The University of Arizona

Program in Applied Mathematics

January 2021 Number XXI

Greetings from the Chair, Program in Applied Mathematics

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

2020 was a difficult year for everybody, to say the least. However, and in spite of many COVID-related obstacles, I am happy to report good progress on a number of fronts.

1) Our work on updating the program curriculum and qualification process is almost complete:

a) 2019-2020 was the first -trial- year (two semesters) for the new edition of our three core courses in Applied Mathematics: Theory, Methods and Algorithms. Content of the new courses is now up-to-date and balanced with the state-of-the-art in Applied Mathematics (which is significantly broader what it was 40 years ago, when the program was created). Our AM core courses combine traditional subjects in Applied Mathematics (such as Complex and Fourier Analysis, ODEs, PDEs and Variational Calculus) with a number of more contemporary subjects (Optimization, Control and Elements of Data Science and Statistics for Inference and Learning). In 2019-20 and 2020-21 academic years the courses were led by Prof. Shankar Venkataramani (theory), Prof. Mikhail Stepanov (algorithms) and your humble servant (methods). Dr. Colin Clark, the program Postdoctoral Fellow, was helping the core instructors with inter-course coordination (e.g. via recitations). See https://appliedmath.arizona.edu/students/new-core-courses for more info. This significant change in the program curriculum was considered and approved by a specially formed committee of Applied Math faculty in 2019. The change was also approved by the Graduate Committee of the Math Department in December of 2020, and we expect the updated curriculum to be finalized in the UArizona course catalog shortly -- in time for the start of the 2021-22 academic year.

b) The same committee of Applied Math faculty has worked out respective adjustments in the program's qualification process. Our new qualification process is linked to the successful passing of six exams (from 3 core courses) and it is monitored and approved by three committees (one per core course) each consisting of six faculty. Absolute majority of our (now second year) students passed the qualification process successfully last May – which is good proof that the program continues to attract great students.

2) Our admission numbers went up last year; 16 PhD students were admitted in 2020 (vs 10 in 2019). We expect to maintain the numbers steadily, within the 12-18 range, in the coming years. Our next recruitment event (virtual, due to COVID, utilizing both Zoom and GatherTown platforms) is scheduled jointly with the Graduate Program in Mathematics and Graduate Interdisciplinary Program in Statistics & Data Science for February 28-March 1, 2021.

3) Thanks to efforts of the program steering committee, 45 new affiliate members and 2 new members across 28 Departments of UArizona were added to the list of the program's faculty in 2020. The total number of UArizona faculty affiliated with the program is now 113.

4) The program joined forces with the Department of Mathematics in setting up the Integration workshop which we co-ran for the first time in the August of 2020. The workshop, which we aim to continue annually, focuses on reviewing basic undergraduate mathematics that are critical for the students' future success in the program; identifying gaps in our students' preparation for careers in Applied Mathematics that need attention; and it provides the opportunity to the incoming class to meet each other, program professors and staff. Dr. Colin Clark was instrumental in smoothly running the Applied Mathematics component of the workshop.

5) We have continued the old tradition of conducting the Los Alamos – Arizona days, (resurrected after a 15-year break) in 2019. This year the event was virtual (over zoom). Please check all the great talks by our students, professors and Los Alamos postdocs and faculty, made available at https://appliedmath.arizona.edu/events/los-alamos-arizona-days. We are also working on extending our collaborations with other National Laboratories and Industry. In particular, in the fall of 2020, we hosted virtual visits for teams from Lawrence-Livermore NL and from the Nevada National Security Site. Many collaborations with Raytheon/Tucson and other companies in Tucson, such as Critical Path, are ongoing. Those activities help to set up internships, fellowships and future employment opportunities for our students. Five of our 1st year students had (virtual) summer internships with our National Lab and Industry partners last summer.

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6) The new Applied Math Laboratory opened its doors to the program students and faculty in February, 2020. The Lab is located in renovated office space on the 5th floor of the Physics and Atmospheric Science building. This is a great location with an open space for individual work and discussions (equipped with a sufficient number of tables, monitors and whiteboards), small-scale gatherings and also containing two rooms, e.g. suitable for small table-top experiments.

7) The pandemic did not stop our program colloquia and seminars. All of our regular weekly activities have continued without interruption via zoom. Moreover, a majority of the presentations made at the traditional venues, and some temporary venues (such as a working seminar in Applied Mathematics about Pandemics that we ran in April-June of 2020), are now recorded and posted online at https://appliedmath.arizona.edu/events/seminar-videos-fall-2020.

8) We continue to work on bringing new funding to the program. Faculty of the program are key participants of the newly awarded NSF Research and Training Grant (RTG) in "Applied Mathematics and Statistics for Data-Driven Discovery", led by Kevin Lin. Tim Secomb and the team have received an extension of the NIH training grant "Computational and mathematical modeling of biomedical systems". These two training grants are financing 8 semesters in the 2020-21 academic year of our students' Research Assistantships. We are also expecting responses to a number of other grant submissions made on behalf of the program recently.

I would like to thank all of you for your help and support. Finally, I am especially grateful to Stacey and Keri working days and often nights for keeping the program running.

Sincerely Yours, Misha Chertkov

Obituary tribute for Robert E. O'Malley Jr., 1939–2020

by Mark Kot (MS 1984), Professor, University of Washington

It is with great sadness that I report that Bob O'Malley, the founder of the Program in Applied Mathematics at the University of Arizona, passed away December 31, 2020 at the age of 81.

Bob was born on May 23, 1939 and grew up in Somersworth, New Hampshire. He began his higher education at the University of New Hampshire, where he earned a B.S. in Electrical Engineering in 1960 and an M.S.in Mathematics in 1961. Bob then earned his Ph.D. in Mathematics in 1966 at Stanford University, where he wrote a dissertation on two-parameter singular perturbation problems under the supervision of Gordon E. Latta.

Bob had a long and illustrious career. After short appointments at the University of North Carolina, Bell Labs, the Courant Institute at New York University, and the Mathematics Research Center at the University of Wisconsin, Bob returned to New York University in 1968, where he worked with Joseph Keller and others. Bob then spent a year visiting the University of Edinburgh. His lectures at these institutions formed the basis for his book, *Introduction to Singular Perturbations*, published in 1974.

In 1973, Bob moved to the University of Arizona. In Tucson, Bob founded the Program in Applied Mathematics in 1976. He also worked on singular perturbation problems in control theory. Bob was a forceful advocate for applied mathematics at Arizona and was especially supportive of young faculty. Many years later, he (and I) would fondly reminisce about all the wonderful people in Tucson.

In 1981, Bob moved to Rensselaer Polytechnic Institute, where he was Ford Foundation Professor, Chairman of the Faculty, and Head of a Department of Mathematical Sciences that emphasized applied mathematics and computer science. Many years later, in 1999, Bob's colleagues at RPI hosted an O'Malley-fest, a workshop on singular perturbations that brought some 60 mathematicians to Troy, New York to celebrate Bob's 60th birthday.

At the end of 1990 and soon after a sabbatical to the Technical University of Vienna, Bob moved to the Department of Applied Mathematics at the University of Washington. He served our department as Chair, as Graduate Program Coordinator, and in many other ways, for many years. He retired in 2009, but he remained active, as a Professor Emeritus, after that.

Bob was extremely productive, and he received many honors. He was a member of the inaugural class of fellows for both SIAM and for AMS, and SIAM specifically cited Bob's contributions to asymptotics and singular perturbations. He authored four books, and *Mathematical Reviews* lists 161 publications for Bob.

He was extremely active in SIAM. Bob was President of SIAM from 1991 to 1992. He served as Vice President for Publications, on many editorial boards, and as program chair for several meetings. In 2000, Bob became the Editor of the Book Reviews section of *SIAM Review*, a job he loved so much that he continued in this role through 2014, five years after his retirement.

I never got to know Bob at Arizona — he was leaving just as I was arriving as a graduate student. He was, however, my neighbor and colleague at the University of Washington for many years. I quickly learned four things about Bob: (1) He loved his work. He came into work, even after he retired, until the pandemic hit, and I had a better chance of running into Bob than any other colleague. Bob wrote his 2014 book on *Historical Developments in Singular Perturbations* after retiring, and he was working on a new book on differential equations when he passed away. (2) Bob loved books. He loved reading them, writing them, reviewing them, and talking about them. His office was always filled with stacks of books, dangerously so during his many years as Book-Review Editor for *SIAM Review*. (3) Bob loved the history of mathematics. He loved reading and writing about this history, and he often peppered his lectures with fascinating historical anecdotes. (4) Bob loved people. He always kept an open-door policy, and he would gladly drop whatever he was doing to talk with whomever entered his office. Our graduate students loved Bob, and many former students and colleagues would detour on their way through Seattle to visit Bob. He was a wonderful colleague, and he will be sorely missed.

Bob's funeral mass took place in St. James Cathedral in Seattle on January 9, 2021. His son Patrick gave an especially eloquent tribute to how Bob's mathematics opened up the world for his family and how it also brought the world to their door. Bob is survived by his wife Candy and by his sons, Daniel, Patrick, and Timothy.

A Note on Bob O’Malley

by Michael Tabor, Professor Emeritus, Head of Applied Mathematics GIDP (1992-2015)

When I arrived at the University of Arizona to become Head of Applied Mathematics in 1992, I quickly learned about Bob’s central role in starting the Program from colleagues who were there at the time. With Bob’s passing, and the fact that many others who were involved have either retired or passed away, I thought it appropriate to record those early days by sharing an extract from the 1991 Academic Program Review that tells the story:

“The Program in Applied Mathematics at the University of Arizona had its beginnings with submission of a memo to Executive Vice President Albert E. Weaver from Professors P.C. Fife, D.O. Lomen, R.E. O’Malley, H. Rund, and A.R. Seebass, dated January 23,1976. In the memo, the professors wrote as follows:

We have been discussing the formation of a Center for Applied Mathematics with various colleagues. Our discussions have lead us to the conclusion that there are many benefits to be derived from such a center here. Consequently, we propose that you appoint an ad-hoc committee to advise you regarding the need for such a center as well as possible mechanisms for its formation. We believe that a Center for Applied Mathematics at the University of Arizona would provide a broadly based interdisciplinary program of high quality research and advanced study in applied mathematics ...

On March 13, 1976, Dr. Weaver reacted to the memo by forming an ad-hoc committee, consisting of Professors D.G. Dudley, R.L. Hamblin, R.E. O’Malley (Chairman), M.L. Rosenzweig, A.R. Seebass, and M.O. Scully. In his charge to the committee, Dr. Weaver stated: If the Committee finds that such a program is needed ... and that we have the resources to make it a first-rate program, it should be reported to Dr. Carter. In this case, it should recommend the general nature and characteristic of the curriculum, the resources needed, the individuals who, or the departments which, should be invited to participate, and in general delineate the proposed program in sufficient detail so that an estimate of the cost, the needs, the student demand, the quality of the program, etc., can be made ...

The Committee accepted the charge from Dr. Weaver, completed its study early in the summer of 1976, and reported the results to Dr. Carter, Coordinator of Interdisciplinary Programs. As a result, President John Schaefer appointed a University Committee on Applied Mathematics to “begin work on developing an interdisciplinary program of research and graduate education in applied mathematics at the University of Arizona.” R.E. O’Malley was appointed Chairman of the University Committee and on October 28, 1976 issued invitations to join the program to 30 selected faculty across a broad range on disciplines on campus. On December 10, 1976, Professor O’Malley announced that the degree program had received the approval of the Graduate Council and Regents and, with this action, the Program in Applied Mathematics was officially established.”

By the time I had arrived in Arizona, Bob was already established at the University of Washington. We would run into each from time to time at conferences and SIAM meetings. He was always friendly and eager to hear news of the Program he had helped start.

Bob’s vision for a successful interdisciplinary program aimed at solving real-world scientific problems lives on to this day.

Comments in Remembrance of Bob O’Malley

By Alan Newell, Regents Professor, Mathematics

“As I recall, it was key that Bob was supported by Hanno Rund, then Chair of Mathematics. Hermann Flashka, Dave McLauglin, Jim Cushing, Paul Fife were also very instrumental. But without Hanno it would have been difficult to get the whole thing going. (It should be also noted that Ted Laetsch who became Chair after Hanno helped enormously by committing Mathematics to share its TA’s although this was a year or two later.) Another crucial ingredient in the beginning was the support of Engineering and many of the engineering sciences and Dick Seebass, then an Associate Dean of the College of engineering, was key to organizing that support although it was my understanding and experience after I came here in 1981 that the support from Engineering was widespread. I recall Bill Sears (a mentor for Dick Seebass) and Don Dudley as being particularly enthusiastic supporters. Optics, and in particular Harry Barrett, and several of the young guys there was also a staunch ally.

One of the great successes of the program was student quality as Arizona was able to attract a class of students who, without the flexibility offered by the program, would have been unlikely to come. A second was the applied mathematics colloquium which attracted a huge following. For a while at least, it offered an intellectual home for all those in the University whose work involved mathematical thinking and models. I think the fundamental idea that applied mathematics was rooted in science based research (and not just about learning how to produce better algorithms for inverting matrices, popular in many other schools at the time) was what separated the Arizona program from the rest. And Bob O’Malley certainly deserves credit for fostering that approach despite the fact that his own research tended to be rather analytical.”

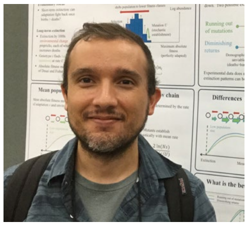
The Don Wilson Applied Mathematics Endowed Fund for Excellence

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.*

Due to the COVID-19 pandemic, no Don Wilson travel awards were distributed in Spring or Fall semesters of 2020. 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

Al Scott Lecture

Kevin Gomez (PhD 2020), Senior Research Engineer, Raytheon Missile Systems



Last Spring, I had presented the Al Scott prize lecture as part of the applied math colloquia series. Dr. Alwyn Scott was a Professor at the University of Arizona, the founding director of the Center for Nonlinear Studies at Low Alamos National Lab, and a founding editor of Elsevier's Nonlinear Phenomena Journal. Dr. Scott was also known for his work on nonlinear systems in Biology, an area I came to appreciate more and more in my study of evolution as a graduate student. I was honored to give the memorial lecture in remembrance of his remarkable career and contributions.

In my talk, I introduced a two-dimensional traveling wave model that I developed to study trait evolution in large asexual populations. Natural selection often acts on multiple traits at once, and genetic correlations between traits help shape how traits evolve. This topic has been studied extensively for quantitative traits in animal and plant populations. Modeling trait evolution of large asexual populations such as microbes presents unique challenges due to their rapid evolution. Specifically, these populations produce many beneficial mutations that concurrently attempt to spread. Competition among the mutant lineages results in the loss of beneficial mutations whose lineages are driven extinct, a phenomenon known as clonal interference. Recently developed one-dimensional traveling fitness waves in population genetics have allowed significant advances in the study of asexual adaptation with clonal interference. In my presentation, I discussed my development of a two-dimensional traveling wave and used the model to show how clonal interference gives rise to genetic interactions that resemble functional constraints limiting the evolution of adaptive traits. The work was exciting and brought together my interests in stochastic processes and evolutionary theory.

I successfully defended two weeks before giving the Al Scott prize lecture. Following the talk, I devoted time and energy to consider what I would do after graduation before starting my new position at Raytheon. The pandemic made it impossible for me to visit family and friends back in California, as I had originally planned. Luckily, I have always been a big fan of hiking, and Tucson is a splendid place if you are into that sort of thing. I settled for plans to visit new trails and subsequently got my chance to reconnect with the natural world that I had grown to admire in my study of evolution. I started my new position at Raytheon in June of 2020. The change has brought new challenges and opportunities into my life, and I am excited to see where my career takes me.

New Program Affiliate Profiles

Laura Miller, Professor, Mathematics

Laura Miller joined the faculty of the Department of Mathematics at the University of Arizona in the fall of 2020. She is also an affiliate member of the Program in Applied Mathematics GIDP. Before joining the University of Arizona, she was a Professor in the Departments of Mathematics and Biology at the University of North Carolina at Chapel Hill. She received an M.S. in Zoology from Duke University in 1999 and a Ph.D. in Mathematics from the Courant Institute in 2004.

I have used my training in both mathematics and biology to understand how organisms have adapted to their mechanical environments. More specifically, I apply mathematical modeling, computational fluid dynamics, and experimental fluid dynamics to reveal the interactions between fluid forces and organ and organism form and function. In particular, I am interested in how biological structures have evolved to increase fluid transport and locomotion efficiency, the ways in which fluid forces constrain biological design, and the role of fluid dynamic forces during development. My previous work has focused on developing mathematical models and experiments to describe the pumping mechanics of embryonic and tubular hearts, fluid transport through biological filtering layers, the fluid dynamics and structural mechanics of jellyfish swimming, and the aerodynamics of flight in the smallest insects. A central goal of my more recent work is to couple problems in biological fluid dynamics to electromechanical models of organs and organisms whose dynamics rely on environmental cues and neural activation through the action of pacemakers. At the larger scale, I am developing models to quantify how the behavior of small organisms can affect their long distance dispersal in air and water.

To study these problems, I have used a three-pronged approach that consists of measurements of morphology and kinematics, the use of physical models to measure forces and flow velocities, and numerical simulations to understand the fluid dynamics of systems that are difficult to approach experimentally. These approaches complement each other in a variety of ways. Measurements of morphology and kinematics are used to set appropriate parameter values for simulations and physical models. In many cases, physical models can be used to study a large range of parameter values that would be difficult to investigate numerically. Numerical simulations can be used to obtain detailed descriptions of flow fields and to model biological systems with complicated mechanical properties.

In terms of computational tools, the majority of my work has focused on using the immersed boundary method to solve the fluid-structure interaction problem of an elastic organ or organism in a viscous fluid. The immersed boundary method provides a mathematical framework and numerical method for solving the Navier-Stokes equations with immersed elastic structures. Various fiber models give the immersed boundary certain desirable material properties relevant to many scientific applications. Some examples of fiber models used in my work are linear and torsional springs and beams, target points for preferred motion, massive points, porous interfaces and volumes, and muscle fibers. The use of springs, torsional springs, beams, and target points in the immersed boundary framework are now somewhat standard. The modeling challenge is to find the correct spring or beam model (or combination) with the appropriate parameter values to describe the system of interest. Often new models and numerical methods are required to describe porous tissues and muscles, and no one-size-fits-all model is available.

Given the versatility of immersed boundary methods, the potential impact of the research performed by my group and our collaborators is quite broad. The results of numerical simulations of swimming and flying animals have been used to inform the design of biologically inspired micro-air vehicles and autonomous underwater vehicles. Furthermore, it is expected that the computational tools developed in our work may also drive innovations in medicine. For example, our results could inform studies that aim to address basic scientific questions such as the fluid-structure interactions that drive the formation of the developing heart to studies that consider the function of the lymphatic system. Immersed boundary methods have already been used to develop and test artificial heart valves, and the tools that we provide should enable more cardiovascular scientists and engineers to answer fluid-structure interaction questions computationally. Our new method for treating the immersed boundary as a source or sink for chemical concentrations should find many applications in biological problems including gas exchange in the lung, nutrient uptake by the gut and in filter feeding animals, and heat dissipation in a variety of organisms.

I am currently designing an undergraduate modeling course that will focus on organisms living within moving fluids and fluid flows through organs. The natural world is replete with examples of animals and plants whose shape influences flow to their benefit. For example, the shape of a maple seed generates lift to allow for farther dispersal. The structure of a pinecone helps it to filter pollen from the air. A falcon's form during a dive reduces drag and allows it to reach greater speeds. The design of heart valves minimizes turbulence and increases the efficiency of pumping blood throughout the body. In this course, students will develop semester long projects with the goal of understanding how organisms deal the air and water around them and fluids within them. Throughout the semester, students will mathematically describe the shape of organs and organisms using photogrammetry, 3D scanning, and computer aided design (CAD). We will use the resulting 3D objects in numerical simulations of flow around organisms and within organs. We will also 3D print these objects and place them inside flow tanks for comparison to simulation. I anticipate that some of these projects catalyze new research directions in my group. This course will be taught in Spring 2021 as MATH 481.

Joshua A. Levine, Associate Professor, Computer Science

Joshua A. Levine is an associate professor in the Department of Computer Science at University of Arizona and an affiliate member of the Applied Math GIDP. Prior to starting at Arizona in 2016, he was an assistant professor at Clemson University from 2012 to 2016, and before that a postdoctoral research associate at the University of Utah's SCI Institute from 2009 to 2012. He is a recipient of the 2018 DOE Early Career award. He received his PhD in Computer Science from The Ohio State University in 2009 after completing BS degrees in Computer Engineering and Mathematics in 2003 and an MS in Computer Science in 2004 from Case Western Reserve University. His research interests include visualization, geometric modeling, topological analysis, mesh generation, vector fields, performance analysis, and computer graphics.

My research falls at the intersection of things that can be done visually with problems that benefit from applying interesting mathematical frameworks. While my focus has evolved over time, these days I focus mostly on visualizing data from physical simulations (e.g. climate simulations, energy applications, astrophysics). Often, these datasets contain interesting features that can be described through either geometric or topological properties. Quite literally, I study techniques that help to extract the "shape" of data, which in turn leads to properties we can show domain experts.

To robustly compute shape-based features, I rely on techniques in topological data analysis for visualization. In the past couple decades, topological data analysis has provided a powerful tool set. There are multiple keys to its success. First, these methods are based on algebraic topology, which provides a natural discretization of data that avoids many of the numeric precision errors of other techniques. For example, a geometric operation such as computing "do two line segments intersect?" forces one to solve an equation and do arithmetic using floating point precision. Inevitably, there will be an edge case where two infinitesimally close lines will require special care to distinguish from two barely overlapping lines. By comparison, topological tools rely on integer operations that ultimately improve robustness. Second, these methods are naturally multiscale. This allows the analysis chain to separate feature from noise and provide both coarse-grained summaries and fine-grained investigation. Finally, especially for the domains I work with, we can compute explicit features in the forms of data structures such as Reeb graphs and Morse-Smale complexes. These features can be embedded within the domain of the dataset and directly visualized as proxies for the data. So it's a win-win-win for data analysis: we avoid computational problems, we provide natural filters to interact with data, and we can present these features using visualization.

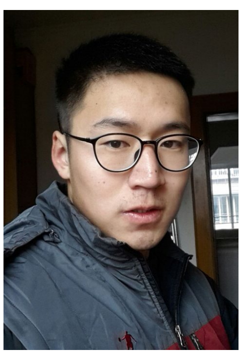
My most active project (Analyzing Multifaceted Scientific Data with Topological Analytics) focuses on studying topological properties of simulations that produce many simulation outputs that need to be analyzed simultaneously. A great example of this is climate simulation. These multiphysics codes model all aspects of climate -- spanning land, air, and sea -- including temperature, pressure, humidity, precipitation, sea ice temperature, wind flow, ocean flow, and more. These codes are enormously complex because they are trying to find the most accurate prediction possible of a huge chaotic system.

Topological data analysis already provides the tools we need to study any one aspect (e.g. temperature). I want to develop new techniques that are suitable for analyzing combinations of aspects (e.g. what does air temperature tell us about humidity combined with sea ice levels?). There is a huge opportunity here since both the mathematical frameworks and the computational tools are somewhat less developed. Particularly, the tools that tell us about shape by analyzing topological properties work great for one-at-a-time analysis, but do not yet address the use case of"many-at-a-time. Machine learning, on the other hand, works great for looking at distributions of data. My research group has been asking "how can we use machine learning to study the shape of many variables simultaneously?" Particularly, how can we study distributions of topological features and how can we learn the relationships that exist between these distributions?

Solving these problems is a great opportunity for computer scientists and mathematicians to work together closely with subject matter experts. A boon of being affiliated with the Applied Math program is we get to work at this intersection. Besides the climate example described above, there are lots of stakeholders here at UA who want to investigate applications in combustion science and materials research. The same problems are also of significant interest to the Department of Energy national laboratories, for which we have many close collaborations. The connections I have developed through the Program in Applied Math have already been fruitful, and I look forward to many opportunities to forge new ones in the coming years.

Alumni Profiles

Zhuocheng Xiao (PhD 2020) Swartz Postdoctoral Fellow, Courant Institute of Mathematical Sciences, New York University



The scientific career is usually made up of the 'dynamics' of self-motivation, self-discipline, and peer pressure - at least it is true for me. I was first obsessed with computational neuroscience with the elegance of the mathematical models and their potential to explain the complicated phenomena in our brains since my freshman year at Peking University (PKU). Since then, my career goal has been posed as a mathematician studying the brain.

'Do you think it fun?' once said Prof. Louis Tao, my advisor in PKU, 'If not, go tech companies for higher salaries, or maybe Wall street if you can. Don't hesitate.' Well, so far, I am still fascinated by my research. My undergraduate degree in biology and PhD training in applied math provide me a unique background. I come up with views from the experimental side when looking at the mathematical models. I can also process the information from a neuroscience paper in a quantitative way for modeling. In all, I play with my dog bone on the eternal field between math and neuroscience. That is my biggest motivation for now.

However, interest is just the start, and it never lasts long alone without reward. Nothing provides a better reward than solving a little scientific problem by yourself. After that, one may find another one to solve, possibly larger. For that, it is necessary to undergo rigorous training to acquire a good sight of the field, as well as strong skills to dig into any potentially interesting problem. Coursework and exams assigned by UA applied math program were never big deals to me as one of the 'exam problem solvers' ('做题家,' a self-mockery from many Chinese students who received strict test-oriented education in childhood). Instead, my biggest challenges during my PhD years were:

A. Always leaving my safe zone for something I was not familiar with, and

B. Self-regulation when multitasking.

I did fine for A. I once did some pure theoretical study in my undergraduate years with Louis and thought that was the whole world about computational neuroscience. But my first project in UA with Prof. Kevin Lin, my adviser in math, was with completely different flavors: multilevel Monte-Carlo (MLMC) for spiking networks. The goal was to provide a more efficient algorithm for simulations in computational neuroscience, and the project involved simulations, estimations of statistics, and heavy proofs ultimately. The most important thing I learned from Kevin and this project was that one has to be 'omnivorous' when working in such an interdisciplinary field. Problems always emerge from unexpected aspects, and you are never entirely prepared by your previous coursework. If needed, one should keep absorbing new skills and information.

Therefore, after MLMC, I decided to learn some 'real' neuroscience by working closely with experimentalists since I did not want to play with 'spherical brains in a vacuum' my whole life. I joined Prof. Jean-Marc Fellous' lab in the Psychology Department (who is also affiliated with the applied math program) and started working on electrophysiological data from rat behavior experiments. My previous illusions of animal experiments collapsed in the first minute I touched the data: Raw data is never organized as wished for theoretical studies, and no analysis can be carried out before some dull and time-consuming data processing. After that, one might develop a specific hypothesis from modeling thinking, which worked perfectly on dataset 1. On dataset 2, well, some issues popped up, but still tolerable. On dataset 3, oops, it went thousands of miles away. It was then time to decide: Should we go back to modify/discard the hypothesis, or we can convince ourselves to proceed since dataset 3 was not recorded correctly, hence should be excluded? Such problems occurred throughout my time in the lab, and I found it impossible to keep my hands 'clean' as if I was still doing pure theory. On the other hand, I would never have a more comprehensive understanding of computational neuroscience without these experiences and projects with Jean-Marc.

However, I did a much worse job for B. It is generally good to sort everything on one's plate by the degree of importance and urgency. However, just like many other PhD students in many different areas, my life went into a mess when I faced more than three tasks simultaneously. Obtaining a PhD seems to attract many procrastinators, including myself. Instead of solving the most urgent issues first and keep investing a consistent amount of time in the most important ones, I kept doing first the ones I liked most and stalling the ones I disliked until the last moments. Being a slave to the deadlines, I also suffered from the high pressure that I could have avoided, which often resulted in insomnia.

The situation became much more intolerable when I finally had to face peer pressure. I started to seek a postdoc position last fall. I was writing one manuscript with Jean-Marc and analyzing data for another project with him and revising my MLMC paper at the same time. One day in September, Kevin suddenly asked me, 'Do you want to get a postdoc next year? If so, let's start preparing your applications now, as well as your graduation next summer.' And my first reaction was like, 'WHAAAAT? At THIS moment?' Kevin then explained the pros and cons: There were great opportunities at that time since many great places were releasing postdoc positions for computational neuroscience; Completing my PhD work in 4 years was a little hurry, but not an unreachable goal; On the other hand, one more year bought me a better possibility for more papers, yet the postdoc market would be unpredictable in 2020 (what an unintentional prophecy for covid-19!).

My mind was finally made, then overwhelmed by peer-pressure soon after I started my application. While I was still torturing (or being tortured by - both work) the data in Jean-Marc's lab, my old friends at PKU started to publish in the top journals, i.e., Cell, Nature, etc. Looking back to my hopeless CV after congratulating my friends, I fell into panic inevitably. Though Kevin and Jean-Marc did a lot to soothe my nervous emotion, I could not help believing that the great institutes would not even review my materials, and nobody would care about my work, since I did so petty in computational neuroscience and wasted so much time doing different things. I literally cried out one night, desperately scolding myself as a useless person, until my roommates were disturbed.

I would never forget my postdoc interview with my current advisors at NYU (one from Courant Institute and one from Center of Neural Science). After an intense interrogation of my studies, they told me I was an excellent fit for the position. I was informed that my most significant attracting point was my experiences in those studies with completely different themes, exhibiting the potential to develop complicated projects with skills from various fields.

What could I say? I have been dreaming of working in Courant since my freshman year at PKU.

The last few months in UA applied math program were overwhelmed by paperwork: writing and revising in front of my desktop. I missed seeing Kevin and Jean-Marc in person due to the pandemic, and I still haven't got a chance to take a photo with my PhD academic dress. After graduation, I move to New York, and my postdoc life inevitably becomes multitasking again with even more tasks in parallel, including projects based on my original ideas. But this time, I am much more prepared, not only by the PhD degree but also by the invaluable training provided by UA applied math program. There are lots of uncertainties in the future, but so far, I still find my academic life fun. To current students (including many of my friends): You may sometimes doubt if your efforts are in vain during your journey pursuing your PhD, just like what I did. But trust me, they never are.

Peter D. Miller (PhD 1994) Professor, University of Michigan Ann Arbor

Peter Miller at the Mackinac Bridge in northern Michigan, 2004.

I first came to Tucson in 1989 for my PhD after getting my bachelor's from Southern Methodist University, and I graduated in 1994. I lived in different parts of town in those 5 years, for instance staying near Glenn and Campbell for the first year, and in an apartment behind what used to be called Reay's Ranch Market on Speedway for the last year. But what was by far the best was the intermediate period where I had a great apartment just north of River on 1st Avenue with a view of the Tucson Mountains and the arroyos in between. I had a little hibachi grill on the balcony (is that even safe? I'm pretty sure it was not allowed.).

My current research interests include all aspects of nonlinear wave theory, especially those connected with integrable systems, and analysis applied to related problems also in the fields of special functions and mathematical physics. I have a particular interest in asymptotic analysis problems; if a small parameter is going to zero somewhere, I'm there! As an example, in recent work with Deniz Bilman and Liming Ling, we studied rogue waves of increasingly large amplitude and showed that in the limit the rogue wave achieves a universal form that is given by a particular nonlinear special function solving equations in the Painlevé-III hierarchy. It is an example of a ``universal wave pattern'' that emerges either in different problems or from different initial data in a suitable asymptotic limit. The rogue wave problem is rooted in physics but the analysis involves lots of beautiful mathematics. I want to explain how I got involved in these kinds of problems and what happened to me along the way. It started when I was a student in Tucson.

I really got a lot out of the coursework during the first few years in the program. So many things just clicked. The main courses at the time were "Principles of Analysis" taught by Hermann Flaschka, "Methods of Applied Math" taught by Alan Newell and Marty Greenlee, and "Numerical Analysis" taught by Bruce Bayly. I was certain that the teachers of these courses were meeting together weekly to conspire about introducing the same topics simultaneously from three different perspectives, and while I don't know for sure whether that was the case, it is what I prefer to believe, because it gave the material a cohesive appearance that I really appreciated then and still do today. After the first year and the exams, I remember taking the course in PDE and pulling all-nighters on the homework sets with classmates at a Denny's-like place on Campbell Ave. that has since morphed into Yoshimatsu.

In my first year, I also took a special topics course on "Excitable Media" taught by Al Scott and Art Winfree. In talking with Al Scott I found out that he was interested in the quantum theory of nonlinear oscillators, which really sounded interesting to me as I had always found quantum mechanics to be a fascinating subject. We used to meet in his office to informally discuss things, and sometimes later Al would put a paper in my mailbox to read if it was relevant to our discussions. One day when I looked in my mailbox I saw a preprint of his with some computations of the spectrum for the "N=2" sector of a coupled system of quantum oscillators, and there was a sticky note on the paper that said "Would you like to try this for N=3?" I took this as both a challenge and an invitation to participate in research, and it was the gateway drug for me. As it turned out, the N=3 case was tractable by similar methods but required substantially more computation. In the end one could make plots of the energy spectrum partitioned according to a momentum coordinate, and I really liked those plots because they showed a discretized form of the band-gap structure that I had seen in solid-state physics books, except now it was coming from my own computations.

At that time, Al Scott spent half of his time in Tucson and the other half in Copenhagen, Denmark, at the Danish Technical University. In the spring of 1992 I went with him to Denmark. While there, I had the opportunity to visit the University of Salerno in Italy with Al, and to speak there in a seminar about the project we were working on together. It was my first time giving a talk, and I was nervous, but it went well. While staying in Copenhagen for the rest of the semester and summer, I got to know lots of great people, many of whom I have continued to maintain some sort of contact with to this day. For instance, Ole Bang was a graduate student at DTU whom I met then; later our paths crossed more substantially on the other side of the planet when we worked as postdocs in the same department (more about that soon).

Another subject that I first learned about from Al Scott was soliton theory and integrable systems. Al had written some of the earliest papers on this topic, but actually the whole math department at Arizona was teeming with experts in this area. As my interests developed, I started talking with other faculty members, and ultimately I ended up writing my dissertation with Dave Levermore as my advisor, although I learned equally much from Nick Ercolani and Al Scott as I did from Dave. I think of the three of them equally as my advisors in graduate school.

The mid-1990's were a very difficult time to be on the job market. The iron curtain had fallen just a few years earlier, and the market was flooded with very highly-qualified academics from the former Soviet Union who were free to seek employment overseas for the first time. I remember receiving advice from my mentors that it might be necessary to wait out the wave, and that it would be important to keep an affiliation with an institution --- regardless of whether I could be paid --- in order to have a base for future applications. I think in the end after sending out many applications I had two positive reactions, but actually it is enough to have just one! That becomes the door to your future.

Left to right: Connie Schober (PhD 1991); Alvaro Islas (MS 1992); Annalisa Calini (PhD 1994); Brenton LeMesurier; and Peter Miller (PhD 1994).

For me, that door opened to the remote Southern hemisphere, and a job in the Optical Sciences Centre at the Australian National University in Canberra. I still remember the day I went in to see Dave, after thinking about my options and coming to a decision to accept the job offer in Canberra. As I walked into his office, he simply asked: "So, are you off to see the wizard?"

Moving to Australia after graduate school in Tucson turned out to be one of the best decisions I ever made! I was a little hesitant at first, because I thought of myself as an applied mathematician (of course) and this job was not even in a mathematics department! I felt a little better when I learned that the Optical Sciences Centre shared a building with the Applied Mathematics department, although after I arrived down under I quickly learned that this was poorly named as it was really a department of folks working in surfactant chemistry. But in the Optical Science Centre there was a lot of soliton theory going on, which made me happy and feel at home. Shortly after I arrived in Canberra, so did Ole Bang coming from Denmark, and it was a treat to work in the same department with somebody I had known from before and with whom I had already some common scientific interests. We ended up writing several papers together. I had lots of projects in the time I spent in Canberra, some more mathematical and some quite applied, but all very interesting.

Another aspect of my time in Canberra was that I was able to develop what has become a lifelong interest in jazz music. I was a little curious before then (that time with Al Scott in Copenhagen had something to do with it) but in the mid 1990's there was a book you could download for free from the proto-internet that was called "The Jazz Improvisation Primer", and with some PhD students and colleagues we decided to go through this thing in detail together. Ultimately, we formed a small band that we called "The Light-Headed Trio" (there were 9 of us, obviously; and did you catch the pun on optics?). We all learned an enormous amount, and we even were able to get some chances to play in public around town (that's an advantage of living in a smaller city!). Some of us still talk about "getting the band back together".

When my position was coming to an end in Canberra, I found two opportunities almost simultaneously: a research fellowship at Monash University further south in Melbourne, and a membership at the Institute for Advanced Study in Princeton. I was torn, because I saw the IAS membership as a great opportunity, especially as a stepping stone to a permanent position in the US; but I also had come to love living in Australia and wanted to go further with that. However, it worked perfectly, because I was able to negotiate a delayed starting date for the Monash fellowship until after the program at IAS was scheduled to finish.

So next I moved from Canberra to Princeton, for a year. I lived on Einstein Drive! One of the things I liked the best from this year was that I overlapped there with a good friend from high school whom I hadn't really seen since then and who had also become a (pure) mathematician. Another important thing that happened to me during that year in Princeton was that I began a collaboration with Ken McLaughlin, whom I had met at a conference when we were both students and whose father had been the very person who had recruited me to Tucson for my PhD! Working with Ken really opened up a whole new toolbox of mathematical methods for me. Some of the tools I first learned during that year in Princeton are still my go-to techniques in many situations, and I have continued to collaborate with Ken on several projects since then.

While I was at IAS, I took the opportunity to apply for permanent positions around the US. One of the interviews I got was at the University of Michigan, where they were building a program in applied mathematics. I really liked the feel of Ann Arbor when I visited, although it snowed during my visit late in the spring semester. (As a person used to living in some warmer climates, I have gotten used to this once-jarring phenomenon since then.) The wheels of bureaucracy turned slowly, so a job offer did not come immediately, but that was OK with me because I had a research fellowship waiting for me back in Melbourne.

So, I got back on the big plane and returned to Australia. My fellowship there let me work on my own research without other obligations, so I made rapid progress on the circle of problems that I had been discussing with Ken McLaughlin back in Princeton. The only downside to such a position is that some days you work hard but can't prove a darn thing. On those days I felt a little jealous of friends and colleagues who had more traditional positions and who could earn a sense of daily accomplishment from teaching and service duties when the math doesn't flow. But "Galaxy Quest" had just come out at that time, and the catchphrase "Never give up; never surrender" from that movie spoke to me, I guess.

When I was working at Monash University, I took a night-school class in the Japanese Studies Centre on that campus, and that is where I met my wife! So that is really the most important thing that happened to me during all of that time back and forth across the Pacific Ocean.

During the first year of the fellowship, I got the call from Ann Arbor. So, I negotiated a delayed starting date to let me finish two years of the fellowship in Melbourne. Then in August of 2000 I moved to Michigan, where I have lived ever since. In 2005 another alumnus of the Arizona GIDP in Applied Mathematics came to work at Michigan: **Aaron King (PhD 1999)**, who also worked with Al Scott. Aaron and I are both still here; just a few weeks ago he spoke in our Applied and Interdisciplinary Mathematics seminar (over Zoom - there's a pandemic going on), and it was my great pleasure to introduce him.

I really like living in Michigan. The Great Lakes are, well, great. The proximity of Ann Arbor to Lakes Erie and Huron has a mitigating effect on the winter weather (although for people living on the western side of the state, proximity to Lakes Michigan and Superior has the opposite effect). In the summer, Ann Arbor hosts an annual summer festival with lots of free outdoor entertainment over a three-week period as well as an annual Art Fair that brings artists from all over the world to show off their works. Every Labor Day weekend we have the Detroit Jazz Festival, which is the biggest free jazz (i.e., jazz that you don't have to pay to listen to, not necessarily the oeuvre of Ornette Coleman) festival in the world.

I also like very much working at the University of Michigan. Our mathematics department is huge, so there is a lot of variety of expertise around. Like Arizona, applied mathematicians work side-by-side with pure mathematicians in the same department, and we have a culture of collegiality that also reminds me of Tucson. Since we are a large department, there are many different regular seminars so there is always something interesting to learn about. A substantial fraction of our faculty consists of postdocs who continually add energy to the department. One of my longest-standing collaborators, Jinho Baik, is also a professor here, and we run a weekly seminar on integrable systems and random matrix theory. The commitment of our department to applied mathematics as a subdiscipline is evidenced by a new Michigan Center for Applied and Interdisciplinary Mathematics (MCAIM), that sponsors seminars and colloquia as well as conferences and short and long-term visitors.

In the past 20 years a lot has happened. I got to teach versions of the courses I remembered from Tucson to new classes of graduate students, and I have had the chance to see how they react to the material and learn about what they think is the most interesting. For five years I got to direct Michigan's own graduate program in Applied and Interdisciplinary Mathematics, and I'm proud of the students who've graduated from our program. I've had the chance to write lots of papers on lots of interesting topics with lots of interesting co-authors, and a few books too. I've mentored my own PhD students and even more postdocs (for those of you looking toward the job market, Michigan hires lots of postdocs every year- please apply).

It has been 25 years since I moved away from Tucson after graduating. But I've been back many times to visit since then, even spending parts of two sabbaticals there. The influence that the people, the living and working environment, and my studies at the time have had on me throughout this phase of my career has been monumental. The real gem in Tucson isn't to be found at the Gem Show, but at the intersection of 6th St. and Santa Rita Ave., in the building shaped like a multiplication sign and its more recent nearby outposts.

With other Arizona alumni at the ICIAM Conference in Valencia, Spain, 2019.

Current Student Profiles

Jessica Pillow (5th Year Student)

During the summer of 2015, I did an REU (Research Experience for Undergraduates) at the Florida Institute of Technology. The research was on a particular inverse PDE problem, and eight weeks flew by as I studied functional analysis and coded up numerical methods. I had a great experience with full-time mathematical research, and I was even lucky enough to present our work at several conferences the following school year, which was my senior year at Rhodes College in Memphis, TN. The summer made me realize that I wanted to continue studying and researching mathematics, so I applied to several graduate schools and was very happy when I received the news that I had been accepted to the University of Arizona's Program in Applied Mathematics.

I did NOT realize just how hard the first year of the program would be! The math was difficult, the homework was endless, teaching undergraduates added a whole new challenge, and then being far away from home for the first time made it that much harder. Between the

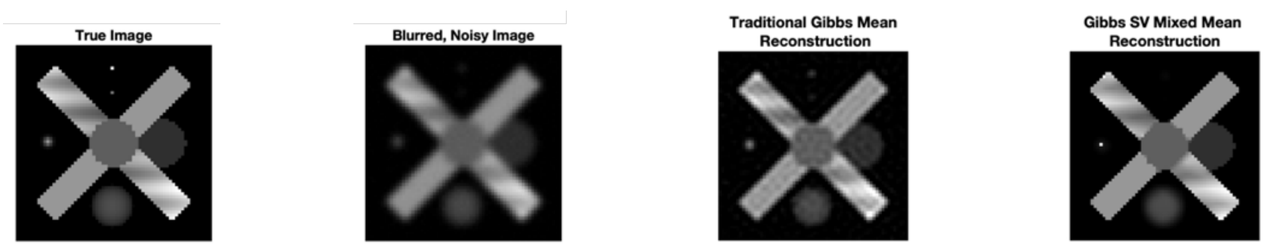
Current Student Profiles *(continued)*

start of the program in August 2016 and when I passed the qualifying exam in January 2018, I had thoughts of quitting the program at least fifty times. I'm glad I held on, though, because in September 2018, Matti Morzfeld asked me if I wanted to join him and his collaborators at the Nevada National Security Site (NNSS) on a fully funded research project. One of his students who had been working with the NNSS (now AM alumnus, Jesse Adams, 2019) was graduating soon, and Matti wanted to continue his working relationship with the lab by bringing on a new graduate student. When I first met with Matti to discuss the possible research project, I was hooked.

The project focuses on developing new techniques to deblur images, specifically images captured by high-energy X-ray machines during material science experiments conducted at the NNSS. Deblurring is formulated as a deconvolution problem, which is ill-posed in the presence of noise. Reconstructions can be obtained by Tikhonov regularization; however, this method requires one to choose the value of a parameter that serves as a tradeoff between smoothing and fidelity to the data. By assuming a Gaussian distribution on the added noise, the issue of choosing the parameter's value can be avoided by using a Bayesian framework and letting the unknown parameter be a random variable. By assuming certain prior information on the underlying image, we construct a posterior distribution, which in this case is a distribution of all possible image reconstructions for the given corrupted image. The optimal deblurred image is the estimated mean of the posterior. Samples are drawn from the posterior using a Gibbs sampler, a Markov chain Monte Carlo (MCMC) method.

My work extends this statistical process of deblurring by assuming each pixel in the image requires its own regularization value. Therefore, the balancing act between the effects of regularization and fidelity to the data is varied throughout the image. My work also incorporates the use of another common technique—Total Variation (TV) regularization, which preserves edges. Tikhonov and TV regularization should not both be applied to the same pixel, so we enforce regularization-based partitioning of the blurred, noisy image. We have developed such a method based on statistical properties of the image; however, it requires a high level of involvement from the user. We hope to automate this process in the future, perhaps by implementing machine learning techniques.

Now, after two-and-a-half years of research and two summer internships with the NNSS, I am wrapping up the project and writing my dissertation. My research advisors are Matti Morzfeld (now at UCSD), Matt Kupinski (UA Optics), Marylesa Howard (NNSS), and Jesse Adams (NNSS). As I now spend most days writing my dissertation, I often stop and think how lucky I am to have been included in such an extraordinary group of scientists. Thank you for everything. I am also thankful for this five-year chapter of my life in Tucson. In particular, during this time I came out as a member of the LGBTQ+ community, met Liz (the love of my life), and married her just last year. Tucson has been an amazing home to us, and we've had many adventures hiking and trail running in the mountains. As my time in Tucson comes to an end, I want to thank everyone in the applied math program for welcoming me in over four years ago and for your continued support and encouragement. I feel lucky to have been a part of this program, and I'm looking forward to the next chapter.



Alberto Acevedo (4th Year Student)

Quantum mechanics is the field of physics used to study the properties and/or dynamics of molecular systems, atomic systems , nanoscale material and so much more. Of particular interest to quantum information scientist, amongst other things, is the study of quantum decoherence which is focuses on the dynamical behavior of the so-called coherences exhibited by a quantum systems. There is a one to one correlation between these quantum coherences and the "super position" principle so one may think of them as being relatively the same phenomenon. These coherences are not just curiosities but are also fundamental in any quantum computation scheme or algorithm. Indeed, quantum computation cannot exist without the existence of quantum coherences, and it is therefore of great importance that to understand how these coherences are formed, how robust they are and how they evolve in time.

In the beginnings of quantum theory physicist where content with so called "collapse" models of decoherence where the superposition nature of any given quantum states were completely wiped out after a measurement. An example is the famous double slit experiment in which a beam of electrons is shot through a double slit onto a subsequent detector wall/pad. If the beam of electrons remained undisturbed one observes a diffraction pattern on the barrier situated after the double slit but if disturbed by some measuring mechanism, e.q. photons, then one would witness only a projection of the slit as expected classically. Now, it turns out that if the intensity of the measurement device is diminished gradually, we can continuously go from the two-fringe case to the diffraction case. This observation already hinted at a more subtle dance between quantum coherence and the environment the quantum system evolves in. It wasn't until models invoking the appropriate Markovian-master equations for the study of quantum open systems that we began to really grasp origin of "decoherence", i.e. the decay of quantum coherences due to environmental influences.

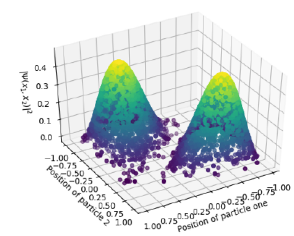
With my advisor Dr. Janek Wehr I have had the privilege of studying the rich field of quantum decoherence via the study of quantum open systems. More recently we have been interested in the study of compound quantum open systems, i.e. we study multiple open systems at the same time and analyze their dynamics in parallel. An example would be the state of some semi-classical particle and n conglomerates of scattered photons each with a trajectory terminating in the retina of a human observer. In such a system the particle is assumed quantum, and of course the photons will be quantum as well. We undoubtably know that anytime we see something in some room anyone other person in the same room facing the observed object should see the same thing, i.e. same configuration, and so there should be a link between this "classical" reality and the quantum one that says that a quantum state may be in a superposition. It turns out that there is, and the link is essentially decoherence theory. It turns out that a quantum system as described above decoheres to a state known as a "Spectrum Broadcast Structure" which gives us al of the statistical information about the state that of the particle that our n observers monitoring, minus the superposition.

Aside, from my research and course work at the UofA I have had the pleasure of completing two summer internships.

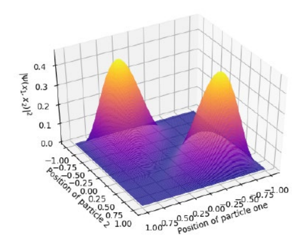
Summer 2019 I worked at Argonne national lab for the computational science department on several molecular dynamics' projects. Using variational methods that utilized a novel framework, qiskit, manufactured by IBM for quantum computation using quantum computers. My ANL project set the stage for what I would be doing the following summer during the corona virus pandemic from the comfort of my house. During the summer of 2020 I received and internship from IPAM which was to take place in Sendai Japan but COVID-19 happened and I had to work from home. Lucky for me I got to implement my knowledge of quantum variational methods on a new problem. This time I was working on the n-body problem but with focus on optimizing an MCMC (Markov-Chain Monte Carlo) approach for estimating ground state energies of quantum systems. Attached is an image of an MCMC simulation used to approximate the probability density function of a system of two fermionic particles in a potential well.

Currently I am finishing my coursework and commencing on the work which will eventually turn into my PhD dissertation. Wish me luck!

Using the Two particles in a box Ansatz as an example. We set $(\alpha_1, \alpha_2) = (1.95, 0.95)$.
$\Psi_{\alpha_1,\alpha_2}(x_1, x_2) = (1 - x_1^{2\alpha_1})(1 - x_2^{2\alpha_2})x_2 - (1 - x_2^{2\alpha_1})(1 - x_1^{2\alpha_2})x_1$



Sampling with MCMC 10000 times.



Actual $|\Psi_{\alpha_1,\alpha_2}(x_1, x_2)|^2$.

Hannah Kravitz (5th year student)

Networks are all around us, from city water grids to social media connections to the design of lasers. A network is made up of a series of points (nodes) and the connections between them (edges). In the past, modeling of partial differential equations (PDEs) on networks has primarily focused on interaction between the edges by assuming that the solution exists only at the nodes and is transferred instantaneously to other nodes via the connecting edges. However, in many applications (lasers, water flow, gas flow, etc.) the transmission is not instantaneous, and so the travel of information along the edges must be taken into consideration. This necessitates the construction of a special type of network called a metric graph, a network in which the notion of physical distance is defined on each edge. Even though there are numerous engineering applications, the mathematics of PDEs on metric graphs is still in its infancy. I am excited to be conducting my research in this rapidly developing field.

The current focus of my research is the study of the wave equation on connected, finite metric graphs. One application of particular interest to me is the design and construction of lasing networks. In this type of laser, a pulse of light is sent through a network of interconnected waveguides. Only certain frequencies resonate and in certain parts of the network. These lasing networks can be tailored and enhanced to achieve a desired configuration. Mathematically, this process can be represented by an eigenvalue problem (the eigenvalues of the wave equation correspond to lasing frequencies and the eigensolutions to the light waves along the waveguides). Thus, if the eigenvalues of the wave equation can be found for a given graph, one can predict the behavior of the network laser. Interestingly, some eigensolutions are zero nearly everywhere, with the entirety of their energy existing only on a localized shape. I study these network systems from both an eigenvalue perspective and a time-dependent numerical finite difference once.

I feel very fortunate for the opportunities the Program in Applied Mathematics has

Current Student Profiles *(continued)*

afforded me. The interdisciplinary nature of the program has encouraged me to share my research and collaborate with experts in optical science, public health, and mathematics. I attended the SIAM (Society for Industrial and Applied Mathematics) Workshop on Network Science in Utah in 2019 and was able to discuss the latest trends in network theory research with other researchers who share my passion. I also had an opportunity to present a poster at the virtual Los Alamos Days 2020, in which I was able to interact with and present my work to researchers at a national lab.

In addition to my research, I have spent much of my time at the University of Arizona developing my skills as an educator. I have taught a range of classes from Business Calculus to Ordinary Differential Equations and have been able to refine my teaching philosophy and improve my teaching skills throughout my five years here. By attending teaching seminars, working with experienced educators in the Math Department, and through sheer trial-and-error, I have developed an active-learning style of teaching in which I keep lectures to a minimum and instead focus on worksheets in which students work together to solve problems. Of course, this approach had to be refined yet again in the coronavirus-era to accommodate online learners. It has been quite challenging to continue to implement active learning online, but so far, my students and I have found success with Zoom breakout rooms, polls, and online forums. One of my primary goals as a mathematics instructor is to make math accessible to students who lack mathematical confidence. Lack of confidence in their mathematical ability keeps many students from pursuing STEM careers entirely. Most students taking an introductory math course do not plan to be mathematicians and instead see mathematics as a tool to use in their desired career, or even just an obstacle to overcome in order to continue on the path toward earning their degree. Therefore, when teaching non-math-major courses, I include applications to science and business, fun mnemonics (songs, memes, etc.) to help students remember concepts, and the use of smaller building blocks to build up to more difficult concepts. I have had many students tell me that they hated math until they took my class. Hearing that I have turned former "math haters" into "math tolerators" is enough to get me through even the toughest semesters of graduate school.

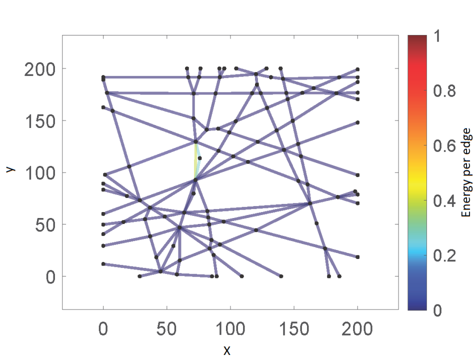


Figure 1: Solution is localized to an inner triangle

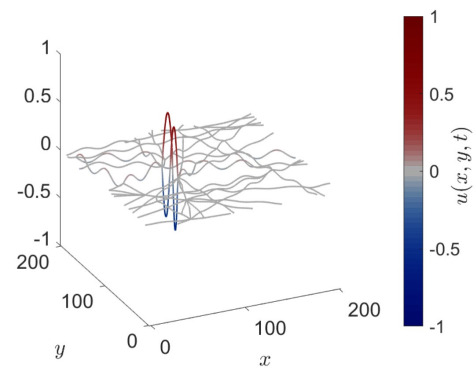


Figure 2: The time-dependent solution also shows a localized wave

News from Members and Affiliates

Bredas, Jean-Luc (Chemistry and Biochemistry) Top 5 Recent Publications: 1) 1165. "Nucleation-Elongation Dynamics of Two-Dimensional Covalent Organic Frameworks", H. Li, A. M. Evans, I. Castano, M.J. Strauss, W.R. Dichtel, and J.L. Brédas, Journal of the American Chemical Society, 142, 1367-1374 (2020). 2) 1167. "Understanding Charge Transport in Donor/Acceptor Blends from Large-Scale Device Simulations Based on Experimental Film Morphologies", H.Y. Li, G. Sini, J. Sit, A.J. Moule, and J.L. Brédas, Energy & Environmental Science, 13, 601-615 (2020). 3) 1168. "Structural and Electronic Impact of an Asymmetric Organic Ligand in Diammonium Lead Iodide Perovskites", S. Silver, S.N. Xun, H. Li, J.L. Brédas, and A. Kahn, Advanced Energy Materials, 1903900/01-06 (2020). 4) 1171. "Organic Solar Cells Based on Non-fullerene Small-Molecule Acceptors: Impact of Substituent Position", T. Wang and J.L. Brédas, Matter, 2, 119-135 (2020). 5) 1174. "Modulation of Broadband Emissions in Two-Dimensional 100 -Oriented Ruddlesden–Popper Hybrid Perovskites", J. Yin, R. Naphade, L. Gutierrez Arzaluz, J.L. Brédas, O.M. Bakr, and O.F. Mohammed, ACS Energy Letters, 5, 2149-2155 (2020).

Breiger, Ronald (School of Sociology) 5 Publications in 2020: 1) Basov, Nikita, Ronald Breiger, and Iina Hellsten. 2020. "Socio-Semantic and Other Dualities." Poetics 78 (1): 1–12. https://doi.org/10.1016/j.poetic.2020.101433. 2) Dabkowski, Matthew F, Neng Fan, and Ronald Breiger. 2020. "Finding Globally Optimal Macrostructure in Multiple Relation, Mixed-Mode Social Networks:" Methodological Innovations 13 (3): 1–17. https://doi.org/10.1177/2059799120961693. 3) Mützel, Sophie, and Ronald L. Breiger. 2020. "Duality beyond Persons and Groups: Culture and Affiliation." Oxford Handbook of Social Networks, edd. Ryan Light and James Moody. Oxford University Press. https://global.oup.com/academic/product/the-oxford-handbook-of-social-networks-9780190251765?cc=us&lang=en&# 4) Pachucki, Mark C., and Ronald L. Breiger. 2020. "Network Theories." Cambridge Handbook of Social Theory, vol 2: Contemporary Theories and Issues, ed. Peter Kivisto. Cambridge University Press. https://www.cambridge.org/core/books/cambridge-handbook-of-social-theory/8E4225D618E166517A206DAEB09EA560 5) Rambotti, Simone, and Ronald L. Breiger. 2020. "Extreme and Inconsistent: A Case-Oriented Regression Analysis of Health, Inequality, and Poverty." Socius: Sociological Research for a Dynamic World 6 (January): 1–13. https://doi.org/10.1177/2378023120906064.

Chesson, Peter (Ecology and Evolutionary Biology) Became Regents Professor effective January 2021.

Lemoine, Derek (Dept of Economics, Eller College) Published in 2021 "The Climate Risk Premium: How Uncertainty Affects the Social Cost of Carbon." Journal of the Association of Environmental and Resource Economists 8 (1): 27–57. https://doi.org/10.1086/710667.

Parent, Bernard (Aerospace and Mechanical Engineering) My lab won two grants this year: 1) Preliminary Estimates of Plasma Properties in Hypersonic Boundary Layers Using CFD: The objective of this study was to gain a better understanding of plasma effects in vehicle boundary layers at hypersonic speeds. The study compared the results of two CFD codes (CFDWARP and LEMANS) in modeling plasmas including plasma sheath effects. Additional analysis activities included investigating plasmas at lower Mach numbers via sublimation of the ablation layer partly composed of cesium. Resulting data generation was used to estimate how plasmas can effect radio communication and electron transpiration cooling. Sponsor: Raytheon Missiles and Defense. Duration: May 2020 — December 2020. Project funding: 45K. 2) Advanced Aerocapture System for Enabling Faster-Larger Planetary Science & Human Exploration Missions: This is phase 1 of a NASA Innovative Advanced Concept (NIAC) Project. The "Advanced Aerocapture System" consists of using MHD forces — instead of control surfaces — to guide and control a capsule entering Mars's and Neptune's atmosphere. The University of Arizona's role in this project is to perform simulations using CFDWARP of the coupling between the plasma flow surrounding the capsule, the plasma sheaths near the electrodes, and the Lorentz forces generated by the electromagnet. Sponsor: NASA Langley Research Center. Duration: September 2020 — May 2021. Project funding: 125K.

Raza, Taqi (Management Information Systems, Eller College) Two Publications: 1) Muhammad Taqi Raza, and Songwu Lu, "Uninterruptible IMS: Maintaining Users Access During Faults in Virtualized IP Multimedia Subsystem", in IEEE Journal on Selected Areas in Communications (Volume: 38, Issue: 7, July 2020), 2) Muhammad Taqi Raza, Fatima Muhammad Anwar, Dongho Kim, and Kyu-Han Kim, "FERRET: Fall-back to LTE Microservices for Low Latency Data Access" in USENIX HotEdge, 2020.

Wehr, Jan (Mathematics) just received a message from the Simons Foundation that my proposal, Mathematics of open quantum systems, to the Simons Fellows in Mathematics program has been recommended for funding. This will enable me to spend the academic year 2021/22 working on mathematical problems of quantum theory. This work involves two graduate students from the Applied Mathematics program: Dustin Keys and Alberto Acevedo. My research will be on open quantum systems. It will be done in collaboration with three physics groups: at the institute of Photonic Science in Barcelona (Spain), at Ecole Normale Superieure in Lyon (France) and at the Center for Theoretical Physics in Warsaw (Poland). I will be studying quantum systems interacting with their environment with a particular focus on quantum measurement. The influence of the environment can be modeled as quantum noise, leading to a description of open quantum systems known as quantum Langevin equations. Mathematical theory of these equations, which has been created by Hudson and Parthasarathy provides several probabilistic representations of the evolution of a quantum system, leading to fascinating questions in both mathematics and physics. Here is the webpage with the description of the fellowship: https://www.simonsfoundation.org/grant/simons-fellows-in-mathematics/

Xubin Zeng (Hydrology and Atmospheric Science) Received the 2021 Charles Franklin Brooks Award for Outstanding Service to the Society from the American Meteorological Society. The citation reads "For skillful and effective service in senior leadership roles that has materially improved the Society's meetings and other activities."

Zhang, Chicheng (Computer Science) Published in the NeurIPS 2020 conference this year: 1) Crush Optimism with Pessimism: Structured Bandits Beyond Asymptotic Optimality. Kwang-Sung Jun (also affiliate member of the applied math program) and Chicheng Zhang. 2) Efficient Contextual Bandits with Continuous Actions. Maryam Majzoubi, Chicheng Zhang, Rajan Chari, Akshay Krishnamurthy, John Langford, and Aleksandrs Slivkins. 3) Efficient Active Learning of Sparse Halfspaces with Arbitrary Bounded Noise. Chicheng Zhang, Jie Shen, and Pranjal Awasthi.

Recent Graduates

Kevin Gomez, (PhD, Spring 2020) is currently a Senior Research Engineer at Raytheon Missile Systems, Tucson, AZ.

Travis Harty (PhD, Fall 2020) is currently searching for opportunities in industry.

Zhuocheng Xiao (PhD, August 2020) is currently a Swartz Postdoctoral Fellow, Courant Institute of Mathematical Sciences, New York University.

Kenneth Yamamoto (PhD, August 2020) is currently an NSF-RTG Postdoctoral Visiting Professor, Department of Mathematics, Southern Methodist University (SMU), Dallas, TX.

John McKinnon (MS, May 2020) is currently a graduate student in the Atmospheric Sciences PhD program, University of AZ.

Kathryn Stefanko (MS, May 2020) is currently an Educator at Numerade.

Jessica Zanetell (MS, May 2020) is currently faculty at North Yarmouth Academy, Maine.

News from Alumni

Amir, Orna (PhD 1999) Five years ago I started working at Google in Israel where I have lived since graduation. Initially I led the Data Science and Product Analytics group at Waze which grew over the years from 12 to 20+ people. It was exciting managing at this larger scale and also solving problems with data and algorithms that improved the Waze App, an app I loved using on my commute and travels. After 3 years of mostly managing though I missed working more hands on and developing models and algorithms. In those years there were so many advancements in the area of Machine Learning that I felt could really help improve the product so I started a new smaller Machine Learning team working on improving Waze's estimated time of arrival (ETA) algorithm as well as other interesting drive related ML features. Ultimately my team and I were able to improve the Waze ETA algorithm by a mix of simple algorithms and some sophisticated deep learning models, both of which were very satisfying.

Having spent that time learning Python and new modeling techniques and working mostly as an individual contributor I started missing having a substantial management role, which brought me to my latest position as a lead and Data Science manager in the Growth and Notifications Team at Google. The group is responsible for ensuring that Google sends high quality notifications to its users. It has been fascinating working with teams across Google's various apps to understand their needs in communicating with their users and working to improve notification quality for Google users.

I started my current role/adventure 2 months into the new reality of working from home, with all or part of my family working/learning from home, depending on the local restrictions. My two boys, Aviv and Gal who are in high school and junior high respectively are now doing hybrid learning, and my husband mostly works from his office. Besides my "day job" at Google I have also been able to spend some time mentoring women in and outside of Google to start careers or take on more challenging roles in Computer Science, Math and Data Science.

It has been a crazy year, and I really look forward to getting vaccinated and being able to travel again - hopefully sometime soon.

Beauregard, Matthew (PhD 2008) was recently appointed as the interim chair of the Department of Physics, Engineering and Astronomy at Stephen F. Austin State University.

Coombs, Daniel (PhD 2001) spent a lot of 2020 thinking about mathematical modelling applied to the covid-19 epidemic in Canada, and how to communicate projections from models effectively. This has included giving advice about modelling to the provincial and federal public health agencies, and the federal science advisor's office, as well as talking to a lot of journalists. It has been an interesting year but not one that I want to repeat. Cheers, Dan Coombs

Garcia Naranjo, Luis (PhD 2007) is now an associate professor at the Mathematics Department "Tullio Levi-Civita" at the University of Padua in Italy.

Glasgow, Scott (PhD 1993)

I hope each of you can click on the link below and see what we believe is one of my more important contributions to physics, namely a "time-resolved" analysis of scattering of a photon off of an electron—Compton Scattering. (If you read the abstract, intro and conclusion you should understand the main novel claims of this work.) All but two of my papers in the last 20 years have had some sort of support by the NSF, and this one and its logical predecessor in 2016 regard Quantum Electrodynamics (QED), what Feynman called "the crown jewel of physics," this because it is the only nontrivial physical theory in which its predictions are verified by experiment to no less than ten significant digits. In case you want to know more: https://link.aps.org/doi/10.1103/PhysRevA.102.062203

Like a lot of students of physics I was intimidated by Quantum Field Theory, QED arguably the beginning, this because the usual introductions to it seem to rely on a lot more than just a deep and thorough knowledge of Quantum Mechanics (my PhD thesis is effectively a treatise on QM), but rather on that plus some sort of almost religious acceptance of certain axiom-like propositions such as the Feynman rules, which, together with certain perturbation series with infinite coefficients arising from them, seemed (infinitely) unmotivated and hard to swallow. A German researcher Rainer Grobe from the University of Illinois with similar misgivings—his PhD thesis was on Quantum Chaos yet he couldn't get through the first chapter of any QFT canon—started a program of learning QFT by, first, "taking QED seriously", which meant trying to do the obvious thing for him (and for me and anyone else I can easily relate to), namely write down and solve the dynamical equations of motion for certain straightforward initial value problems related to it. In doing so he finally started to understand QFT and realized a lot of the paraphernalia associated with it is not only optional, but it some ways historically accidental and even misleading and obfuscating. Meanwhile Justin Peatross from BYU physics informed me a decade or so ago that there does not exist an unimpeachable classical theory describing how a charged particle interacts with its own field. ("Classical" here means non-quantum mechanical, whether or not relativistically correct.) This seemed ludicrous to me so I supposed that something closer to a "theory of everything" should work, even if it amounted to using too big a gun. QED seemed to be that bazooka, so I used funds for a "Special Year in Quantum Optics" in 2011 to invite several big names in that area to BYU to give relevant talks. In doing so I met (and became mesmerized with) Rainer Grobe, and ultimately co-authored a paper with him in 2012 (on the "Phi-4" QFT Model), along with BYU alumnus Sebastian Acosta. (Mesmerized: for example, Rainer gave a talk in the BYU physics auditorium--standing room only--in which he had the students and faculty laughing out loud most of the hour yet learning new things with most every sentence. I was the MC and he answered my final question before I could finish it, by belting out "42!". The audience erupted once more into laughter.)

Since then Rainer produced a paper in Physical Review Letters—the Inventiones Mathematicae of physics—drumming up interest in the above kind of obvious approach to QFT, namely to go ahead and try to solve obvious initial value problems, and our BYU group has followed that direction of trying to continue to take things seriously (or literally, if you like). In doing so we have not kept up with Rainer and his army of post-docs in volume, with their 7 to 10 papers a year, but in our last two publications we have taken things even more literally than we think he and his people were able, for example by discovering certain ways of computing finitely with massless particles (genuine photons) rather than with vanishingly small but still massive approximations to such. (Something like division by the mass of the particle arises in those dynamical theories.) Thus, we believe we're keeping up with a certain mandate that Henry Eyring seemed to hint at a few years ago, namely that of producing high quality if not also quantity of work.

By the way the classical problem of how to account for a charged particle interacting with its own field is, we believe, completely solvable now, albeit by taking into account lessons learned for the larger, enveloping theory of QED. Rainer has made progress there and about the only thing missing is how to do such with large numbers of such particles, ultimately then countenancing issues like those arising in various of the many-body problems.

Hardesty, Quintina (MS 2010) while at Raytheon, had 3 submissions for Raytheon Intellectual Property where one was selected as a trade secret and another for an innovation award. Since then, I have moved to Huntsville, AL to work as a Test Team Manager for SAIC. On the path to get my PE License in Industrial and Systems Engineering, I was recently certified as an Engineer-in-Training (EIT) in Texas and working on getting certified as an EIT in Alabama. I have been happily divorced for a year and have spent the time focusing on my boys, moving to Alabama and training to compete at the 2022 USA Weightlifting National Masters Championship in Salt Lake City, UT.

Hunke, Elizabeth (PhD 1994) This year, was an author on two papers that received "Top Downloaded Paper for 2018-2019" awards, from Journal of Geophysical Research: Atmospheres and Journal of Advances in Modeling Earth Systems, and the Los Alamos National Laboratory (LANL) Fellows awarded her their Prize for Leadership. In addition to leading the CICE Consortium and serving as LANL's program manager for the Department of Energy (DOE) Office of Science Biological and Environmental Research Division's portfolio in Earth and Environmental Systems Sciences, Elizabeth also took on a new role leading Earth System Model Development for DOE's Integrated Coastal Modeling project, whose goal is a robust, predictive understanding of coastal evolution that accounts for the complex, multiscale interactions among physical, biological, and human systems. Check out her article in SIAM News (Oct 2020) for more information about her sea ice modeling work: https://sinews.siam.org/Details-Page/the-challenges-and-opportunities-of-one-size-fits-all-sea-ice-models.

Johnson, William (PhD 1978) moved to the mountains about 20 miles from Los Alamos to be close to my son and his family. I continue to consult remotely for Sandia National Laboratories and do some technical work with friends. Here are 2 journal papers and one meeting that we have. There are others but I am no longer trying to keep track of all of them as I am reaching 70 shortly. 1) D. R. Wilton, J. Rivero, F. Vipiana, W. A. Johnson, "Evaluation of static Integrals on Triangular Domains", 10.1109/ACESS.2017.DOOI IEEE ACCESS

J. Rivero, F. Vipiana, D. R. Wilton, W. A. Johnson, "Evaluation of 6-D Reaction Integrals via Double Application of the Divergence Theorem", submitted for publication in IEEE Trans. on Antennas and Propagat. 2) J. Rivero, F. Vipiana, D. R. Wilton, and W. A. Johnson, Evaluation of MOM Reaction Integrals Applying the Divergence Theorem, URSI GASS, Rome, Italy August 29-September 5, 2020.

Kilen, Isak (PhD 2017) published a paper in PRL this year: Propagation Induced Dephasing in Semiconductor High-Harmonic Generation - PRL Vol 125, 2020.

Love, David (PhD 2013) has a new position at American Express as Manager, Chat Bot Development, New York City, NY.

Lyttle, David (PhD 2013) earlier this year started a job as a computational biologist, (doing research on the human gut microbiome, i.e. poop science, haha) for Finch Therapeutics in Boston, MA.

Mercado, Gema (PhD 1999) was the Secretary of Education in the local government of the state I lived, Zacatecas, Mexico from September 2016 to August 2020. Now, I'm taking a break until this following December to catch up with a bunch of family matters. In January I might go back to my academic job in the local University where I am a math Professor.

Rossi, Lou (PhD 1993) In August, completed a successful term at Chair of the Department of Mathematical Sciences at the University of Delaware. My plans to enjoy a sabbatical were thwarted again when I was named Dean of the Graduate School and Vice Provost for Graduate and Professional Education. I still find time to solve mathematical problems involving plankton and flow down tree bark. Last year, I enjoyed a brief visit with Michael Shelley (PhD 1985) where he is doing amazing work in computational biology at the Flatiron Institute in NYC. Tammy and I still have great memories of the Program in Applied Mathematics where we met. Our daughter just completed her degree in mathematics and computer science, and our son has chosen to similarly major in mathematics and computer science.

Soneson, Joshua (PhD 2005) Our son (with Subok Park, PhD 2004) is now 10 and doing well with distance learning. Subok is still working at FDA and I left FDA in favor of a job at Johns Hopkins University Applied Physics Laboratory as a "senior acoustics modeling engineer." I took a virtual walk through the UofA campus the other day using Google Streetview. I really miss Tucson and the open spaces of the American West. Hope to visit when the pandemic is over.

Stockbridge, Rebecca (PhD 2013) is now an Android developer at Detroit Labs. While I am no longer directly involved in mathematical research, the skills gained from the Program help me every day in this new field. I've even been able to do a little statistical consulting for my company, which I've really enjoyed.

Uribe, Guillermo (PhD 1993) after 28 years of full-time work and 36 years of total commitment to the University of Arizona, I retired on June 30, 2020. My last year was productive. I co-authored two papers on effectiveness of active learning techniques in STEM courses, one through the Math department and the other in collaboration with the College of Engineering. I taught three courses during the year, two of which ran during the fateful Spring 2020, in the middle of the pandemic. My experience in technology helped the staff develop strategies to support faculty and students adapt to online teaching and learning.

Washburn, Ammon (PhD 2018) will become a Vice President of the projections pillar of Corporate Treasury at Goldman Sachs, Salt Lake City, UT. I will be in charge of automating and validating our liquidity projections. In Goldman, there are only five titles: Analyst to Associate to VP to Managing Director to Partner. Just for context, around 20% or so of Goldman employees are VPs.

Williams, Katie (PhD 2016) was elected President of Women In Bio for the 2022 term (she will be President-Elect in 2021). Women In Bio (WIB) is a non-profit organization comprised of 13 active chapters in the United States and Canada along with over 2500 members. WIB aims to promote the professional advancement of women in STEM.

Alex Young (PhD 2017) and Katie Williams (PhD 2016)

Current Student Achievements

Abrams, Ruby (4th Year Student) participated in a remote summer internship at LANL XCP/EEP division attempting to answer the question "Why do earthquakes look like explosions?" and I passed my oral comprehensive exam! :)

Deeny, Sheldon (2nd Year Student) spent this past summer as an intern at Nevada National Security Site (or MSTS Inc, a contractor) based out of Las Vegas. I worked for the Signal Processing and Applied Math (SPAM) group under Dr's Marylesa Howard and Dan Champion (former UA math alum). This is the same organization that **Jessica Pillow (5th year student)** is working and doing her dissertation with.

Hyett, Criston (2nd Year Student) remotely attended a summer 2020 internship at LANL, CCS-2, mentor Daniel Livescu. Presented at APS Division of Fluid Dynamics "on-demand session", online, November 22-24, 2020 "Machine Learning Statistical Geometry of Turbulence".

Kravitz, Hannah (5th Year Student) was named the ARCS Foundation's Kathryn Johnston West Scholar for the 2020-2021 school year. This award consists of a scholarship from ARCS, a supplemental cash award and travel grant from the Graduate College, and an opportunity to represent the University of Arizona and present my research at an upcoming virtual poster presentation. I was also given an opportunity to present a virtual poster titled "Eigenvalue Problem for the Wave Equation with Applications to Random Network Lasers" at Los Alamos Arizona Days in May 2020.

Luca, Sarah (2nd Year Student) attended the Woods Hole Marine Biological Laboratory (MBL) virtual workshop on Brains, Minds and Machines August 10-21, 2020.

Luna, Kevin (5th Year Student) In January 2020, presented a conference paper titled "The Role of Fluctuating Dissipative Fluxes in the Receptivity of High-Speed Reacting Binary Mixtures to Kinetic Fluctuations" at the AIAA (American Institute of Aeronautics and Astronautics) 2020 SciTech Forum in Orlando, Fl. 2) In November, 2020 presented a poster titled "Accelerating GMRES with Deep Learning in Real-Time" at SC20 (The International Conference for High Performance Computing, Networking, Storage, and Analysis; Also known as Supercomputing) that was held virtually this year. This poster was a "Best Research Poster" nominee meaning that it was in the top 4 out of 71 accepted posters. I also gave a corresponding talk at a session for best poster finalists. 3) In January, 2020 was a funded participant of the 2020 Winter Workshop on Optimization, Differential Equations, and Data Analysis held at UC San Diego. 4) Over the summer and Fall 2020, I interned at the National Energy Research Scientific Computing Center (NERSC) at Lawrence Berkeley National Laboratory. I worked on developing and implementing a methodology to accelerate PDE-based simulations with deep learning in real-time. 5) In April 2020, was awarded a Department of Defense (DOD) Science, Mathematics, And Research For Transformation Defense Scholarship Program award which will fund me for two years and provide guaranteed employment placement at a DoD lab.

McLaren, Sam (5th Year Student) in January 2020, published an article titled Microscopic modeling of transverse modeling of transverse mode instabilities in mode-locked vertical external-cavity surface-emitting lasers in the Applied Physics Letters journal. In February, 2020 attended the 2020 Photonics West LASE conference at the Moscone center in San Francisco, CA., and presented during the Vertical External-Cavity Surface-Emitting Lasers (VECSELs) X subconference. My talk, Microscopic modeling of transverse non-equilibrium dynamics in mode-locked VECSELs, was published in the conference proceedings.

Puente, Patricia (2nd Year Student) has been working in collaboration with Dr. Laura E Condon from the Hydrology and Atmospheric Sciences Department to present the work titled Identifying Patterns in Long Term Streamflow Variability and Predictability in the Upper Colorado River Basin using a Nonlinear Dynamics Approach. I presented this work in an eLightning poster session titled Uncertainty Analysis in Hydrology and Water Quality at the American Geophysical Union (AGU) Fall Meeting on December 14, 2020. Although no travel was necessary, I was funded by Dr. Condon to cover the conference registration and AGU membership fees.

Toner, Brian (2nd Year Student) Over the Summer of 2020, interned remotely for the US Food and Drug Administration (FDA) in the Division of Imaging, Diagnostics, and Software Reliability (DIDSR). I explored how Deep Convolutional Neural Networks could be used in classification tasks to reduce the amount of recalls for mammogram screenings. Will be presenting a poster on the research in February, 2021 at the SPIE Medical Imaging Conference (most likely virtual, but still possibly in San Diego) titled "Classification of round lesions in dual-energy FFDM using a convolutional neural network. Simulation study."

Woodward, Michael (3rd Year Student) In January, 2020 gave a poster presentation titled "Hypersonic Boundary Layer Flows, Transition prediction, and Reduced Order Models" at the 3rd annual Physics Informed Machine Learning conference in Sante Fe NM. In November, 2020 presented a talk titled "Machine Learning of Reduced Lagrangian Models for Turbulence" at the APS-DFD (American Physical Society - Division of Fluid Dynamics), and in December, 2020 published an AIAA (American Institute of Aeronautics and Astronautics) conference paper titled "Direct Numerical Simulations of Laminar-Turbulent Transition for Transonic Boundary Layers". Was also awarded the Physics Informed Machine Learning conference student travel grant supporting my attendance and travel to Sante Fe, NM. Over the summer 2020, interned at Los Alamos National Labs in the Computer, Computational and Statistical Sciences Division where we worked on developing machine learning algorithms of reduced Lagrangian models for Turbulence.

Incoming Class Fall 2020

Program in Applied Mathematics, University of Arizona

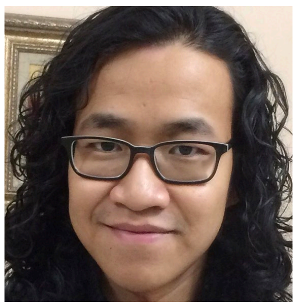
Nick Bagley
Cornell University

Alyssa Burritt
University of Cincinnati

Jalen Cates
University of Alabama, Tuscaloosa

Eonho Chang
UC Santa Cruz

Alex Christensen
University of Arizona



Bao Do
Columbus State University, GA

Robert Ferrando
City University of New York

Dunia Fernandez
Montclair State University

Addie Harrison
Wake Forest University

Fiona McCann
University of Massachusetts, Amherst

Matthew McCaskey
Appalachian State University

Erica Papke
Mercer University, Macon, GA

Marta Sowinski
CUNY - Hunter College

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