Newsletter of the **Department of Mathematical Sciences** @ University of Delaware

RECKONINGS

SUMMER **2022**

Inside

UNIVERSITY OF DELAWARE

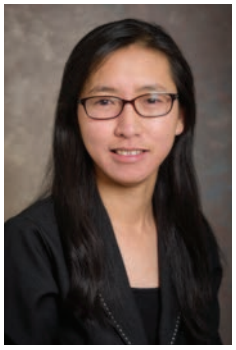
Message from the Chair

MARK GOCKENBACH

Greetings from the UD's Department of Mathematical Sciences! I hope that this latest edition of our newsletter finds you in good health and spirits.

Here are some highlights of the past year:

We welcomed two new faculty in Fall 2022: **Assistant Professor Novi Bong** (PhD 2017 from the University of Newcastle in Australia) and **Assistant Professor Audrey Dietz** (PhD 2018 from Clemson University). We are currently searching for faculty in Actuarial Science, Data Science, Discrete Mathematics, Mathematics Education, and foundational instruction.



Novi Bong

The department continues to do cutting edge research in the mathematical sciences. Over the past year, our faculty have published more than 100 research papers and two books, and landed more than $1.5 million in new grant funding.

Audrey Dietz

We are expanding opportunities for our students: We participate in UD's new interdisciplinary PhD in Quantum Science and Engineering (see the article in this newsletter), some of our graduate students are earning dual degrees in Data Science (MS) and Mathematics or Applied Mathematics (PhD), and we are in the process of creating a new bachelor's degree in Mathematics and Data Science.

Speaking of students, last year we graduated 67 students with bachelor's degrees, nine with master's degrees, and eight with the PhD. Five of our PhD graduates went on to research postdocs, two to faculty positions, and one to a position at an investment firm.

For more information about our activities, please read on. You will find details about recent student activities, career reports from some recent graduates, news of recent grants, and more. I especially recommend the article from **Pam Cook**, who is retiring after a distinguished career at the University of Delaware.

Thank you for your interest in UD's Department of Mathematical Sciences. If you are inclined to support us with your charitable giving, your contribution will be used to advance mathematics through original research and innovative teaching, and above all to encourage UD students in their mathematical studies. I wish you all the best in the coming year.

Mark S. Gockenbach
Professor and Chair

FACULTY RESEARCH

Highly efficient, accurate and robust computational methods for nonlinear kinetics and fluid models

Professor Jingmei Qiu was awarded an NSF grant to support her research on Eulerian-Lagrangian Runge-Kutta discontinuous Galerkin Methods for Nonlinear Kinetics and Fluid Models.

In her research she studies a class of Eulerian-Lagrangian (EL) discontinuous Galerkin (DG) approach for linear and nonlinear transport dominant PDE models. The EL DG method is a generalization of the semi-Lagrangian (SL) DG method for linear advection problems, base on the design of a localized adjoint problem for the test function that approximately tracks characteristics. Such feature allows flexibility, especially for high dimensional and nonlinear problems, where characteristics are difficult to track. The errors occurred in approximating characteristics will be integrated in time by Runge-Kutta methods via the method-of-lines approach. Thus the fully discrete EL DG scheme will be termed ``EL RK DG". Inherit from the SL framework, when the characteristics are approximated well, the very restrictive CFL constraint in the RK DG framework can be greatly relieved, leading to significant CPU savings. The proposed EL RK DG method can be viewed as a general framework, in which both the classical Eulerian RK DG formulation and the SL DG formulation can fit in. Thus, existing research on positivity preserving limiters, well-balanced treatments, asymptotic preserving properties, theoretical analysis on L^2 and entropy stability, error estimates on Eulerian RK DG methods can be explored and generalized to the EL RK DG framework. A key assumption and one of the main challenges, motivated from CPU savings, is the large time stepping size with nonlinear stability. Finally, EL DG algorithm has a full potential to be generalized to a moving mesh reference frame for tracking material interfaces and moving boundaries.

Successful development of EL DG methodology will have a broad impact for CFD-related applications. To the best of our knowledge, characteristic based DG methods with large time stepping sizes are still underdeveloped for kinetic and fluid applications. Theoretical foundations are yet to be established for quantifying the time stepping sizes allowed for stability. The proposed work will establish close connections on existing state-of-art computational tools and theoretical analysis on Eulerian RK DG methods and SL DG methods. There is great potential in further methodology development to the moving mesh frame and application to moving boundaries/interfaces problems. Further impact comes from the education, students training, publications, participation and organization of workshops and mini-symposium sections in conferences.

Fundamental Limits in Ambiguous Communication

The grant with the above title was awarded to **Prof. Ivan Todorov** by the National Science Foundation through its Communication and Information Foundations program. The research will be carried out in the period 2021–2024. The proposal lays down the foundations of *quantum* and *state-dependent* communication in the presence of ambiguity, identifying *fundamental communication limits* and establishing computable bounds. Based on the quantisation paradigm in physical sciences, it uses the interplay between classical and quantum information to make advances that can be broadly described as follows:

classical information sources/channels	⇝	quantum information sources/channels
memoryless sources/channels	⇝	state-dependent sources/channels
multiple, independent resource use	⇝	time-dependent compound resource use.

The proposal identifies the optimal *compression rate* of a classical information source with memory, equipped with a confusability relation, and formulates a global viewpoint on *zero-error capacities* of information channels that allows to view the Shannon's zero-error capacity of a memoryless channel as a one-shot parameter. It characterises the compression rate of a quantum memoryless source with a distinguished quantum confusability relation, and the *probabilistic zero-error capacity* of a quantum channel. Finally, it formulates a broad context to study *parallel repetition* of two prover (non-local) games,which leads to the new concept of a *non-local game with memory*, and identifies its optimal winning rate in an intrinsic manner, lifting the classical Kolmogorov-Sinai theorem to the realm of quantum information theory.

As quantum technologies are entering the stage of physical implementation, the proposed research will contribute to the better understanding of their power and limitations, establishing concrete links among information and quantum information theory, graph theory, ergodic theory, non-commutative combinatorics, semi-definite optimisation and functional analysis. It will develop a continuous model for non-local games, after a continuing evidence for the importance of their classical discrete versions in important problems both within theoretical physics and operator theory.

FACULTY REMINISCENCE

My Years at UD

PAMELA COOK

I arrived at UD in the summer of 1983 on a very hot and dusty day. Back then the campus was fairly rustic—the beautiful brick walkways came later. I wondered what I had done leaving a tenured position at UCLA for the job at UD (a dual-career move). On arriving in the department, I went to look for some of the applied mathematicians I had interviewed with, but others were now in their offices. Finally, frustrated, I went to the department secretary and asked where is x? The response was: "Oh, all the applied mathematicians have moved over to Rees Hall". This was not a welcome sign for me, an applied mathematician with an assigned office in Ewing Hall. Also isolating, I was the only woman among the tenured/tenure-track department faculty.

Over time things changed immensely. When David Roselle became president in 1990, he undertook a "campus beautification" project. These improvements, plus a focus on research, resulted in major changes to the campus. I became department chair a year after Dr. Roselle arrived (the first female chair of a natural science department at UD), and stepped down nine years (and three deans) later to become College of Arts and Sciences associate dean for research and planning and, soon after, the College of Engineering associate dean for faculty. I was later honored to be named a Unidel Professor of Applied Mathematics. While working in administration, my research and service remained within the department.

During the '90s the department made significant strides in resources, focus, and size. Working with the dean, we were able to parlay our one Unidel named professorship into three Unidel professorships. With the input of the president and the dean at the time, the Math Preparatory Center, an independent unit reporting directly to the dean, was absorbed into the department.

The department continued to focus attention on applied mathematics—hiring a faculty member in industrial applied mathematics. Another focus, on secondary mathematics education, was bolstered by hiring a faculty member in that area. To support faculty hires in each of those areas whose portfolios might differ slightly from those of conventional mathematical faculty, addenda were created to the P&T documents. And, the department obtained a position for an Information Technology expert to handle our computers (which were obtained through infrastructure grants of admirable faculty members). The department was able to consolidate into one building, Ewing Hall, as those who had shared it with us (Anthropology and History) moved to other locations. This extra space, plus funding from SUN Microsystems and from the State of Delaware allowed us to envision and create our computer classrooms (Ewing 207, 209). The department also reached out to other university entities to create a new joint undergraduate major (BS in MathEcon) a predecessor of other departmental joint degrees such as the BS in Quantitative Biology, and the new Data Science degrees, among others.

My mathematics research, which had focused on transonic aerodynamics pre-UD, turned to investigating the mathematics of complex (viscoelastic) fluids. I received a secondary appointment in the UD Department of Chemical Engineering and carried out several research projects jointly with faculty from that department as well as from the Department of Mathematical Sciences. I benefited from overseeing the research of a number of UD applied mathematics PhD students, and working with the graduate students in the department on several initiatives (the graduate student/Hallenbeck seminar, local AWM chapter, local SIAM chapter) and in mentoring students to their PhD and beyond.

Over the years, in addition to NSF research grants, I initiated and was principal investigator on a multi-million-dollar NSF ADVANCE IT (Institutional Transformation) grant. This grant, being for Institutional Transformation, focused on improving the climate for all faculty at UD. This work allowed me to continue to mentor and advocate for faculty. The resulting UD ADVANCE Institute continues now after the grant through support from the provost's office. The Institute faculty work with other university faculty to develop and deliver workshops and support mechanisms for recruiting and for retaining an excellent and diverse faculty.

Working with the UD faculty, the department, the College of Arts and Sciences and the College of Engineering, and with the UD administration have been fulfilling challenges. I am indebted to the many faculty who I have worked for or with here at UD—you all made the challenges doable and even, in most cases, fun to solve. And, my thanks to the many graduate students and undergraduate students who have studied here at UD, who have enriched our department, and who have left their legacy.

Dr. Pam Cook Awarded a University of Delaware Medal of Distinction

MICHELLE CIRILLO

On May 10, 2022, Department of Mathematical Sciences' **Professor L. Pamela Cook's** professional contributions were recognized with a University of Delaware Medal of Distinction at a UD ADVANCE and Women's Caucus event. According to Professor Debra Hess Norris, Chair of the Honorary Degrees and Awards Committee of the Board of Trustees, "The Medal of Distinction is awarded to a person who has made humanitarian, cultural, intellectual, or scientific contributions to society, or achieved noteworthy success in his/her chosen profession, or given significant service to the University, community, State, or region."

Prior to presenting the medal, Dr. Norris cited Professor Cook's many contributions during her 40-year career at UD. Dr. Cook served as the Chair of the Department of Mathematical Sciences from 1992–2000, and she served as an Associate Dean of Engineering from 2003–2019. Professor Cook's continuous work as the Principal Investigator of two NSF ADVANCE grants, totaling over $3.5M, focused on recruiting and retaining an increasingly diverse pool of talented faculty to UD and has been transformative to the University of Delaware.

Associate Professor Michelle Cirillo, and Professor and Dean John A. Pelesko congratulate Pam on her award.

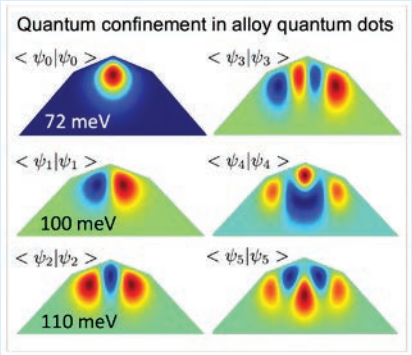
Additionally, Dr. Cook is not only a Unidel Professor of Mathematics but has also held a secondary appointment as Professor of Chemical Engineering. She has been recognized in numerous ways for her work as a mathematician by the Society of Industrial and Applied Mathematics (SIAM) such as: serving as Editor-in-Chief of the *SIAM Journal of Applied Mathematics* (2002–2008), achieving the honor of SIAM Fellow in 2009, and serving as the elected secretary of the SIAM organization for three terms, as Vice President for Publications (2012–2014), and as elected SIAM President in 2015–2016. Professor Cook was also selected as the 2018 SIAM Julian Cole lecturer. The Julian Cole Lectureship is awarded every four years to an individual who has made an outstanding contribution to the mathematical characterization and solution of a challenging problem in the physical or biological sciences, or in engineering, or for the development of mathematical methods for the solution of such problems. Among her many other accolades, Dr. Cook was also recognized as a fellow of the American Association for the Advancement of Science (AAAS) in 2012. Congratulations to Pam for receiving the Medal of Distinction and for her long and illustrious career.

Beth Brand places the Medal of Distinction on Pam Cook, while Debra H. Norris looks on.

Mathematical Sciences Contribute to a Vibrant Interdisciplinary Program

IVAN TODOROV AND PETR PLECHAC

A new graduate degree program Quantum Science and Engineering (QSE) welcomed the first cohort of graduate students at the University of Delaware in the academic year 2022–23. The program is a combined effort of several departments within the College of Science and College of Engineering at UD. The Department of Mathematical Science participated in the creation of the program from the inception of its idea. The program aims to deliver a high profile education and research in the fast developing field of quantum computing, information, algorithms, theory and nanotechnology for quantum engineering. The QSE program is cross-disciplinary, and the Department of Mathematical Sciences is part of its theoretical strand, providing expertise in the fields of quantum information and computing, functional analysis, quantum algorithms and probability theory.



Quantum science and engineering (QSE) is a discipline focused on understanding and exploiting the unusual behavior of particles and excitations governed by the laws of quantum mechanics. The QSE program at UD has two major components. First, we facilitate interactions and collaboration among the UD faculty working on all aspects of QSE. Second, we train a new generation of scientists and engineers with the skills and knowledge required for the "quantum workforce" that will carry this field into the future. Students follow one of three tracks:

The Quantum Nanotechnology Track will train students for experimental work on the materials, physics and devices used to create the hardware thenables quantum technologies.

The Quantum Theory Track will train students for theoretical work that requires detailed knowledge of quantum hardware, such as designing or simulating the electrical and optical pulses that implement logic operations.

The Quantum Algorithms and Computation Track will train students to develop algorithms and computing architectures that implement and take advantage of quantum software.

We invite you to explore both our research and educational programs at **qse.udel.edu**.

DEPARTMENT LIFE ACTIVITIES • FACULTY

Winter Research Symposium

PAK-WING FOK

This year, the annual Winter Research Symposium (WRS) took place on February 25th, 2022, in the Trabant Multipurpose Rooms. The WRS is one of the most important research events for the Department of Mathematical Sciences, showcasing the outstanding work of our graduate students.

Senior students **Boyang Xu**, **Avishek Mukherjee**, **Teddy Mishura, Dheer Noal Desai**, and **Dongbin Li** gave presentations about their dissertation research. The talks covered a diverse range of topics in mathematics, from simulating wave propagation to spectral graph theory. **Daniel Hayes** was the winner of the Wenbo Li Scholarship Prize. Based on his prize-winning paper, he gave a talk about his work with **Professor Bacuta**, "Saddle Point Reformulation of Mixed Variational Problems".

The keynote speaker was **Rayanne Luke** from Johns Hopkins University and the National Institute of Standards and Technology (NIST). Dr. Luke graduated from the Department in 2021 under the advisement of **Professor Braun**. Her talk "Improving SARS-CoV-2 diagnostic testing accuracy by moving to higher dimensional probability models" discussed ways to improve the accuracy of COVID tests, which is clearly an important topic in these times.

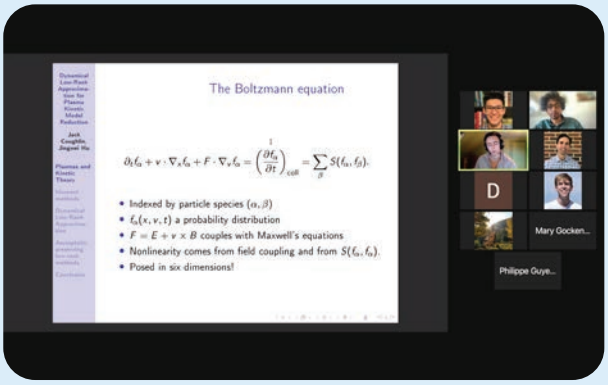
Finally, the posters session at the WRS provides a focal point for students to socialize and discuss mathematical ideas over food and drinks. This year, **Joseph Nakao**, **Katherine Funk**, **Li-An Chen** and **Jerome Troy** all presented posters, with the best posters receiving awards. Traditionally, postdoctoral researchers have decided the winner and this year, **Drs. Benjamin Civiletti** and **Nikolas Schonsheck** awarded the poster prize to Joseph and Jerome.

Congratulations to all our graduate students for making the WRS a success! We are especially grateful also to Pam Irwin and the College of Arts and Sciences for helping to plan and organize the event.

UD Student SIAM Chapter

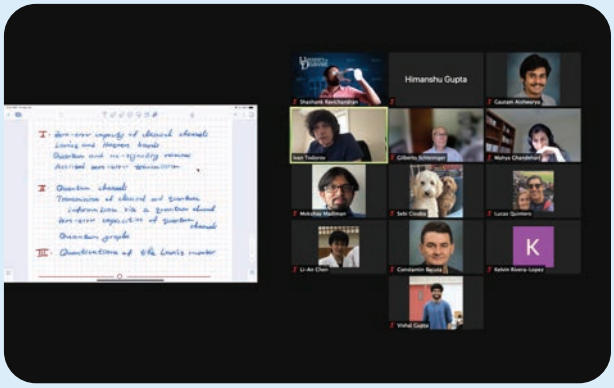
SHASHANK RAVICHANDRAN

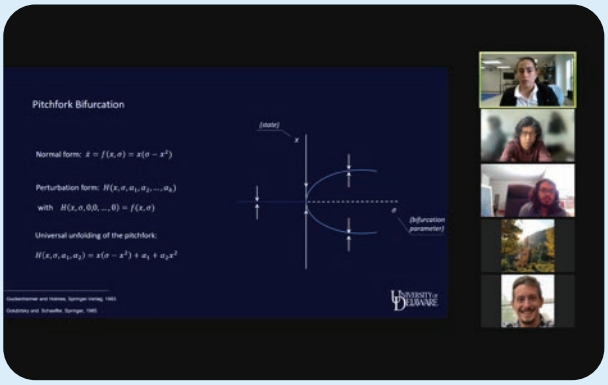
The student chapter of the Society for Industrial and Applied Mathematics (SIAM) at UD, has kept pace with the events of years past even through the pandemic and its reopenings. From luncheons, and seminars, to apple picking, we are happy to say that students from our department and SIAM members from across the university, were able to enjoy talks by students, and faculty, and take a break from their schedules over socials.



We hosted a couple of seminars through the SIAM Seminar series, covering a range of interests in mathematics and engineering. Like Abhishek Khetan's talk on Cheeger Inequalities for Graph Limits, Kleio Baxevani's talk on Multi-Behaviour planar systems, and Jack Coughlin's talk on Dynamic Low rank approximations for Plasma Kinetic Model reduction. All graduate students from TIFR Bombay, Dept. of Mechanical Eng. at UD, and U. Washington, Seattle, respectively. The main aim of these seminars was to have students and postdocs from other departments talk about their work, and hopefully form collaborations and a network amongst students of our own in the process.

We also had our wonderful semester-ly SIAM Special Topics lecture series online. These lectures aim to serve as introductions to topics that are of interest to graduate students but are not usually covered in regular coursework. Prof. Ivan Todorov spoke on Quantum Information Theory, covering topics such as the zero error capacity of classical channels, and quantization of the Lovasz number, in the spring, and in the fall, Prof. Mahya Ghandehari spoke on Graph Limit Theory. Covering topics such as graphons, graph homomorphisms, and random graphs, and introducing us to many famous limit theorems and results for graphs and other discrete structures.





Finally, we were relieved to get some fresh air after a year of hosting socials online. We hosted a General Members Meeting for SIAM members, outside of Ewing Hall, with plenty of pizzas, laughs and leftovers. We were also able to reignite our tradition of apple picking with a trip to Milburn Orchards, and provide for bags of fresh apples to share and tasty apple cider donuts. We thank SIAM and the department for supporting us through these ventures; to bring scholarly and social events to the graduate students of our department and SIAM members at large. Also, we thank the students and faculty for their participation and enthusiasm and hope to keep organizing such events for you in the future!

Hallenbeck Graduate Student Seminar, Spring 2022

MARY TARANCHUK

Once a week, graduate students gather to eat pizza and listen to a talk from their peers at what is affectionately known around the department as HGSS. With the naturally acquired motto "come for the pizza, stay for the fun!" the seminar provides a friendly, informal environment for talks related to research, internships/summer schools, and candidacy papers, as well as panels on various topics including studying for preliminary exams, teaching and much more. The nature of the seminar is guided primarily by the principle that it be "by and for the graduate students of the math department."

For many students, one of the first talks they give after joining the math department is at HGSS when they practice presenting the research paper that will be the focus of their public talk during their candidacy exam. It's a great chance to practice slide transitions, catch any typos, prepare for questions, and most of all, receive encouragement and support!

This isn't the only type of talk, however. This year, a student presented a talk based on thesis work, which he hopes to use in future job interviews. Another student prepared a talk related to his research work, but this time focused on introducing first year graduate students to the topic. While both talks covered the student's chosen research area, the intended audience and scope of the presentation varied drastically. HGSS provides an avenue where the nature of both talks is appreciated, and this benefits both the speaker and the audience. It is a good exercise for the speaker to tailor their presentations to a specific audience, and it provides inspiration and examples for other students to follow. Finally, in one of our most recent seminars, a student who presented in the fall semester came back with a follow up talk, based on a question received during the first talk. These examples showcase the true spirit of the seminar–providing a format for community learning and support.

The seminar is named for former professor **Dr. David Hallenbeck**, a longtime member of the UD math department who retired in 2003, and later passed away in 2007. He worked in the field of complex analysis and was active in the department, serving as both director of undergraduate studies and department chair at different times. He was known for being efficient and well prepared, and had numerous hobbies including running, chess, and bird watching. Please read this tribute to him published in a previous UD math department newsletter on page 7. We are grateful for the support we receive through the David Hallenbeck Fund, and admire his many accomplishments.

By **Mary Gockenbach**, Co-organizer of HGSS 2021–2022, along with **Himanshu Gupta**

Summer Research in GEMS

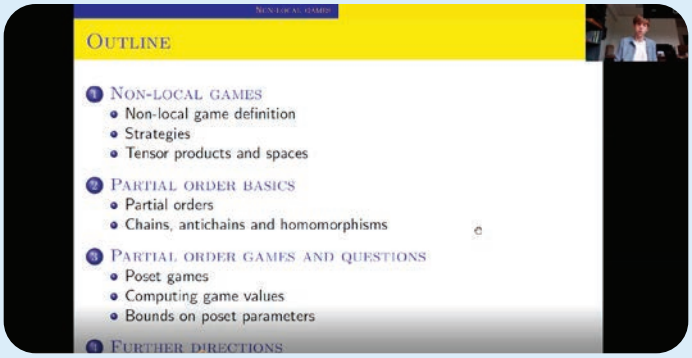
GAGE HOEFER

Over the summer of 2021, thanks to the generous support of the mathematics department here at UD, I was able to participate in the GEMS (Groups Exploring Mathematical Sciences) program for a summer research project. Under the direction of my advisor, **Dr. Ivan Todorov**, I used known methods of analysis from non-local game theory for a homomorphism game played on partially ordered sets (or posets, for short). Additionally, my mentee **Evan Liszewski** and I attempted to compute the value of a homomorphism game between posets of small enough size, when using only a subclass of game strategies known as "local". Our projects lay at the intersection of many different areas of mathematics, including functional analysis, quantum information theory, and graph theory.

During those three months, I spent a large amount of time reading, discussing, re-reading, and trying (repeatedly) to strike upon a good idea or getting the technicalities of a proof in place. The process of background research is inherent to any new mathematical endeavor, and this project was no exception; this was, however, the first time that I felt the full effect of just how much reading and thought that might entail. Additionally, Evan and I spent our time working on code which would produce real outputs to supplement the larger picture we were trying to consider. There were technical limitations on the computational side we had to overcome, and with some clever ideas and hard work we were able to make some progress on that front. The initial results we obtained were promising, and our observations suggested a potential generalization to a wider class of non-local games than what we focused on.

While the majority of my time was spent working either alone or in collaboration with my mentee, participants in the program also had the opportunity to connect with others.

Every graduate student in the program was required to give an hour-long talk about their summer research, detailing the set up for each problem and the results they might have obtained. I had only ever presented research in a talk with a group of collaborators before, and so the prospect of presenting solo was both anxiety-producing and exciting. Luckily for everyone in the program, we could not have asked for a better and more receptive audience. It was great to have that experience, and to see what interesting projects our colleagues were focused on.



In short, I found the GEMS program to be a very positive experience, and I am lucky to have been able to participate. Being able to see how research in mathematics is done was invaluable, and has continued to shape the course of my time here as a graduate student. Specifically, it helped solidify my choice for what branch of math to pursue going forward, and provided a concrete example of how real progress often means learning from repeated failure and struggle. I would like to thank the department for their support, my advisor for their tireless guidance and help, and my friends and fellow students for making the program so enjoyable (and for answering so many of my pestering questions). I highly recommend anyone who is interested in mathematics research to give it a chance; I hope you would like what you find.

Internship Network in Mathematical Sciences Program

JEROME TROY

Throughout my graduate career, I never considered the professor route in mathematics; for me, my future after graduate school was always in the STEM industry. I knew this would mean looking for jobs before graduating, but I did not know how or where to look. Through the Internship Network in Mathematical Sciences (INMAS) program, I got experience applying for jobs outside of academia and learned the answers to questions about the process I had never thought to ask.

INMAS is a program that prepares graduate students in mathematics with the skills required to land an internship in an industry field related to the mathematical sciences. During the academic year, the program consists of monthly workshops. These workshops allow students to learn necessary skills and augment the knowledge they acquired in graduate school to prepare them for the world of industry. The skills taught in these workshops include "hard" skills like various programming languages, tools, and techniques; and "soft" skills such as resume preparation, interviewing skills, and how to sell oneself. The program culminates near the end of the academic year when students can apply to a pool of internships from various companies INMAS has contacted. The companies range in topics and applications, from biomedical sciences to finance to cryptography. These internships take place during the summer and allow students to get hands-on industry experience.

I joined the INMAS program in my 4th year of graduate school at UD after my advisor, Dr. Petr Plechac, recommended it. First, four hard-skills workshops focused on implementing and using various tools in the Python programming language. The last of these workshops was a group project in which teams of participants would examine a contemporary problem using machine learning, which took place over a long weekend. My group's project analyzed data from the stock market and COVID-19 during the 2020 fiscal year. Our job was to understand the relationship between these and build a mathematical model for the interaction.

This project pushed our group to the limit in terms of mathematical difficulty. It challenged us to use our academic experience to give us an edge in a mock-industry setting. My group was not directly provided any data like in many academic projects. Instead, we needed to determine what aspects of the stock market and COVID we would examine and which sources we would use to collect our data. Initially, we thought about using news headlines regarding COVID but later decided only to use caseload values. Similarly, we decided to use the S&P 500 index as a marker for the health and performance of the stock market. At the end of the workshop, each group gave a short presentation on our findings. The idea was to present as we would to a boss in a company setting. Specifically, this meant dialing back the technical speak and focusing on the "so-what." In my group's case, this came down to answering the question—did the stock market eventually "learn" the behavior of COVID, and begin to move to counteract its effects.

The soft-skills workshops were tremendously helpful since those skills are not typically part of higher education curriculums. During one of the workshops, we learned how to present mathematical ideas in ways that someone without the same mathematical expertise could easily understand. The workshop leaders told us that our boss would likely be from a business background. As a result, terms like "Fourier Transform" and "Differential Equations" would not be the most effective way to convey our ideas. So rather than talk about *how* we did the computations, we focused on the so *what* and the *why* of the conclusions. "What does

this mean for the audience?" was a common question after our presentations.

The final soft-skills workshop was a mock interview. For my interview, I talked about my work with finite-element-based simulations of mechanical fracture and machine learning. I framed the information in a way that would be useful to an employer without mathematical expertise. Afterward, we received feedback to help us improve. During the final workshop, we also conveyed our preferences for an internship.

After this, INMAS began providing us with shortcut applications to various internships. Each student would apply by describing why they thought they would be a good fit and rank the internships in order of preference. The companies offering internships would then contact students and conduct interviews. This process was very hectic and exciting. Over three weeks, I had done six interviews and was deciding between a few internship offers. Next, I needed to decide—was I more interested in writing software for a government agency or developing machine learning methods in medical imaging?

I decided to go the medical imaging route and am now working on developing methods to analyze pre-clinical drug trials through InVivo Analytics. The INMAS program did a fantastic job preparing me to work on an industry problem and has helped me better communicate my ideas and results with industry professionals. I highly recommend this program to anyone considering a career outside of academia. During graduate school, we often become so specialized it can be hard to see how the tools we use would be useful in other areas. INMAS showed me how to use the skills I have acquired in studying mathematical models of material science to solve problems in medical drug trials. It also helped me learn to better communicate with people outside of mathematics, collaborate, and solve incredibly complex problems.

Secondary Mathematics Education Senior Wins Top University Student Teaching Aware

MICHELLE CIRILLO

Prior to her senior year as a secondary mathematics education major at the University of Delaware, if you asked **Megan Reeves** why she wanted to teach, Megan would have told you about one or two of the great teachers that she had when she was in school. However, by the end of her senior year, after completing a teacher preparation program and student teaching, Megan was not only ready to embark on her new career as a high school mathematics teacher, but she also developed new answers to the question, "Why do you want to be a math teacher?"

To this question, Megan might now tell you stories about the wonderful students she had the pleasure to teach this past year. She'd tell you that she wants to interact with a room of 30 students and show them why she loves math. Megan might also say that she enjoys waking up each morning, seeing the tired faces of her teenaged students, and greeting them each day. When her students asked her why she wants to teach high school math, she told them that she wants to get to know all of the Toshas, the Kennys, the Emmas, and the Darnells that she might have the opportunity to teach in any given year, and that she wants to teach for them. After telling a story about a student who asked if she planned to name one of her future children after him, Megan wrote in her journal, "It's also the moments that don't involve math when you are just being a human connecting to the other humans in the room where you develop understanding, respect, and compassion. Those are the reasons that I want to be a teacher." This passion and enthusiasm for teaching earned Megan a special university-wide award.

In spring, 2022, Megan Reeves, a Department of Mathematical Sciences program graduate from Margate City, NJ, received the 2022 Delaware Association of School Administrators Award (DASA). The DASA award is presented to a graduating senior in a teacher education program who has demonstrated outstanding qualities of scholarship, leadership, and character and who exhibits promise in making a meaningful contribution to the teaching profession. Reeves was chosen from the more than 1,400 students currently enrolled in the various undergraduate teacher education programs offered at UD within the colleges of Agriculture and Natural Resources; Arts and Sciences; Health Sciences; Business and Economics; Earth, Ocean, and Environment; and Education and Human Development.

Megan was nominated for the DASA award by program faculty who documented the many ways in which she exemplifies the qualities for the award. In the nomination letter, Megan was described as a smart, responsible, friendly, thoughtful, proactive, and positive person. As noted in the nomination letter, Megan is already a reflective practitioner who, "demonstrates a commitment to equity by working hard to engage *all* students in her classes, and she appropriately uses humor to develop connections with her students."

Megan graduated with an Honors Bachelor of Science degree in Secondary Math Education with a minor in Statistics. While maintaining a near-perfect GPA, Megan also engaged in extracurricular activities and took on various leadership roles, including working as a peer tutor in UD's Mathematical Sciences Learning Laboratory and serving as Academics Chairwoman and Education Vice-President for her sorority. In the 2022-2023 academic year, Megan will begin the University of Pennsylvania's Master's Degree Program in Teaching as part of the Independent School Teaching Residency, which she will engage with in St. Louis, MO.

STUDENT CORNER • PHD ALUMNI

SAMUEL COGAR

I first visited the University of Delaware in March 2015, arriving on campus after a several-hour drive from my home state of West Virginia. Despite the long trip, I immediately felt comfortable there. A few short months later, Ewing Hall became my academic home for what would be a fantastic few years of learning, laughing, and laying a strong foundation for the rest of my research career.

From the day I began college, I have had a strong interest in contributing to national defense, which led me to successfully apply for a National Defense Science and Engineering Graduate Fellowship with the help of **Prof. David Colton** and **Prof. Peter Monk**. Representative of the capable and caring faculty at UD, they have served as my advisors, mentors, and friends ever since. They taught me about far more than scattering theory and Sobolev spaces; with their guidance, I learned how to be a mathematician.

It was bittersweet to complete my PhD in 2019, knowing that I would be leaving Newark for the next phase of my career. It had become my home, where I made lifelong friends and transformed as an academic. It was also where I had found joy in giving back to the department that had been such a monumental part of my education. I had organized the Hallenbeck Graduate Student Seminar, held multiple positions in the SIAM Chapter, volunteered with other graduate students at the Delaware Science Olympiad, and—most importantly—learned to play surprisingly well in the department bocce tournament. All of that led to my first step beyond graduate school, and—with many thanks to the UD Department of Mathematical Sciences and the friends I made along the way—it was a confident step.

My first position was as a Hill Assistant Professor in the Department of Mathematics at Rutgers University, New Brunswick. It may have only been ninety minutes north of Newark, but I had entered a different world, where I was no longer the graduate student in the room. I had research of my own to direct, and I was responsible for students and teaching assistants. Fortunately, my mentors at Rutgers—Prof. Michael Vogelius and Prof. Fioralba Cakoni—built upon the foundation that UD had established, even when the COVID-19 pandemic began only a few months into my time at Rutgers. While teaching online and trying my best to continue pursuing research, I had time to think about my career. I thought about why I wanted to become a mathematician in the first place, and I returned to the lessons I had learned from my advisors at UD. I realized that, while I enjoyed the freedom of academic research, I wanted to pursue my goal of contributing to national defense more directly.

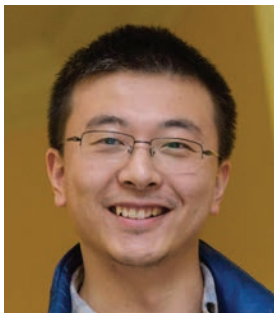
After two years at Rutgers, I moved to my current position as a Senior Mathematician at The Johns Hopkins University Applied Physics Laboratory in Laurel, MD. Every day I have the privilege of working with some of the smartest and most clever people I have ever met—physicists, engineers, oceanographers, computer scientists, and other mathematicians—to solve problems critical to the security of our nation and the world at large. My few years at the University of Delaware equipped me with the necessary skills—both as a mathematician and a person—to do this meaningful work for many more years to come. For that, I will always be thankful.

SHUKAI DU

Before coming to UD, I was a master student in China.In a conference in 2014, I met a UD graduate (Dr. Liwei Xu, supervised by Prof. George Hsiao). From him I first heard about the UD math department and its strong faculty group in applied math. At that time, I had no idea how this flutter of butterfly would change the course of my life afterwards.

I became a UD PhD student in the summer of 2015. As an international student, I first went to the language school, where I met many other students coming from all over the world. The UD math department offered an extraordinary supporting and friendly environment. Thanks to these, I adapted quickly to my first year of student life in UD.

In the summer of 2016, I joined a summer research program (at that time named "GEMS"), the purpose of which was to offer graduate students early research experience, to help them transit from "students" to "researchers", and also to help them choose their advisors. In that summer, I was lucky enough to work with **Prof. Francisco-Javier Sayas** on a project about visco-elastic waves. The project was mathematically rich and had a promising application background. By the end of the summer, I learned about many intriguing mathematical theories and numerical tools, and was able to generate interesting



simulations that mimic the behaviour of viscoelastic material. Because of this fun and fruitful experience, I decided to continue to work with Dr. Sayas, who later became my official advisor after I passed my candidacy exam.

Since my advisor's nickname was "Pancho" and he was a man with humour, we (himself and his students) referred to ourselves as "Team Pancho". To me, Team Pancho felt like a new home in the US, where we were supported not only academically but also in our daily lives. As members of Team Pancho, we regularly had

"coding party", where we worked intensely for about two hours to implement numerical methods. This experience has greatly increased our ability to work in collaboration. After the "party", we would usually go to coffee shops to just chat and relax. He also provided us many opportunities to present our work and encouraged us to make connections with other researchers. Thanks to his support, I have been to conferences in Spain, Austria, and Chile to present my work.

In the fall of 2018, I was shocked to know that Francisco was diagnosed cancer. To the great sadness of all in the department, he passed away in April of 2019. Despite this, the department provided me lots of support to overcome the difficulties after I lost my advisor. For instance, they appointed a collaborator of his, Dr. Bernardo Cockburn, as an adjunct professor in the math department, so that I could continue to work on my PhD thesis without changing to a different subject. Owing to all the heartwarming support and effort, I was able to graduate smoothly in 2020, and find a post-doctoral position at the University of Wisconsin-Madison as research associate. I could continue to chase my dream as an applied mathematician and numerical analyst.

When I first heard about the UD math department in that 2014 conference in China, I had no idea that my life would be so closely connected with and enriched by my alma mater. It has been my great pleasure to know all the people I met at UD and to be a UD graduate. The four years of UD experience will serve as an invaluable asset of mine, to help me pursue my career goals and to overcome the difficulties.

P.S. I learned until recently that my father once published a paper which played an important role in his career, and the editor of which was **Prof. Zuhair Nashed**, who was an emeritus professor at UD. This adds another layer of cordial feelings between me and the UD math department.

NAVID MIRZAEI

My name is Navid Mohammad Mirzaei, and I am a Visiting Assistant Professor at the University of Massachusetts Amherst. Currently, my research involves the data-driven modeling of cancer. I am part of a large team of mathematicians, biologists, and clinicians working on the initial steps of creating a cancer patient digital twin, a project funded by NCI/DOE. In this research, I use various tools and mathematical approaches such as ODEs, PDEs, parameter estimation, sensitivity analysis, and machine learning. My position also requires that I teach, and while I have taught courses such as calculus and linear algebra, I have also been able to teach several upper-level courses. These include Introduction to Scientific Computing, Applications of Scientific Computing, and Nonlinear Dynamics & Chaos with Applications. I feel very lucky to have gotten this position at UMass Amherst, and my time at the University of Delaware played no small part in preparing me for a career in academia.

I entered the mathematics PhD program at the University of Delaware in 2015 as an international student from Iran. In prior coursework, my background was primarily pure mathematics. However, my master's thesis was a mixture of PDE theory and simulation. This work was my first exposure to mathematical modeling and numerical simulation, and I knew it was what I wanted to do with my career. One of the main reasons I chose UD as my graduate program destination was my amazement at the math department's applied mathematics research. In particular, I was drawn to the work of **Dr. Pak-wing Fok** (who later became my advisor) because of his research in biomathematics. I worked with Dr. Fok on modeling arterial thickening and atherosclerosis. I was excited by this problem because it involved solid mechanics and biological interaction models working together. During this time, I was able to take courses such as solid mechanics and mathematical physiology from other departments to better prepare for my dissertation research. Looking back, not only did the problem I chose to work on for my dissertation set the stage for my research moving forward, but the support I found at UD to seek out faculty from other departments who might help me fostered my love of collaboration across fields. This work produced presentations at prestigious conferences as well as publications in reputable journals, both of which were helpful in my search for a postdoctoral position after graduation. In addition, I learned how to work with High-Performance Computing clusters—a skill that has turned out to be essential to my current position.

In addition to incredible research experiences, the mathematics department at the University of Delaware also prepared me to teach mathematics at postsecondary institutions. From where I'm standing now, the University of Delaware is an incredibly organized department in terms of its teaching, and this makes a difference in how well an instructor can plan and teach their course. As a graduate student, I built up my teaching portfolio by being an instructor of record during winter and summer sessions. I found out later that this was instrumental in my getting hired by UMass Amherst—teaching experience put me in front of other applicants when securing a job. I was also the recipient of one of the 2019 University of Delaware Excellence in Teaching Award for graduate students. I know that without the aforementioned opportunities in teaching I would not have been able to secure the job I have now. I will be forever grateful that the math department gave me the opportunity to explore who I was both as a mathematician and as a teacher.

Though my experiences with research and teaching in the department were the most important in terms of securing my future in academia, I would be remiss if I did not mention the math community at UD. Particularly since I was far from home, my best memories from UD (especially in the math department) have to do with the atmosphere. I made many friends, and it was with each other's support that we were able to make it through the PhD program. At the beginning of the program, we were always together, doing homework assignments or studying for examinations. Later in the program, you could often find us crammed into an office on the first floor,

explaining our research and mulling over hurdles that had presented themselves. We played soccer on the hockey court outside of Trabant every weekend that we could. Once, we even entered the intramural indoor soccer tournament! (But do not ever ask how we did). Getting a doctoral degree is an incredible undertaking. The sense of community that I felt, not just from other doctoral students but also from faculty and administration in the math department, made the experience more enjoyable.

I have found that, upon graduation, everyone will think that you are an expert in your field (as they should). It is somewhat overwhelming at times, having to rely on yourself and the knowledge you gathered during your doctoral studies. However, I have found that there has been no hurdle in my current postdoctoral position (both in teaching and research) that I did not feel prepared for during my time at UD. In closing, I'd like to say "Congratulations!" to the graduate students in the math department. Whether you are recently accepted, in the middle, or at the end of your doctoral journey—you have made a wise choice to study mathematics at UD. You are in good hands!

PHD GRADUATES 2021–2022

Fall 2021

Gautam Aishwarya
Mathematics (Advisor: Dr. M Madiman)

Hansen Pei
Applied Mathematics (Advisor Dr. L. Rossi)

Spring 2022

Dheer Desai
Mathematics (Advisor Dr. S. Cioaba)

Michael Bush
Mathematics (Advisor Dr. C. Liaw)

Jiajie Chen
Applied Mathematics (Advisor Dr. J. Qiu)

Boyang Xu
Applied Mathematics (Advisor Dr. P. Guyenne)

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