a Mixed Integer Programme. We accounted for lack of data by estimating Origin-Destination Matrices and discussed complexity of the problem. We obtained empirical results of run time of the algorithm as a function of number of inspectors and conjecture that this problem is NP-hard. We also proposed heuristic methods to solve this problem.

Bell, Brian (3rd Year) was elected to be a Data Science Ambassador at the Data Science Institute at the UofA.

Edwards, Luke (6th Year) Summer 2019 worked as a graduate researcher at Los Alamos National Lab in the Shock and Detonation Physics group. Recently published the following paper: L. D. Edwards and A. Tumin, "Model of distributed receptivity to kinetic fluctuations in high-speed boundary layers," AIAA J., vol. 57, no. 11, 2019. Presented at the 2019 American Physical Society, Division of Fluid Dynamics conference. Title: "Modeling of the Cellular Structure of Detonation in Liquid Explosives" Accepted a position at Raytheon in Tucson to begin in the Spring, 2020 as a Senior Systems Engineer I in the Aerodynamics group of the Guidance, Navigation and Control division.

Hofstrand, Andrew (7th Year) I recently had a major part of my thesis accepted as first author in Physical Review Letters. I submitted the paper in August, although technically the acceptance date was Jan 2, 2020. I also had work as first author published in Physical Review A in November. The title of the Physical Review Letter: "Optical carrier-wave subcycle structures associated with supercritical collapse of long-wavelength intense pulses propagating in weakly anomalously dispersive media" by A. Hofstrand and J.V. Moloney. The title of the Physical Review A: "Bidirectional shooting method for extreme nonlinear optics" by A. Hofstrand, P. Jakobsen, and J. V. Moloney

Kravitz, Hannah (4th Year) Attended the Society for Industrial and Applied Mathematics (SIAM) Workshop on Network Science, May, 2019 in Snowbird, Utah with funding from the Don Wilson Travel Grant and the Graduate and Professional Student Council (GPSC) Travel Fund.

Lockhart, Ethan (7th Year) Working as a Senior Computer Vision scientist, BAE Systems FAST Labs, Research Triangle Park, North Carolina

Luna, Kevin (4th Year) In January, 2019 I Presented a conference paper titled "Receptivity of High-Speed Boundary Layers In Binary Mixture of Gases to Kinetic Fluctuations" at the AIAA (American Institute of Aeronautics and Astronautics) 2019 SciTech Forum in San Diego, CA. In February I Presented a poster titled "Modification and Application of a Method for Studying Stability of High-speed Boundary Layers" at the 2019 SIAM Conference on CSE (Computational Science and Engineering) in Spokane, WA. In July I Gave a talk titled "Sampling the Thermodynamic Free Energy of a Ginzburg Landau Model" at the Workshop on Computational Modeling of Soft Matter and Complex Fluids in Berkeley, CA. In November, I gave a talk titled "The Role of Fluctuating Dissipative Fluxes in the Receptivity of High-Speed Chemically Reacting Boundary Layers in Binary Mixtures to Kinetic Fluctuations" at the 72nd Annual Meeting of the APS(American Physical Society) Division of Fluid Dynamics(DFD) in Seattle, WA. In December, I presented a poster titled "The Role of Thermal Noise in Hypersonic Transition to Turbulence" at the 2019 GIDP Student Research Showcase in December 2018 Awarded a travel grant through the sustainable horizons institute (SHI) to attend the 2019 SIAM CSE conference. Received a Don Wilson Fund travel award to present at the 2019 APS DFD meeting. Attended a workshop at the American Institute of Mathematics as a funded participant in April. Over the summer, I interned in the Multiscale Modeling and Stochastic Systems group within the Center for Computational Sciences and Engineering at Lawrence Berkeley laboratory. I worked on extending an importance sampling method known as umbrella sampling to the context of partial differential equations with noise

McLaren, Sam (4th Year) July 2019, I attended the 2019 NDSEG Fellow's Conference in San Diego, CA and presented a poster titled: Transverse Microscopic Many-Body Model for Mode-locked VECSELs. The trip was funded by my NDSEG fellowship.

Nwaigwe, Dwight (5th Year) Co-author of 2 papers: 1) Overdamped dynamics of a Brownian particle levitated in a Paul trap 2) On WKB Solutions to the Damped Mathieu Equation.

Pillow, Jessica (4th Year) Summer 2019 internship at the Nevada National Security Site (NNSS) in Las Vegas. I worked with our collaborator Marylesa Howard on my current research in image processing

Swierczek, Stan (4th Year) in the Fall, 2019, traveled to Oregon (with support from the Don Wilson Travel award) and participated in a 5-day OOI Coastal Endurance Fall 2019 Deployment sea cruise to deploy an array of moorings off the coast of Washington. It put me in closer proximity with the oceanographers who actually put the instruments out at sea that make observations I will use in my ocean data assimilation.

I also received the Don Wilson Award in Spring 2019 to attend the 2 week ECCO (Estimating the Circulation and Climate of the Ocean) Summer School at the University of Washington's Friday Harbor Laboratories on San Juan Island, WA.

Thompson, Craig (3rd Year) In May 2019 I attended the SIAM Conference on Applications of Dynamical Systems in Snowbird, Utah. In the Summer. I had an internship in the ATR Center program at Wright State University, which is sponsored by the Air Force Research Laboratory. In December,2019 I presented a paper at the 58th IEEE Conference on Decision and Control titled, "Drive-Based Motivation for Coordination of Limit Cycle Behaviors" in Nice, France.

Current Student Achievements (*continued*)

Yamamoto, Ken (5th Year) Worked with physicists in Prof. Eran Sharon's laboratory at the Hebrew University of Jerusalem in January 2019 to compare experimental insights into the wrinkling of thin sheets with my theoretical findings. The trip was supported by the 2019 Prof. Rahamimoff Travel Grant from the United States – Israel Binational Science Foundation. I gave an oral presentation at the 2019 APS March Meeting (American Physical Society) in Boston, MA (supported by a Graduate and Professional Student Council Travel Grant) titled "Geometric defects, weak forces, and self-similar buckling in non-Euclidean elastic sheets." I gave a poster presentation at the 2019 Workshop on Mathematical Models for Pattern Formation at the Center for Nonlinear Analysis at Carnegie Mellon University in March, 2019 titled, "Geometry, mechanics, and dynamics of leaves, flowers, and sea slugs." I attended the 55th Meeting of the Society for Natural Philosophy: Microstructure, defects, and growth in mechanics at Loyola University Chicago in Sep 2019. I gave an oral presentation at the SIAM Conference on Analysis of Partial Differential Equations in La Quinta, CA in December, 2019 (supported by a SIAM Student Travel Award) titled, "Discrete geometry and PDE-constrained optimization for mechanics of hyperbolic elastic sheets." I won the 2020 Louise Foucar Marshall Foundation Dissertation Fellowship awarded annually to six outstanding graduate students at the University of Arizona within one year of completing and defending their dissertation.

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.*

2019 Don Wilson Fund Recipients:

J. Ruby Abrams (3rd year student) was awarded $500 in the Spring, 2019 to give a talk at the SIAM CSE 2019 Conference in Spokane, WA.

Justin Crum (4th year student) was awarded $500 in the Spring, 2019 to give a talk at the International Geometry Summit - Solid and Physical Modeling in Vancouver, Canada.

Travis Harty (6th year student) was awarded $500 to present a poster at the American Geophysical Union in San Francisco, CA in the Fall, 2019.

Hannah Kravitz (4th year student) was awarded $500 in the Spring, 2019 to attend the SIAM Workshop on Network Science in Snowbird, UT.

Kevin Luna (4th year student) was awarded $500 to give a talk at the 72nd Annual Meeting of the American Physical Society of Fluide Dynamics in Seattle, WA in the Fall, 2019.

Nikki Plackowski (5th year student) was awarded $500 as an off-cycle award to attend the 2020 Joint Mathematics Meetings in Denver, CO.

Stan Swierczek (4th year student) was awarded $500 in the Spring, 2019 to attend the ECCO Summer School, 2019 at the University of Washington. He was also awarded $500 in the Fall, 2019 to attend the OOI Endurance Array Fall 2019 Deployment Cruise in Newport, OR.

Zhuocheng Xiao (4th year student) was awarded $500 in the Spring, 2019 to present a poster at the 2019 SIAM Conference on Applications of Dynamical Systems in Snowbird, UT.

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/program-info/donate

New Students Fall 2019

Incoming class, August 2019 *Top row from left:* **William Gammel**, Smith College, North Hampton, MA; **Adrienne Kinney**, Centre College, Danville, KY; **Theodore Broeren**, Northwest University-Evanston, IL; **Sheldon Deeny**, Colorado State University; **Brian Toner**, College of The Holy Cross, MA; **Criston Hyett**, University of Arizona.

Bottom row from left: **Sarah Luca**, University of North Carolina, Ashville; **Sarah Pungitore**, Lafayette College, PA; **Brady Gales**, Wake Forest University, NC; **Patricia Puente**, Texas Woman's University. Not pictured: **Robert Ferrando**, CUNY College of Staten Island, NY.

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