JOINT MATHEMATICS MEETINGS

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MATHEMATICAL ASSOCIATION OF AMERICA

January 2020

Prizes and Awards

4:25 PM, Thursday, January 16, 2020

Program

Opening Remarks
Michael Dorff, Mathematical Association of America

Award for Distinguished Public Service
American Mathematical Society

Bôcher Memorial Prize
American Mathematical Society

Chevalley Prize in Lie Theory
American Mathematical Society

Frank Nelson Cole Prize in Number Theory
American Mathematical Society

Leonard Eisenbud Prize for Mathematics and Physics
American Mathematical Society

Levi L. Conant Prize
American Mathematical Society

Joseph L. Doob Prize
American Mathematical Society

Leroy P. Steele Prize for Mathematical Exposition
American Mathematical Society

Leroy P. Steele Prize for Seminal Contribution to Research
American Mathematical Society

Leroy P. Steele Prize for Lifetime Achievement
American Mathematical Society

Louise Hay Award for Contribution to Mathematics Education
Association for Women in Mathematics

M. Gweneth Humphreys Award for Mentorship of Undergraduate Women in Mathematics
Association for Women in Mathematics

Microsoft Research Prize in Algebra and Number Theory
Association for Women in Mathematics

Sadosky Research Prize in Analysis
Association for Women in Mathematics

Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student
American Mathematical Society
Mathematical Association of America
Society for Industrial and Applied Mathematics

Communications Award
Joint Policy Board for Mathematics

Chauvenet Prize
Mathematical Association of America

David P. Robbins Prize
Mathematical Association of America

Euler Book Prize
Mathematical Association of America

Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching of Mathematics
Mathematical Association of America

Yueh-Gin Gung and Dr. Charles Y. Hu Award for Distinguished Service to Mathematics
Mathematical Association of America

Closing Remarks
Jill C. Pipher, American Mathematical Society

AMS

American Mathematical Society

Award for Distinguished Public Service

This award was established by the AMS Council in response to a recommendation from their Committee on Science Policy. The award is presented every two years to a research mathematician who has made recent or sustained contributions through public service.

Citation

David Eisenbud

The 2020 AMS Award for Distinguished Public Service is presented to David Eisenbud, Professor of Mathematics at the University of California Berkeley and Director of the Mathematical Research Institute (MSRI) in Berkeley, CA, for his exceptional leadership and outreach efforts while Director of MSRI, President of the AMS, and Director for Mathematical and Physical Sciences at the Simons Foundation. As the long-time Director of MSRI he has been instrumental in fostering or creating programs to enhance the public understanding of mathematics—for example, the Numberphile YouTube channel and Podcast, the Mathical Book Prize, the National Math Circles Library, the Celebration of Mind events, the National Math Festival, and the initiation of the National Math Circles organization. He also brought a large and broad non-academic community of enthusiastic supporters to the Institute. As President of the AMS, he was an enthusiastic proponent of new outreach efforts, advocating for the Mathematical Research Communities program as well as creating and sustaining the Current Events Bulletin sessions at the Joint Math Meetings. As the first Director of Math and Physical Sciences at the Simons Foundation, he was instrumental in forging policies that now provide significant and novel non-governmental support for the mathematical and physical sciences.

As a research mathematician, Eisenbud's work is centered in commutative algebra and algebraic geometry. He has advised more than thirty doctoral students, including thirteen since first becoming Director of MSRI. His book *Commutative Algebra: With a View Toward Algebraic Geometry* was honored with a Leroy P. Steele Prize for Mathematical Exposition in 2010.

In each of these roles, David Eisenbud has gone far beyond the ordinary as an exuberant advocate for the mathematical sciences. He has changed the way others think about our subject and changed aspects of the mathematics profession itself. His exceptional service will affect mathematics for years to come.

Biographical Note

David Eisenbud served as Director of MSRI from 1997 to 2007, and began a new term in 2013.

He received his Ph.D. in mathematics in 1970 at the University of Chicago under Saunders Mac Lane and Chris Robson, and was on the faculty at Brandeis University before coming to Berkeley, where he became Professor of Mathematics in 1997. He served from 2009 to 2011 as Director for Mathematics and the Physical Sciences at the Simons Foundation, and is currently on the Board of Directors of the Foundation. He has been a visiting professor at Harvard, Bonn, and Paris. Eisenbud's mathematical interests range widely over commutative and non-commutative algebra, algebraic geometry, topology, and computer methods.

Eisenbud is Chair of the Editorial Board of the journal *Algebra & Number Theory*, which he helped found in 2006, and serves on the Board of the *Journal of Software for Algebra and Geometry*, as well as Springer Nature's book series Algorithms and Computation in Mathematics.

Eisenbud was President of the American Mathematical Society from 2003 to 2005. He is a Director of Math for America, a foundation devoted to improving mathematics teaching. He has been a member of the Board of Mathematical Sciences and their Applications of the National Research Council, and is a member of the U.S. National Committee of the International Mathematical Union. In 2006, Eisenbud was elected a Fellow of the American Academy of Arts and Sciences.

Eisenbud's interests outside of mathematics include theater, music, and juggling. He is co-author of a paper on the mathematics of juggling. He plays the flute and sings Bach, Brahms, Schubert, Schumann, ...

Response from David Eisenbud

I am very pleased by this recognition from the AMS for the work that I have had the good luck to be able to do on behalf of the mathematics community and of the public's appreciation of the power, beauty, and fun of mathematics!

Looking back, it seems to me that the mentoring I received played a great role both in my enthusiasm for this sort of work and for enabling me to take on the positions—principally at the AMS, at the Simons Foundation, and at MSRI—that has put me in a position to act on behalf of the community.

This began in graduate school: among my mentors were Irving Kaplansky and Saunders Mac Lane. Kap (as everyone not a student called Kaplansky) was a great advocate for engagement with the AMS: I remember him telling me and other students that we must join the AMS, because...it was “our union”! He was also a president of the AMS, and was the second Director of MSRI—I first visited during his Directorship. Mac Lane was a model in a different way. I was very much aware, already during my graduate student time, of the service he gave to the National Academy of Sciences (and he too had been president of the AMS). We became personally close, and his example in these matters was quite important to me.

After graduate school I went to Brandeis University as a postdoc, and wound up staying there 27 years. David Buchsbaum’s presence was what drew me. The university was small and relatively new, and he was deeply involved and caring about both department and university politics. Happily for me, we not only collaborated mathematically, but he regularly shared his insights and his stories with me—a kind of mentoring that I think very few junior faculty receive.

Finally, when I came to be Director of MSRI, Elwyn Berlekamp took me under his wing, and spent countless hours telling me tales from his wide experience, and introducing me to his friends. Elwyn, whose father had been a minister, was also focused on the idea of service. Although Elwyn and Bill Thurston, my predecessor as Director, had strong differences, Elwyn very much appreciated and pushed forward Bill’s ideas of public engagement and of broadly cultivating talent, and Elwyn strongly encouraged me in these directions.

Among other contacts he made for me was with his old friend and former partner, Jim Simons (re-made, really, since I first knew Jim through my parents!) Elwyn and I convinced Jim to join the MSRI Board, where he has had a great impact. Jim and I liked each other, and that was ultimately the path that led to my work at the Simons Foundation.

Another person who played a major role on the MSRI Board in recent years is Roger Strauch. Experienced in many areas of engineering and business, and eager to help mathematicians make their way in the world, he too has been a great friend and teacher.

These mentors in public service (and of course others, also in research) have played an enormous role in my life, one whose magnitude and coherence I only recently came to appreciate. I’m grateful for this chance to reflect on my path, and express my indebtedness to all of them. I can only wish such good fortune for others.

Bôcher Memorial Prize

This prize, the first to be offered by the American Mathematical Society, was founded in memory of Professor Maxime Bôcher, who served as president of the AMS 1909–10. The original endowment was contributed by members of the Society. It is awarded for a notable paper in analysis published during the preceding six years. The work must be published in a recognized, peer-reviewed venue.

Citation

Camillo De Lellis

The 2020 Bôcher Memorial Prize is awarded to Camillo De Lellis for his innovative point of view on the construction of continuous dissipative solutions of the Euler equations, which ultimately led to Isett's full solution of the Onsager conjecture, and his spectacular work in the regularity theory of minimal surfaces, where he completed and improved Almgren's program. Examples of two papers that represent his remarkable achievements are "Dissipative continuous Euler flows," *Invent. Math.* **193** (2013), in collaboration with L. Székelyhidi, and "Regularity of area-minimizing currents III: blow-up", *Ann. of Math.* **183** (2016), in collaboration with E. Spadaro.

Biographical Note

Camillo De Lellis was born in 1976 in San Benedetto del Tronto, Italy. After earning his undergraduate degree in mathematics at the University of Pisa in 1999, he wrote his doctoral dissertation in 2002 under the supervision of Luigi Ambrosio at the Scuola Normale Superiore di Pisa. He held a postdoctoral position at the Max Planck Institute for Mathematics in the Sciences in 2002-2003, followed by a postdoctoral residency at the Eidgenössische Technische Hochschule in Zürich. De Lellis joined the faculty of the University of Zürich in 2004 as Assistant Professor of Mathematics, and he was appointed Full Professor in 2005. In 2018 he moved to the Institute for Advanced Study in Princeton, where he holds the IBM von Neumann Professorship. He is active in the fields of calculus of variations, geometric measure theory, hyperbolic systems of conservation laws, and fluid dynamics.

Response from Camillo De Lellis

I am grateful and deeply honored to be awarded the 2020 Bôcher Prize jointly with Larry Guth and Laure Saint-Raymond, two colleagues whom I know personally and whose work I have admired for a long time. I am humbled by the list of previous recipients, but one name, Leon Simon, is particularly dear to me: during one sunny Italian summer of (slightly more than) 20 years ago his wonderful lecture notes infected me with many of the themes of my future research in geometric measure theory.

The results mentioned in the citation stem from long endeavors with two dear friends and collaborators, László Székelyhidi Jr. and Emanuele Spadaro: without their brilliance, their enthusiasm, and their constant will of progressing further, we would have not gotten there. But mostly I wish to thank them because working together has been really a lot of fun. Our research has been influenced by the work of several other mathematicians and takes advantage of important past and present developments in many topics in partial differential equations and differential geometry, but this is already explained in full detail in a few surveys and lecture notes.

Let me instead mention here that the seeds of both works were planted during a very important time of my life, while my beloved wife Lorenza was carrying the first of the three most beautiful prizes of my life. I take this opportunity to thank her for her constant support and immense patience.

Citation

Lawrence Guth

The 2020 Bôcher Memorial Prize is awarded to Lawrence Guth for his deep and influential development of algebraic and topological methods for partitioning the Euclidean space and multiscale organization of data, and his powerful applications of these tools in harmonic analysis, incidence geometry, analytic number theory, and partial differential equations. These applications include the proof of the endpoint multilinear Kakeya conjecture, nearly sharp bounds for the distinct distances problem, best-known bounds on the Fourier restriction problem, further development of the Bourgain–Demeter decoupling theory which led to the resolution of the Vinogradov main conjecture, sharp estimates on oscillatory integrals, and a sharp almost-everywhere convergence theorem for solutions to the free Schrödinger equation. Examples of two papers that represent his remarkable achievements are "A restriction estimate using polynomial partitioning," *J. Amer. Math. Soc.* **29** (2016), no. 2, and "A sharp Schrödinger maximal estimate in $\mathbb{R}^2$," *Ann. of Math.* (2) **186** (2017), no. 2, in collaboration with X. Du and X. Li.

Biographical Note

Lawrence Guth is a Professor of Mathematics at MIT. He grew up in Brookline, Massachusetts, and went to Brookline High School. He was an undergrad at Yale and he did his Ph.D. at MIT in 2005 under the supervision of Tomasz Mrowka.

Following a postdoctoral position at Stanford and a junior faculty appointment at the University of Toronto, he was appointed professor at the Courant Institute in 2011, and joined MIT in 2012.

Response from Lawrence Guth

I'm very honored to receive this award. Sitting down to write this response, and thinking back over the time I spent working on these projects, I realized just how many mentors and collaborators played an important role in them. I've been very lucky to have such mentors and collaborators.

Growing up, I learned math from my dad, and also from a lot of dedicated teachers at school, like Michael Narasny and Terry Leverich. In college, I learned from Serge Lang and Peter Jones. Peter first got me interested in analysis. It was from him that I first heard about the Kakeya problem about rotating a needle within a small area and that it had something to do with Fourier analysis. At the time I didn't understand what the connection was, but it sounded intriguing.

In graduate school, I studied with Tom Mrowka. I picked Tom as an advisor because I liked how he worked with his students. I grew up mathematically in Tom's weekly seminar. I remember the first time I spoke, early in my second year; I showed up with two pages of notes and started talking and every ten minutes or so someone would ask a question and I would realize I hadn't really understood what I was saying. The second time I spoke, I showed up with ten pages of notes.

As a graduate student I studied geometry, especially Misha Gromov's work on metric geometry. A common theme in the work we studied in Tom's seminar was using topological arguments to show that some geometric object had to exist and then using that object to prove new estimates in geometry and topology. For instance, we studied pseudoholomorphic curves in symplectic geometry and Yang-Mills connections in gauge theory. Another example, which was not as dramatic but more relevant to the work in this citation, was the way Gromov used the ham sandwich theorem to estimate eigenvalues of the Laplacian on a Riemannian manifold.

I started learning about restriction theory when I was a postdoc by reading Terence Tao's notes from a graduate course he had taught. At that time, I had only worked in differential geometry, and I didn't think I would be able to work in restriction theory. But I started reading the notes because I was curious about the Kakeya problem and about Fourier analysis and I kept going because they are very readable and engaging. Now I give them to my graduate students to read, if they're interested in Fourier analysis. One thing that impressed me about the field was how people looked to quite different parts of math to find new approaches to the problems, like when Bourgain brought in ideas from combinatorial number theory or when Wolff brought in the idea of partitioning from combinatorial geometry.

Just after I read those notes, Zeev Dvir's paper solving the finite field Kakeya problem came out. This paper was a big surprise to people in the field. Until then it had looked plausible that the finite field Kakeya problem was as hard as the central problems of restriction theory, but Zeev's proof was two pages long and accessible to a good undergraduate. The new idea of the proof had to do with high degree polynomials, which was surprising because the problem was just about lines. The method used finite fields in a crucial way, however, and it wasn't clear whether it could be adapted to say something about the original Kakeya problem or related problems in Fourier analysis, which take place over the real numbers. Zeev's argument reminded me of geometry arguments that I had been studying and working on, and that led to my first paper in the area, using the ham sandwich theorem to prove an estimate related to the Kakeya problem.

The next year, I started my first professor job at the University of Toronto. Jim Colliander and Robert McCann invited me to help run a working group on analysis and geometry, and we made the Kakeya problem the theme of the semester. At the end of the semester, we invited an expert, Nets Katz, to come and give some talks.

Over the next week, Nets and I started to collaborate. Nets taught me about combinatorics problems that were connected to the Kakeya problem in different ways. We explored using polynomials to study them, and eventually we worked out the idea of polynomial partitioning together. Ever since then, I've been trying to apply polynomial partitioning in different situations and seeing how much it can tell us about Fourier analysis.

A little bit later, I met Jean Bourgain, and I had a chance to work with him on restriction theory. I had spent a long time studying Bourgain's work and so getting to actually work with him felt special, and a bit overwhelming. Our collaboration started when I showed him an idea about a problem he had worked on in the 1990s. My approach was based on polynomials, building on my first paper in Fourier analysis. But when Jean started to develop the approach, he saw that the polynomials weren't really needed.

Once we started to work together, he would send me notes of things he had worked out, and these notes piled up into a very large pile, which became a joint paper. It took me more than a year to read all those notes. Reading them was a real education in the field.

Since then, I've gotten to work on this circle of questions with more collaborators, including Josh Zahl, Ciprian Demeter, Jonathan Hickman, Marina Iliopoulou, Xiumin Du, Xiaochun Li, Hong Wang, Yumeng Ou, Bobby Wilson, Alex Iosevich, Noam Solomon, and Ruixiang Zhang. I want to thank all of them for their energy and ideas.

Finally I want to thank my family for all of their support and their love—my

parents Susan and Alan, my sister Jenny, my wife Amy, and my children Elan and Bennett.

CITATION

Laure Saint-Raymond

The 2020 Bôcher Memorial Prize is awarded to Laure Saint-Raymond for her transformative contributions to kinetic theory, fluid dynamics, and Hilbert's sixth problem on "developing mathematically the limiting processes... which lead from the atomistic view to the laws of motion of continua." With François Golse, she obtained solutions of incompressible Navier-Stokes and Euler equations as limits of weak solutions of Boltzmann's equations. She also studied the Boltzmann-Grad limit in the hard sphere model, going beyond the kinetic time to derive Brownian motion by tracing a tagged particle in the limit of a Newtonian microscopic model. Examples of two papers that represent her remarkable achievements are "The Brownian motion as the limit of a deterministic system of hard-spheres," *Invent. Math.* **203** (2016), no. 2, in collaboration with T. Bodineau and I. Gallagher, and "Mathematical study of degenerate boundary layers: a large scale ocean circulation problem," *Mem. Amer. Math. Soc.* **253** (2018), no. 1206, in collaboration with A.-L. Dalibard.

Biographical Note

Laure Saint-Raymond was torn between her taste for abstract theories and her wish to understand the world surrounding us a little bit more. She studied mathematics and physics and she finally opted for applied mathematics, and got her Ph.D. under the supervision of François Golse in 2000.

An important part of her work is related to the sixth problem raised by Hilbert in 1900 on the occasion of the International Congress of Mathematicians, which addresses the question of the axiomatization of mechanics, and more precisely of describing the transition between atomistic and continuous models for gas dynamics by rigorous mathematical convergence results. Saint-Raymond has obtained major results concerning the asymptotic theory of the Boltzmann equation in kinetic theory of gases. She has also studied problems of scale separation in the context of geophysical flows, especially for the wind-driven oceanic dynamics.

Hired as a junior researcher at CNRS in 2000, she was promoted to Professor at University Paris 6–Pierre et Marie Curie in 2002. She is currently Professor at the Ecole Normale Supérieure de Lyon, and Fellow of the Institut Universitaire de France. She has been awarded many prizes, among which the Prize of the European Mathematical Society in 2008, the Ruth Lyttle Satter Prize of the American Mathematical Society in 2009, and the Fermat Prize in 2015. She is a member of the French Academy of Sciences, the Academia Europae and the European Academy of Sciences.

Response from Laure Saint-Raymond

I would like to begin these lines by congratulating my colleagues L. Guth and C. De Lellis, whose work is very inspiring to me, and with whom I am happy to share the Bôcher Memorial Prize.

I am actually very impressed and honored to receive this distinction, but I would like to associate my collaborators to this recognition: I always have a lot of pleasure working with them, and without them I would never have had the courage to embark on a program of this size.

Hilbert's sixth problem concerning the axiomatization of physics remains to this day a major challenge, especially since its statement is not very precise and its scope has expanded with the introduction of quantum and relativistic theories. Nevertheless, we have been able to open an important gap in the setting of classical gas dynamics, showing the compatibility of atomic, statistical, and hydrodynamic descriptions (at least in some regimes).

A first significant advance, obtained in collaboration with F. Golse, was to understand the similarity of structure between the Boltzmann equation for rarefied gases and the Navier-Stokes equations of incompressible fluids, and in particular the hypoelliptic mechanism that explains viscous dissipation as a combination of microscopic transport and collision phenomena.

A second key advance concerns the derivation of the Boltzmann equation from the dynamics of a hard sphere billiard, and has led to a series of joint works with T. Bodineau, I. Gallagher, and S. Simonella. The central question here is to understand the processes which are responsible for the decorrelation of particles and that make it possible to obtain a statistical description of the out-of-equilibrium system. Our most recent results, while they do not improve the (very short) time on which we can rigorously show that the Boltzmann equation predicts the most probable dynamics, give a much finer understanding of the limiting process by characterizing the (small or large) deviations with respect to this average dynamic.

In all these problems, entropy plays a major role and one of the projects that is important to me now is to try to understand better its structure and physical meaning.

Chevalley Prize in Lie Theory

This prize was established in 2014 by George Lusztig to honor Claude Chevalley (1909–1984). Chevalley was a founding member of the Bourbaki group. He made fundamental contributions to class field theory, algebraic geometry, and group theory. His three-volume treatise on Lie groups served as standard reference for many decades. His classification of semisimple groups over an arbitrary algebraically closed field provides a link between Lie's theory of continuous groups and the theory of finite groups, to the enormous enrichment of both subjects. The Chevalley Prize is awarded for notable work in Lie Theory published during the preceding six years; a recipient should be at most twenty-five years past the Ph.D.

Citation

Huanchen Bao and Weiqiang Wang

The 2020 Chevalley Prize is awarded to Huanchen Bao and Weiqiang Wang for their fundamental contributions to the theory of quantum symmetric pairs.

This award is based on two publications: the paper "Canonical bases arising from quantum symmetric pairs," published in *Inventiones Mathematicae*, and the monograph "A new approach to Kazhdan-Lusztig theory of type B via quantum symmetric pairs," published in *Astérisque*. In these works, Huanchen Bao and Weiqiang Wang completely extended the known theory of canonical bases from the case of quantized enveloping algebras to the case of quantum symmetric pairs. Bao and Wang applied their new theory to a longstanding open problem: that of describing the character formulas for the category $\mathcal{O}$ attached to an ortho-symplectic Lie superalgebra of type $\mathfrak{osp}(2m+1|2n)$.

In the early 1990s, George Lusztig invented a remarkable theory of canonical bases for quantized enveloping algebras. In the late 1990s, Gail Letzter introduced quantum symmetric pairs (U, U'), where U is the universal enveloping algebra of a complex semisimple Lie algebra $\mathfrak{g}$ and U' corresponds to the fixed points in U of an involution. Bao and Wang extended Lusztig's theory of canonical bases from quantized enveloping algebras to quantum symmetric pairs. Notably, Bao and Wang's construction shows that Lusztig's braid group operators restrict to automorphisms of U'. They introduced a special intertwiner (now known as quasi-K-matrix) in order to define a bar-involution on U' and then proved that finite-dimensional U-modules and their tensor products, when viewed as U'-modules, have canonical bases. In addition, they showed that a certain modified form of U', similar to Lusztig's modified form of U, has a canonical basis.

A milestone in representation theory was the Kazhdan-Lusztig theory, which offered a powerful solution to the difficult problem of determining the irreducible characters in the Bernstein-Gelfand-Gelfand category $\mathcal{O}$ of a complex semisimple Lie algebra. Though the classification of finite-dimensional simple Lie superalgebras over $\mathbb{C}$ was achieved in the 1970s by Kac, the study of representation theory such as the BGG category $\mathcal{O}$ for a Lie superalgebra turns out to be very challenging and progress has been made only in recent years. Among all basic Lie superalgebras, the infinite series $\mathfrak{gl}(m|n)$ and $\mathfrak{osp}(m|2n)$ are arguably the most fundamental ones.

Bao and Wang gave a complete and conceptual solution to the decades-old open problem on irreducible characters in the category $\mathcal{O}$ of modules of integer and half-integer weights for the orthosymplectic Lie superalgebras $\mathfrak{osp}(2m+1|2n)$, of type $\mathrm{B}(m,n)$. They introduced a coideal subalgebra U' of U, which forms a quantum symmetric pair with U, and constructed a new theory of quasi-$\mathscr{R}$-matrix and a new canonical basis (called the ι-canonical basis) arising from quantum symmetric pairs (U, U'). They showed that the subalgebra U' and the Hecke algebra of type B_m form double centralizers on $\mathbb{V}^{\otimes m}$, where $\mathbb{V}$ is the natural representation of U, generalizing the Schur-Jimbo duality. Then they reformulated the Kazhdan-Lusztig theory for Lie algebras of type B via this new duality. Next, they related the ι-canonical basis to the category $\mathcal{O}$ for $\mathfrak{osp}(2m+1|2n)$. Their main result asserts that the entries of the translation matrix between the (dual) ι-canonical basis and the monomial basis of $\mathbb{V}^{\otimes m} \otimes \mathbb{V}^{*\otimes n}$ play the role of Kazhdan-Lusztig polynomials in $\mathcal{O}$.

The construction of quantum symmetric pairs was generalized by Stefan Kolb in 2014 to the case where $\mathfrak{g}$ is a symmetrizable Kac-Moody Lie algebra. In a recent preprint ("Canonical bases arising from quantum symmetric pairs of Kac-Moody type," arXiv:1811.09848), Bao and Wang develop a general theory of ι-canonical bases for the quantum symmetric pairs of Kac-Moody type, introducing several new ideas to overcome major obstacles, and strengthen their previous main results by allowing general integral parameters.

The fact that the theory of canonical bases can be extended to the case of symmetric spaces is entirely unexpected and highly non-trivial. That the new theory has already had dramatic applications to the character theory of Lie superalgebras adds to the significance of the work. Many other applications, for example to a theory of total positivity attached to symmetric spaces, are expected. The two papers of Bao and Wang are the best papers published in Lie theory in recent years and will have an impact on the field for many years to come.

Biographical Note

Huanchen Bao obtained his B.S. in Mathematics at Sichuan University in 2010, and his Ph.D. from the Department of Mathematics at the University of Virginia in 2015. He was a postdoc at the University of Maryland, the Institute for Advanced Study, and the Max-Planck Institute for Mathematics. He is currently an assistant professor in the Department of Mathematics at National University of Singapore.

Biographical Note

Weiqiang Wang is currently a Professor of Mathematics at the University of Virginia. He received a Bachelor degree from the University of Science and Technology of China and a Ph.D. degree in mathematics from MIT in 1995. He was a postdoc at IAS, Yale, and the Max-Planck Institute at Bonn. He is a frequent visitor of the Institute of Mathematics at Academia Sinica in Taipei and East China Normal University. His research interest lies in representation theory, including Lie superalgebras, Hecke algebras, quantum groups, and connections to algebraic geometry. He enjoys collaborations and has learned much from his collaborators and students over the years.

Response from Huanchen Bao and Weiqiang Wang

We are extremely gratified and honored to receive the 2020 Chevalley Prize. We would like to thank George Lusztig for establishing the prize, whose groundbreaking works on Kazhdan-Lusztig theory and canonical bases form the central themes of our work in the cited papers.

When the senior recipient, Weiqiang Wang, was a Ph.D. student under the supervision of V. Kac in the 1990s, character formulas for Lie superalgebras were largely unknown, not even conjecturally. A conceptual solution of the character formula problem for the Bernstein-Gelfand-Gelfand category of orthosymplectic Lie superalgebras was given in the dissertation of the junior recipient, Huanchen Bao, two decades later.

To formulate the solution to the above problem and go beyond, we were led to develop a theory of canonical bases arising from quantum symmetric pairs, extending the canonical bases arising from quantum groups introduced by Lusztig. Our work was inspired by an earlier solution of Jon Brundan's Kazhdan-Lusztig conjecture due to Shun-Jen Cheng, Ngau Lam, and the senior recipient for general linear Lie superalgebras in terms of Lusztig's canonical basis.

The general theory of quantum symmetric pairs was formulated by Gail Letzter in the late 1990s and later extended by Stefan Kolb. The field is expanding rapidly in recent years thanks to the subsequent works of our friends and collaborators. We are very grateful to all of them, in particular to Yiqiang Li and Ming Lu, for

what they have taught us. The junior recipient especially thanks his postdoc mentor, Xuhua He, for his guidance and encouragement.

Finally, we thank our families and friends for their support.

FRANK NELSON COLE PRIZE IN NUMBER THEORY

THIS prize (and the Frank Nelson Cole Prize in Algebra) was founded in honor of Professor Frank Nelson Cole on the occasion of his retirement as Secretary of the American Mathematical Society after twenty-five years of service and as Editor-in-Chief of the *Bulletin* for twenty-one years. The endowment was made by Cole, contributions from Society members, and his son, Charles A. Cole. The prize is for a notable paper in number theory published during the preceding six years. The work must be published in a recognized, peer-reviewed venue.

CITATION

James Maynard

The Cole Prize in Number Theory is awarded to James Maynard for his many contributions to prime number theory. In particular, the prize recognizes the papers (i) “Small gaps between primes” (*Ann. of Math.*, 2015), (ii) “Large gaps between primes” (*Ann. of Math.*, 2016), and (iii) “Primes with restricted digits” (*Invent. Math.*, 2019).

Perhaps the central problem in prime number theory is the Hardy-Littlewood prime k-tuple conjecture which predicts (for a given k-tuple of distinct integers $h_1,\dots,h_k$) a precise asymptotic formula for the number of integers $n \le N$ such that $n+h_1,\dots,n+h_k$ are all prime. A special case is the famous twin prime problem, where it is still unproved whether there are infinitely many pairs of primes that differ by 2. Yitang Zhang, building on a breakthrough of Daniel Goldston, János Pintz, and Cem Yildrm, famously established that there exists a natural number h (below 70 million) such that there are infinitely many prime pairs $n, n+h$. In the paper “Small gaps between primes,” Maynard introduced new multidimensional sieve weights (discovered independently by Terence Tao) and used these weights to establish that for each k, there are k-tuples $h_1,\dots,h_k$ such that $n+h_1,\dots,n+h_k$ are all simultaneously prime for infinitely many n. In other words, Maynard established that infinitely often one can find k primes in intervals of bounded length $C(k)$. This result had seemed inaccessible to the methods of Goldston, Pintz, Yildirim, and Zhang (which treated the case $k=2$). Further, the new sieve weights are extremely flexible, and have led to progress on many related questions.

Instead of making the gaps between prime numbers small, one can ask how large the gaps between consecutive primes can get. If p_n denotes the n-th prime, then the prime number theorem shows that the gap $p_{n+1} - p_n$ is on average about log n. Erik Westzynthius, in 1931, was the first to show that these gaps can be larger than an arbitrary constant times the average gap. Since then a number of mathematicians have worked on quantifying these maximal gaps, resulting in the Erdős-Rankin bound that $p_{n+1} - p_n$ can be larger than $C \log n \log_2 n \log_4 n / (\log_3 n)^2$ infinitely often. Here C is a positive constant, and $\log_j$ denotes the j-fold iterated logarithm. One of Erdős's favorite problems asked for an improvement over this result, replacing C by any function tending to infinity. After more than 70 years, this problem was resolved simultaneously by different methods: in Maynard's "Large gaps between primes," by an adaptation of his multidimensional sieve, and in Ford, Green, Konyagin, and Tao (*Ann. of Math.* 2016) by using the Green-Tao theorem on arithmetic progressions in the primes. Maynard's method allows for better quantitative control, and the state of the art is attained in joint work by both teams in *J. Amer. Math. Soc.*, 2018.

Given a (naturally occurring) sparse subset of the natural numbers, one would like to count the primes in it. For example, do polynomial sequences (such as $n^2 + 1$) contain infinitely many primes? No example of such a univariate polynomial with degree larger than 1 is known, but breakthrough results of John Friedlander and Henryk Iwaniec and of David Heath-Brown establish such a result for polynomials in two variables such as $x^2 + y^4$ (Friedlander and Iwaniec) and $x^3 + 2y^3$ (Heath-Brown). The sets of values in these examples are sparse in the sense that they contain only N^{1-c} natural numbers up to N for some $c > 0$. Maynard's "Primes with restricted digits" establishes that the Cantor-like set of natural numbers whose base b representations have no digit equal to a given $a \in \{0, \dots, b-1\}$ contains infinitely many primes provided that the base b is at least 10. In particular, there are infinitely many primes with no 7 in their usual decimal representation. The number of such integers up to N is about $N^{\log 9/\log 10}$, so that this gives a further striking example of a sparse set that contains infinitely many primes.

Biographical Note

James Maynard studied at Cambridge for his undergraduate and master's degrees, before doing a Ph.D. at Oxford under Roger Heath-Brown. He was a CRM-ISM postdoctoral fellow for a year at the Université de Montréal, and then returned to Oxford first as a Junior Research fellow of Magdalen College and then as a fellow of the Clay Mathematics Institute. He also spent extended time as a research member at MSRI, Berkeley; as a visitor at Aix-Marseille University, Marseilles; and as a member at the IAS, Princeton when a postdoc. Since 2018 he has been a research professor at Oxford.

His interests are in analytic number theory, particularly classical problems about prime numbers. He has previously been awarded the 2014 SASTRA

Ramanujan Prize, the 2015 LMS Whitehead Prize, the 2016 EMS Prize, and the 2018 Compositio Prize. He was also a speaker at the 2018 ICM.

Response from James Maynard

It is a great honor to be awarded the 2020 Frank Nelson Cole Prize in Number Theory. My work builds on the development of a large number of ideas within analytic number theory, including the work of Brun, Selberg, Erdős, (A. I.) Vinogradov, Bombieri, (I. M.) Vinogradov, and, more recently, Pintz, Goldston, Yildirim, and Zhang, as well as many others for whom there is not space to mention. Without these luminaries my contributions would simply not have been possible, and so the final theorems owe rather more to them than they do to me.

I've been exceptionally fortunate to have been supported and encouraged to pursue my interest in mathematics throughout my career from a young age. My parents always encouraged me to follow my interests and my school teachers allowed me to develop my independent tastes. More recently, many people have supported my career and mathematics in various ways, particularly my supervisor Roger Heath-Brown and my postdoc mentor Andrew Granville. Without this support it is likely I would now be doing something rather less interesting than mathematical research!

I've always been attracted to the simplicity of the statements of many important open problems about primes—it is immensely satisfying to be personally involved in some of the partial progress on these questions. More generally, the field of analytic number theory feels revitalized and exciting at the moment with new ideas coming from many different people, and hopefully this prize might inspire younger mathematicians to continue this momentum and make new discoveries about the primes.

Leonard Eisenbud Prize for Mathematics and Physics

This prize was established in 2006 in memory of the mathematical physicist Leonard Eisenbud (1913–2004) by his son and daughter-in-law, David and Monika Eisenbud. Leonard Eisenbud was a student of Eugene Wigner. He was particularly known for the book *Nuclear Structure* (1958), which he coauthored with Wigner. A friend of Paul Erdős, he once threatened to write a dictionary of English to Erdős and Erdős to English. He was one of the founders of the physics department at Stony Brook University, where he taught from 1957 until his retirement in 1983. In later years he became interested in the foundations of quantum mechanics and in the interaction of physics with culture and politics, teaching courses on the anti-science movement. His son, David, was President of the American Mathematical Society 2003–04.

The prize is awarded every three years for a work or group of works, published in the preceding six years, that brings mathematics and physics closer together. Thus, for example, the prize might be given for a contribution to mathematics inspired by modern developments in physics or for the development of a physical theory exploiting modern mathematics in a novel way.

Citation

Kevin Joseph Costello

The Leonard Eisenbud Prize for Mathematics and Physics is awarded to Kevin Costello for his contributions to the mathematical foundations of quantum field theory and his gauge-theoretic explanation of solutions to the quantum Yang-Baxter equations. These have appeared in the works *Factorization Algebras in Quantum Field Theory I*, published by Cambridge University Press in 2017, *Renormalization and Effective Field Theory*, published by the American Mathematical Society in 2011, and the influential article posted on the arXiv (1303.2632) "Supersymmetric gauge theory and the Yangian."

Quantum field theory is the physical framework underlying all modern understanding of elementary particles, fields, and their interactions. From its beginnings with quantum electrodynamics in the 1920s to the development of non-abelian gauge theories, mathematicians have struggled to formulate in precise terms the rigorous underpinnings of the subject as well as to mathematically understand and justify the calculations done by physicists.

Included in this effort was the program of constructive quantum field theory, whose practitioners tried to give analytic constructions of field theories on Minkowski or Euclidean space satisfying the Wightman axioms starting from action principles that physicists used to describe the world. In spite of many beautiful results in infinite-dimensional analysis that came out of this effort, no one has yet succeeded in giving such a construction for realistic field theories in four dimensions.

The interface between mathematics and quantum field theory underwent a dramatic change in the 1980s under the influence of the rich structures underlying string theory, conformal field theory, and topological field theory, resulting in a new geometric synthesis via an axiomatization of the latter two by Graeme Segal and Michael Atiyah. This broad perspective ushered in an astounding panoply of applications including the definition of Reshetikhin-Turaev-Witten invariants of three-manifolds, Gromov-Witten theory, Seiberg-Witten theory, various geometric ramifications of mirror symmetry, as well as a rapid influx of new geometric and algebraic tools and concepts into physics.

Amid the efforts of many mathematicians to explore the foundations of this new landscape, the recent work of Kevin Costello stands out for its depth, comprehensive view, and its relevance to physicists. In his book *Renormalization and Effective Field Theory*, Costello developed a complete mathematical foundation for perturbative renormalization as practiced by physicists, bringing it up to an unprecedented level of rigor and conceptual clarity. In particular, he gave a full mathematical exposition of the renormalization group flow on quantum field theories and a mathematical proof of the renormalizability of Yang-Mills theory, the physics counterpart of which earned Gerardus t'Hooft a Nobel prize in 1999. The key mathematical ingredient in Costello's theory is *derived geometry,* the newest manifestation of the rich categorical generalizations of geometry that have grown out of the Grothendieck revolution of the 1960s. The application to physics lies in the insight that the zero locus of an action functional can exactly be enhanced to such a derived geometry in a way that naturally incorporates gauge symmetries via the Batalin-Vilkovisky formalism. The upshot is that the observables of a quantum field theory come together to form a remarkable mathematical structure called a *factorization algebra* on spacetime, an idea that Costello has been fleshing out systematically in collaboration with his student Owen Gwilliam in the books *Factorization Algebras in Quantum Field Theory I, II.* (The second volume is in the final stages of submission to Cambridge University Press.) These books set up a robust global analytic framework necessary to perform deformation quantization of a field theory expressed as an *elliptic moduli* problem and yield, in particular, rigorous perturbative quantizations of topological field theories such as Chern-Simons theory, the B-model, and Rozansky-Witten theory, as well as non-topological field theories such as Yang-Mills theory. This framework for understanding quantum field theory is developing rapidly, and has already established itself as a new paradigm for mathematical approaches to quantum field theories that encompasses a substantial portion of the classical analytic tradition while interacting with modern geometry and topology in deep and novel ways.

One especially striking application of the theory has appeared in Costello's work on Yangians. The Yang-Baxter equations are consistency relations satisfied by matrices encoding the vertex interactions of lattice models and are understood to be the key to integrability. In the 1980s, Drinfeld interpreted solutions to these equations in terms of quantum groups, certain non-commutative deformations of classical and affine universal enveloping algebras, whereby concrete solutions to the Yang-Baxter equations arise from representations of special quantum groups called Yangians. Costello's remarkable insight is that such solutions can also be understood as arising from four-dimensional supersymmetric field theories that are topological in two directions and holomorphic in one complex direction. More precisely, Costello discovered the remarkable fact that

Yangian Hopf algebras are encoded in the factorization algebra of observables in "Chern-Simons deformations" of twisted $N = 1$ *gauge theories in four dimensions.*

Even though a full explanation of this statement is a bit too elaborate to include here, it is worth emphasizing that Costello has used it to give a unified construction of all the standard rational, trigonometric, and elliptic solutions to the quantum Yang-Baxter equations. In the words of Edward Witten, Costello has *explained* why the Yang-Baxter equations have all those solutions, in a manner that goes substantially beyond Drinfeld's groundbreaking work, resolving a fundamental mystery that has shrouded the equations for many decades since their discovery.

Unlike many mathematicians working on topics originating in physics, Kevin Costello cares deeply about the foundations of physics itself as conceived of by physicists, and is constantly generating physical insights that go beyond mathematical rigor. He is respected by mathematicians and physicists alike and plays a unique role in breaking new and fertile ground on which the two communities can jointly develop directions of research even while coming to a fuller understanding of important known phenomena. He is thus eminently deserving of the Eisenbud Prize for Mathematics and Physics.

Biographical Note

Kevin Joseph Costello was born in 1977 in Dublin, Ireland. He did his undergraduate degree at Cambridge University, and received his Ph.D. from Cambridge in 2003 under the supervision of Ian Grojnowski. He has worked at Imperial College London, the University of Chicago, and Northwestern

University, and is now a Krembil Foundation Chair at the Perimeter Institute in Waterloo, Ontario. He is a Fellow of the Royal Society, a former Sloan and Simons fellow, an invited speaker at the ICM in 2010, and an invited speaker at Strings 2016.

Response from Kevin Joseph Costello

It's a huge honour to receive this award, whose previous recipients include several personal heroes of mine. Some years ago I decided to leave the beaten path of algebra and topology and explore the foundations of perturbative quantum field theory. I've had a great deal of fun doing this, but I did not expect this to be a good career move. However, the mathematics community has been very supportive over the years, as evidenced by this wonderful prize. It's a real privilege to work in a community like ours which is open to interdisciplinary, curiosity-driven research. I'm very grateful to the AMS, the Eisenbud family, and the selection committee.

Levi L. Conant Prize

This prize was established in 2000 in honor of Levi L. Conant to recognize the best expository paper published in either the *Notices of the AMS* or the *Bulletin of the AMS* in the preceding five years. Levi L. Conant (1857–1916) was a mathematician who taught at Dakota School of Mines for three years and at Worcester Polytechnic Institute for twenty-five years. His will included a bequest to the AMS effective upon his wife's death, which occurred sixty years after his own demise.

Citation

Amie Wilkinson

The 2020 Levi. L. Conant prize is awarded to Amie Wilkinson for the article "What are Lyapunov exponents, and why are they interesting?" published in the *Bulletin of the AMS* in 2017.

The article provides a broad overview of the modern theory of Lyapunov exponents and their applications to diverse areas of dynamical systems and mathematical physics. It opens with an illuminating geometric example. The barycentric division of a triangle consists of the six triangles formed by joining each vertex to the midpoint of the opposite side. This process can be iterated, taking the barycentric subdivision of each of the six triangles, and continuing. How quickly do the triangles become skinnier as we iterate? A Lyapunov exponent gives the answer. This leads up to the introduction of Lyapunov exponents as the "magical numbers" that describe the expansion and contraction rates associated with a dynamical system. This concept is then placed in the mathematical framework of cocycles and hyperbolicity.

Starting with the foundational results of Oseledets and Anosov, Wilkinson then moves on to a wide range of modern developments, ranging from smooth dynamics and Pesin theory to translation surfaces and the spectral theory of ergodic Schrödinger operators. While these topics are quite diverse, the article emphasizes the connections between them that are made through the use of Lyapunov exponents and hyperbolicity. An additional common thread tying these subjects together is that they all feature the work of Artur Avila, who was awarded a Fields Medal in 2014. Wilkinson concludes with a short section on "metadynamics" and a summary of some of the major unifying themes running through this research area.

Wilkinson's exposition is original, elegant, passionate, and deep. Throughout the article, she maintains a very high standard of mathematical rigor. At the same time, she provides a great deal of geometric intuition through the use of well-chosen examples and striking visuals. Definitions of abstract concepts are followed by examples and special cases that are natural and relatively simple, but do not trivialize the subject and offer interesting phenomena for analysis. For instance, the discussion of random matrix cocycles, derivative cocycles, and the hyperbolic cocycle behind the barycentric subdivision clarifies the definition of a cocycle and provides valuable insights into how experts think about this concept and how they work with it in practice. The part related to mathematical physics is illustrated by the "Hofstadter butterfly," a fractal (discovered by Douglas Hofstadter of *Gödel, Escher, Bach* fame) whose each horizontal slice is the spectrum of a discrete magnetic Schrödinger operator. The same fractal also has a dynamical interpretation, and deep theorems relate its spectral properties to the dynamical ones. Wilkinson surveys these results. The explanations are clear and accessible to a wide audience. This is an impressive feat, given that this area of research has a reputation for being very technical and difficult to explain to non-experts. The article could be skimmed for a quick introduction to a fascinating part of mathematics, but it also lends itself to careful and repeated study, rewarding the more invested reader with a deeper understanding of the subject. We expect that it will be a valuable resource for many years to come.

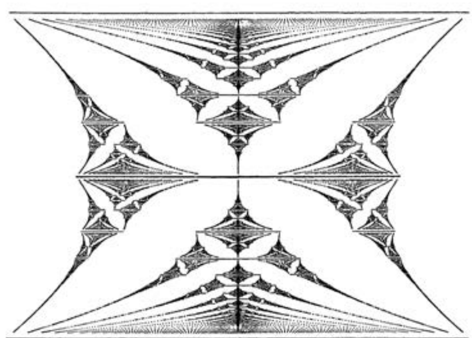

Figure 1: Hofstadter's butterfly. Reprinted figure with permission as follows: Douglas R. Hofstadter, "Energy levels and wave functions of Block electrons in rational and irrational magnetic fields," *Physical Review B* **14** (1976), 2239–2249. Copyright 1976, American Physical Society.

Biographical Note

Amie Wilkinson is a Professor of Mathematics at the University of Chicago working in ergodic theory and smooth dynamics. She received her undergraduate degree at Harvard and Ph.D. at Berkeley in 1995 with Charles Pugh. She held postdoctoral positions at Harvard and Northwestern and rose to the level of full professor at Northwestern before moving to Chicago in 2011.

Wilkinson was the recipient of the 2011 AMS Satter Prize, and she gave an invited talk in the Dynamical Systems section at the 2010 ICM. In 2013 she became a fellow of the AMS for "contributions to dynamical systems," and in 2019 she was elected to the Academia Europaea.

Wilkinson's research is concerned with the interplay between dynamics and other structures in pure mathematics—geometric, statistical, topological, and algebraic.

Response from Amie Wilkinson

I would like to thank the AMS for this great honor. The exponential growth rates measured by Lyapunov exponents are a powerful and yet elusive predictor of chaotic dynamics, and they aid in the fundamental task of organizing the long-term behavior of orbits of a system. Through the mechanism of renormalization, exponents of meta-dynamical systems direct the seeming unrelated behavior of highly structured systems like rational billiard tables and barycentric subdivision. Lyapunov exponents can deliver delightful surprises as well, leading to crazy geometric structures such as the pathological foliations Mike Shub and I have studied. To summarize, I love the subject of this article and am delighted that I might have conveyed this affection to the reader.

I have many colleagues to thank for their input and support; three of them in particular I'd like to mention by name. Artur Avila, whose work was the guiding inspiration for this article, has in many ways shaped how I view Lyapunov exponents and has opened my eyes to their power and versatility. Curtis McMullen explained to me his beautiful analysis of the barycenter problem, which served as the perfect introduction to the subject. Svetlana Jitormirskaya was instrumental in helping me get the facts straight on ergodic Schrödinger operators. Finally, I would like to thank the AMS for first inviting me to talk on the work of Artur Avila at the AMS Current Events Bulletin in 2016, a lecture on which this article was based.

Joseph L. Doob Prize

This prize was established in 2003 by the American Mathematical Society to recognize a single, relatively recent, outstanding research book that makes a seminal contribution to the research literature, reflects the highest standards of research exposition, and promises to have a deep and long-term impact in its area. The book must have been published within the six calendar years preceding the year in which it is nominated. The prize (originally called the Book Prize) was endowed in 2005 by Paul and Virginia Halmos and renamed in honor of Joseph L. Doob. Paul Halmos (1916–2006) was Doob's first Ph.D. student. Doob received his Ph.D. from Harvard in 1932 and three years later joined the faculty at the University of Illinois, where he remained until his retirement in 1978. He worked in probability theory and measure theory, served as AMS president in 1963–1964, and received the AMS Steele Prize in 1984 "for his fundamental work in establishing probability as a branch of mathematics." Doob passed away on June 7, 2004, at the age of ninety-four.

Citation

René Carmona and François Delarue

The 2020 Joseph L. Doob Prize is awarded to the two-volume set *Probabilistic Theory of Mean Field Games with Applications, I and II*, written by René Carmona and François Delarue, and published by Springer Nature in 2018 in the series *Stochastic Analysis and Applications*.

Stochastic game theory is a vastly complicated subject that attempts to model how rational individuals interact within a random environment, while each pursues her/his own, usually conflicting, goals. Understanding even simple-looking model problems requires designing strategies and counterstrategies of often great complexity. But "mean field games," introduced a decade ago by J. M. Lasry and P. L. Lions and by M. Huang, R. P. Malhamé, and P. E. Caines, offer a resolution, looking for simpler strategic structures that sometimes appear in the limit as the number of identically motivated players goes to infinity. The analogy with statistical physics should be clear. The motivating insight is that each individual need not respond much to the precise decision of any other player, but rather to the empirical distribution of the cumulative effects of all the others' actions.

These two magisterial volumes by René Carmona and François Delarue provide an accessible, fully detailed introduction to the exciting prospects for mean field games and to their considerable mathematical subtleties:

Volume I: Mean Field FBSDEs, Control, and Games introduces mean field games for which there are no random effects common to all players, so-called "games without common noise." The reader will find here well-written chapters on finite-person stochastic games, optimality and forward-backward stochastic differential equations (FBSDEs), deriving mean field game limit PDEs, calculus on Wasserstein spaces, and much more.

More complicated stochastic effects lead to much more complex "games with common noise," analyzed in *Volume II: Mean Field Games with Common Noise and Master Equations*. Most of the exposition here is devoted to building solutions of the master equation, a highly non-linear second-order PDE defined on a space of probability measures.

With these two volumes, Carmona and Delarue contribute immensely to our understanding of mean field games (and they in turn generously acknowledge their debt to many other colleagues).

Biographical Note

René Carmona, Ph.D., is the Paul M. Wythes '55 Professor of Engineering and Finance at Princeton University in the Department of Operations Research and Financial Engineering. He is an associate member of the Department of Mathematics, a member of the Program in Applied and Computational Mathematics, and Director of Graduate Studies of the Bendheim Center for Finance where he oversees the Master in Finance program. He obtained a Ph.D. in probability from Marseille University where he held his first academic job. After time spent at Cornell and a couple of stints at Princeton, he moved to the University of California at Irvine in 1981 and eventually to Princeton University in 1995.

Dr. Carmona is a Fellow of the Institute of Mathematical Statistics since 1984, and of the Society for Industrial and Applied Mathematics since 2009. He is the founding chair of the SIAM Activity Group on Financial Mathematics and Engineering, a founding editor of the journal *Electronic Communications in Probability*, and the *SIAM Journal on Financial Mathematics*. He is on the editorial board of several peer-reviewed journals and book series.

His publications include over one-hundred articles and eleven books in probability, statistics, mathematical physics, signal analysis, and financial mathematics. Over the last decade he tried to understand from a probabilistic point of view, a class of mathematical models introduced independently and simultaneously by a couple of French applied mathematicians (Jean Michel

Lasry and Pierre Louis Lions) and a group of electrical engineers in Canada (Peter Caines, Minyi Huang, and Roland Malhamé), known under the name of Mean Field Games. Together with François Delarue, he developed a probabilistic approach to these models. This collaboration culminated in a two-volume book providing the state of the art on the subject.

More information can be found at `http:\\www.princeton.edu\~rcarmona`.

Biographical Note

François Delarue was born in 1976 in Normandy, France. He graduated from the Ecole Normale Supérieure de Lyon (France) where he studied from 1996 to 1999. He received a Ph.D. from the University of Marseille (France) in 2002 working on stochastic differential equations under the supervision of Etienne Pardoux. The same year, he was hired by University Paris 7-Diderot as an assistant professor ("maître de conférence" in the French system) at the research laboratory "Laboratoire de Probabilités et Modèles Aléatoires." He stayed in Paris from 2002 to 2009 working in the team of Francis Comets, who was his advisor for the "habilitation à diriger des recherches" (French degree for supervising Ph.D. theses) that he received in 2008. Since 2009, he has been full professor at the research laboratory of mathematics "Laboratoire Dieudonné" of University of Nice Sophia Antipolis. In 2014, he was appointed a junior fellow of the Institut Universitaire de France for five years. Since 2019, he has been supported by a chair allocation from the "Institut 3IA" (Institute for Artificial Intelligence in Nice). François Delarue's research is in stochastic analysis including mean field particle systems and applications to partial differential equations. He met his co-author René Carmona for the first time in 2009 and he invited him to spend one month in Nice in 2010 in order to initiate a collaboration. Since René's visit, they have been working together on the probabilistic approach to mean field games. François Delarue's research on the subject is supported by the French National Research Agency ("ANR"). Since 2011, François Delarue has been managing, at the department of mathematics of the University of Nice, the European MSc program in applied mathematics "Mathmods", which runs in collaboration with other universities in Europe. Since 2018, he has also been managing the CNRS International Research Network of mathematics between Southern Europe and Northern Africa. Since 2019, he has been co-editor in chief, with Peter Friz, of the journal *Annals of Applied Probability*.

Response from René Carmona and François Delarue

We are deeply honored and grateful to receive the 2020 Joseph L. Doob Prize, and especially humbled by Doob's towering figure in the history of probability and its foundations.

We began working together nearly a decade ago, driven by the common desire to develop stochastic analysis tools that could be used to solve applied problems in mathematical physics. A couple of published journal articles and two years of travel between Nice and Princeton later, we became excited by the potential of an otherwise nascent mathematical model for large anonymous games with mean field interactions. It quickly became clear to us that there was something really special and potentially far-reaching in these models that were introduced independently and simultaneously by a couple of French applied mathematicians (Jean Michel Lasry and Pierre Louis Lions) and a group of electrical engineers in Canada (Peter Caines, Minyi Huang, and Roland Malhame). We are thankful for their groundbreaking innovation.

For us, the next step was to develop an approach that would facilitate the emergence of a subfield that was not limited to the analytic methods used in the subject's earliest works. We worked to further academic understanding of the subject and to generate excitement among students, colleagues, and younger researchers by advising students, teaching short courses, organizing conferences, and generally proselytizing on the subject. In doing so, we came to the conclusion that there was a dire need for a comprehensive presentation of the subject if research was to thrive and ultimately become the basis of a subfield. We started compiling the many motivating examples of the theory's applications, including those from finance, economics, population biology, logistics, and operations research. We streamlined results from all of the works that have appeared on the subject over the last decade, and presented them in a unified framework. As is often the case, in these early stages we did not have a clue just how extensive this project would be, what the final product would look like, and of the toll it would take on our lives. We also did not expect this project to prompt such profound honor and satisfaction, epitomized by this award, which has been granted to so many prestigious and highly influential mathematicians before us.

Of particular note to us has been the wide range of scientific subfields beyond our immediate community that have already cited this book, and the extent to which new generations of researchers are both relying on our probabilistic approach and extending the scope of its applications. Witnessing this, and the many opportunities, conversations, and collaborations that this book has made possible, has been deeply heartening. We want to thank the committee for recognizing all of this, and above all else, for seeing this book's potential to "provide an accessible, fully detailed introduction to the exciting prospects for mean field games and to their considerable mathematical subtleties" and to "contribute immensely to our understanding of mean field games."

Leroy P. Steele Prize for Mathematical Exposition

The Leroy P. Steele Prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein and are endowed under the terms of a bequest from Leroy P. Steele. Prizes are awarded in up to three categories. The following citation describes the award for Mathematical Exposition.

Citation

Martin R. Bridson and André Haefliger

The 2020 Steele Prize for Mathematical Exposition is awarded to Martin R. Bridson and André Haefliger for the book *Metric Spaces of Non-positive Curvature*, published by Springer-Verlag in 1999.

Metric Spaces of Non-positive Curvature is the authoritative reference for a huge swath of modern geometric group theory. It realizes Gromov's vision of group theory studied via geometry, has been the fundamental textbook for many graduate students learning the subject, and paved the way for the developments of the subsequent decades.

At the turn of the 20th century, Max Dehn was interested in topological problems about closed surfaces. He translated these problems into algebraic questions about the fundamental group and then solved them using the geometry of the action of the fundamental group on the universal cover. Subsequently, Dehn and others used combinatorial properties of group presentations in place of geometric properties of spaces to develop combinatorial group theory. It was only in the 1980s, with Gromov's seminal papers drawing parallels between Riemannian geometry and group theory, that the field of geometric group theory came into being. Much of the 1990s was spent finding rigorous proofs of Gromov's insights and expanding upon them. *Metric Spaces of Non-positive Curvature* is the outcome of that decade of work, and has been the standard textbook and reference work throughout the field in the two decades of dramatic progress since its publication in 1999.

A metric space of non-positive curvature is a geodesic metric space satisfying the (local) CAT(0) condition, that every pair of points on a geodesic triangle should be no further apart than the corresponding points on the "comparison triangle" in the Euclidean plane. Examples of such spaces include non-positively curved Riemannian manifolds, Bruhat–Tits buildings, and a wide range of polyhedral complexes.

This book is the definitive text on these spaces and the groups associated with them. The theory is developed carefully, in great generality. All the foundational theorems are proved, and the important examples are covered. The proofs are clear and comprehensive. The necessary density of such a work is offset by the inclusion of a large number of exercises, making it invaluable both as a graduate text and as a reference for active researchers.

Biographical Note

Martin R. Bridson was born in the Isle of Man in 1964. He was an undergraduate at Hertford College Oxford and received his Ph.D. from Cornell in 1991, advised by Karen Vogtmann. He was an Assistant Professor at Princeton until 1996, with extended leaves spent in Geneva and Oxford. He was a Tutorial Fellow and Professor of Topology at Oxford (Pembroke College), then Professor of Pure Mathematics at Imperial College London. Since 2007 he has been the Whitehead Professor of Pure Mathematics at the University of Oxford, where he served as Head of the Mathematical Institute 2015-18. He is now President of the Clay Mathematics Institute.

Bridson's research interests revolve around the interaction of geometry, topology, and group theory. He has been awarded the Whitehead Prize of the London Mathematical Society, the Forder Lectureship of the New Zealand Mathematical Society, and a Royal Society Wolfson Research Merit Award. He gave an Invited Address to the Joint Mathematics Meeting in 2001 and was an Invited Speaker at the ICM in Madrid in 2006. He is a Fellow of the American Mathematical Society, and was elected a Fellow of the Royal Society in 2016.

Biographical Note

André Haefliger was born in Nyon, Switzerland, in 1929. He received his Ph.D. from Paris-Sorbonne in 1958; his thesis director was Charles Ehresmann and the President of the jury was Henri Cartan. From 1961, he spent two years at the Institute for Advanced Study in Princeton. With the help of George de Rham, he created the Department of Mathematics at the University of Geneva, where he remained as Professeur until retiring in 1996. He travelled widely, visiting universities across Europe, the Americas, the Soviet Union, Japan, China, and (many times) India. He was honored by a *Doctorat Honoris Causa* from ETH Zurich in 1992 and the University of Dijon in 1997.

His research interests have ranged widely, including: diverse aspects of the theory of foliations; differentiable maps—jet spaces, immersions and embeddings, knotting for high-dimensional spheres; complex analytic structures; orbifolds and complexes of groups. For the past fifteen years he has concentrated his efforts on the archives of Armand Borel (now in Geneva) and René Thom. He also initiated the publication of the complete mathematical works of René Thom, with critical notes and significant unpublished documents.

Response from Martin R. Bridson and André Haefliger

We are honoured and delighted to receive the Steele Prize for Mathematical Exposition. We are particularly pleased that the Prize Committee commented on the value that students have found in our book; to see it used widely as a textbook has been immensely gratifying. It has also been rewarding to see it serve as a reference for the many colleagues who have advanced geometric group theory so spectacularly over the past twenty years.

We wrote “The purpose of this book is to describe the global properties of complete simply-connected spaces that are non-positively curved in the sense of A. D. Alexandrov and to examine the structure of groups that act on such spaces by isometries.” Misha Gromov brought many ideas from the Alexandrov school to prominence in the West, and his contribution goes far beyond an act of transmission: he gave us an inspiring vision that melded the metric geometry of the Russian school with numerous novel ideas that drew on his unique insights into differential geometry, topology, and group theory. Finitely generated groups, viewed as geometric objects, were at the heart of this vision, and the interaction of groups and geometry is correspondingly central to our book.

It was a desire to extend Serre’s theory of graphs-of-groups to higher dimensions that led to our collaboration. André, who was developing a theory of complexes of groups, visited John Stallings in Berkeley in 1989. Stallings, working with Gersten on triangles of groups, was developing similar ideas. Martin, struggling to understand Gromov’s essay *Hyperbolic Groups* while a graduate student at Cornell, had resolved a challenge in the geometric foundations of polyhedral geometry that had been obstructing the work of both André and Gersten-Stallings. When André learned of this from Stallings, he wrote to Martin and subsequently arranged a position for him in Geneva. It was there in 1992-93 that we decided to write our book, naively assuming that we would finish during our stay at a chalet in the Swiss mountains in July 1993, allowing time for long walks in the afternoons. Our sense of what the book should contain expanded in the years that followed, but as the field expanded we had to accept that there were many things we could not cover. We sent the final manuscript to Springer on the first day of Spring 1998.

We were at opposite ends of our careers when we embarked on this project and we came with our own tastes, but it was a joy to explore the mathematics together and to argue until we agreed on how to present each idea. The structure of our profession does not reward the effort of writing a monograph as readily as it rewards theorems presented in discrete papers published promptly. There are good reasons for this, but the enduring value of a book that gives students and colleagues access to a coherent body of ideas is something to be treasured, and we applaud the American Mathematical Society for recognising that value through the Steele Prize.

Leroy P. Steele Prize for Seminal Contribution to Research

The Leroy P. Steele Prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein and are endowed under the terms of a bequest from Leroy P. Steele. Prizes are awarded in up to three categories. The following citation describes the award for Seminal Contribution to Research.

Citation

Craig Tracy and Harold Widom

The 2020 Steele Prize for a Seminal Contribution to Research in Analysis/Probability Theory is awarded to Craig Tracy and Harold Widom for the paper "Level-spacing distributions and the Airy kernel," published in 1994 in *Communications in Mathematical Physics*.

In this work, Tracy and Widom found the exact asymptotics of the n^{th} largest eigenvalue ($n = 1, 2, \ldots$) of an $N \times N$ random Hermitian matrix, suitably scaled, as N goes to ∞. Tracy and Widom showed that the scaled eigenvalues converge to random variables, each with a specific distribution function $F(n; s)$, which they characterized in terms of a particular solution of a Painlevé II differential equation. The paper emphasizes the close connection between operator theory and random matrices, and proved to be an important step in the development of "integrable probability."

From a statistician's perspective, the introduction of the Tracy-Widom distributions has been a breakthrough of lasting importance. The eigenvalues of sample covariance matrices are fundamental for the analysis of high-dimensional data. For reasons of dimension reduction or otherwise, interest often focuses on the top sample eigenvalues. The Tracy-Widom distributions characterize the limiting distribution of the top eigenvalue in the "null hypothesis" case of no structure, a challenge for statisticians since the 1950s. In particular, the distribution function $F(2; s)$ governs the complex-valued data of signal processing.

Further notable applications of these distribution functions include the celebrated distribution of the length of the longest increasing subsequence in a random permutation and the height-fluctuations random growth models in the KPZ (Kardar-Parisi-Zhang) universality class. The Airy kernel appearing in the title of the nominated paper has been generalized to the Airy process and then to the Airy sheet, used recently in describing the KPZ fixed point.

Craig Tracy and Harold Widom have collaborated on many other works that have had a significant impact. Their discovery of the Tracy-Widom distribution, however, is a towering accomplishment exactly of the kind the Steele Prize for Seminal Contribution to Research is designed to recognize.

Biographical Note

Craig Tracy was born in England on September 9, 1945, the son of Eileen Arnold, a British subject, and Robert Tracy, an American serving in the U.S. Army. After immigrating to the United States as an infant, Tracy grew up in Missouri where he attended the University of Missouri at Columbia, graduating in 1967 as an O.M. Stewart Fellow with a B.S. degree in physics. He began his graduate studies as a Woodrow Wilson Fellow at Stony Brook University where he wrote his doctoral dissertation under the supervision of Barry McCoy. After postdoctoral positions at the University of Rochester (1973–75) and the C.N. Yang Institute for Theoretical Physics (1975–78), Tracy was at Dartmouth College for six years before joining the University of California, Davis, in 1984. He is currently Distinguished Professor of Mathematics at UC Davis.

In 2002 Tracy was awarded, jointly with Harold Widom, the SIAM George Pólya Prize, and in 2007 the AMS-SIAM Norbert Wiener Prize, also jointly with Widom. In 2006 Tracy was elected a member of the American Academy of Arts and Sciences.

Tracy has two daughters, two step-daughters, seven grandchildren and one step-grandchild. He is married to Barbara Nelson, and they reside in Sonoma, California.

Biographical Note

Harold Widom grew up in New York City, where he attended Stuyvesant High School and the City College of New York. He did his graduate work at the University of Chicago, receiving his Ph.D. under the supervision of Irving Kaplansky. He is now distinguished professor emeritus at the University of California, Santa Cruz. His first academic position was at Cornell University where, inspired by Mark Kac, he turned his attention to the study of Toeplitz and Wiener-Hopf operators. This influenced much of his subsequent research and led ultimately to his work (largely in collaboration with Craig Tracy) in integrable systems and random matrix theory. He is an associate editor of *Asymptotic Analysis*, *Journal of Integral Equations and Applications*, and *Mathematical Physics, Analysis and Geometry*. He is an honorary editor of *Integral Equations and Operator Theory*. He is a member of the American Academy of Arts and Sciences. In 2002 he was awarded, jointly with Craig Tracy, the SIAM George

Pólya Prize; and in 2007, also with Craig Tracy, the AMS-SIAM Wiener prize. He has three children and four grandchildren.

Response from Craig Tracy and Harold Widom

We are honored to be named the recipients of the 2020 Leroy P. Steele Prize for Seminal Contribution to Research in Analysis/Probability Theory. We thank the members of the Selection Committee and the Executive Committee of the AMS Council for their decision.

We first express our appreciation of Estelle L. Basor, with whom we wrote our first joint paper on random matrices. She was a Ph.D. student of Widom and had written a joint paper with Tracy on tau-function asymptotics. It was she who suggested that Widom be asked to join them in working on a random matrix problem of Freeman Dyson. This we did and it was the beginning of our further collaboration.

Two who most influenced our early work were Madan L. Mehta and Freeman Dyson. Mehta alerted us to an alternative derivation he devised for the equations of Jimbo, Miwa, Môri, and Sato governing eigenvalue spacings in the bulk of the spectrum. His derivation used Fredholm expansions extensively. We saw that by using some operator theory we could simplify his argument; then we were able to extend the method to obtain equations for other operator ensembles. With Freeman Dyson we had extensive discussions and written correspondence in all aspects of random matrices (especially with regard to our work on orthogonal and symplectic ensembles).

In our subsequent work on random matrices, we had valuable interactions with, among others, Mark Adler, Pierre van Moerbeke, John Harnad, and Alexander Its.

Some years later, we were able to use ideas from Bethe Ansatz to show that a largest eigenvalue distribution function arising in random matrices arises also in a scaling limit of the asymmetric simple exclusion process (a model lying outside the class of determinantal processes).

We also thank the diverse group of researchers in random matrix theory and integrable systems for making this an exciting field in which to work.

Leroy P. Steele Prize for Lifetime Achievement

The Leroy P. Steele Prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein and are endowed under the terms of a bequest from Leroy P. Steele. Prizes are awarded in up to three categories. The following citation describes the award for Lifetime Achievement.

Citation

Karen Uhlenbeck

The 2020 Steele Prize for Lifetime Achievement is awarded to Karen Uhlenbeck for her long-lasting influence in geometric topology and analysis and for her mentorship of young people and women in mathematics. Karen Uhlenbeck's mathematics has laid the foundation for a tremendous range of research in differential geometry and geometric analysis over the past four decades. Her early work with J. Sacks and R. Schoen analyzed the limiting behavior of sequences of minimizers of geometric functionals (such as the energy functional), and showed that, even though there may be no limit in the conventional sense, such sequences often have geometrically understandable limits that appear as "bubbles." This insight gave birth to a whole field of research on harmonic maps and minimal surfaces which allowed for their many applications in geometry and topology, and it was a direct inspiration for M. Gromov's work on pseudo-holomorphic curves in symplectic geometry. Karen Uhlenbeck was also the founder of analytic studies of gauge-theoretic equations in higher dimensions. By showing how to analyze the behavior of non-convergent sequences of solutions to these natural, semi-linear partial differential equations, she provided precisely what is needed to apply these equations effectively to fundamental problems in topology and geometric topology. These ideas were elaborated in her work with S. T. Yau on the existence of Yang-Mills connections, as well as in the ground-breaking work by S. Donaldson and later C. Taubes that applied gauge theory to analyze the structure of four-dimensional manifolds. Throughout her career, Karen Uhlenbeck has worked to support young mathematicians and strengthen the mathematical community. In particular, she was a co-founder both of the Park City Mathematical Institute and of the Women and Mathematics Program at the Institute for Advanced Study, co-directing the latter with C.-L. Terng for over twenty years. As only the second woman to give a plenary ICM address and the first to be awarded the Abel Prize, she has expanded the reach and visibility of women in mathematics, and is an inspiration to all mathematicians.

Biographical Note

Karen Uhlenbeck was born in 1942, the first of four children. Her mother was an artist and her father an engineer. She grew up in rural northern New Jersey and graduated from Bernards High School in 1960. She received her B.S. in mathematics from the University of Michigan in 1964 and her Ph.D. from Brandeis University under the direction of Richard Palais in 1968. After post doctoral positions at MIT and the University of California, Berkeley, she became an assistant professor at the University of Illinois in Urbana in 1972, followed by associate and full professor at the University of Illinois in Chicago (1977–83). In 1983 she moved to the University of Chicago. After four years at the University of Chicago, she moved to the University of Texas at Austin in 1987, and spent most of her career there as a Sid Richardson Professor of Mathematics, retiring in 2014. Since this time she has had a visiting position at the Institute for Advanced Study in Princeton.

Karen Uhlenbeck has been on the council of the AMS, a Vice-President of the AMS, and was elected a Fellow of the AMS. Among her honors are a MacArthur Fellowship, election to the National Academy of Sciences, the National Medal of Science, the Steele Prize for Seminal Contribution to Research, election to the American Philosophical Society, and honorary degrees from seven colleges and universities. Most recently, she received the Abel Prize in 2019. She is proud to have been one of the founders of the Park City Mathematics Institute, of her work with Chuu-Lian Terng in starting the Women and Math Program at IAS, and of the outreach projects at the University of Texas (which include Saturday Morning Mathematics and the Distinguished Lectureships for Women). According to the Mathematics Genealogy Projects she has had 19 Ph.D. students (but she counts 20).

Response from Karen Uhlenbeck

It is an honor to be the second woman to receive the Steele Prize for Lifetime Achievement from the AMS. It has been an interesting and rewarding career. I have had ample opportunity in the past year to review my mathematical career, and I continue to be amazed at how well it worked out. I seem to have been at the right place at the right time, and to have received support from the right individuals along the way.

I would most like to talk about the mathematics; how the subject of global analysis came about and developed into geometric analysis, became entwined with theoretical physics and continues to flourish. There is not space here for this story, but that I have been able to take part in this mathematics is due to the mathematical environment we live in.

I am indebted to the mathematics community for the encouragement and support I received as an undergraduate, a graduate student, a postdoc, and a developing researcher. My thesis advisor, Richard Palais, was a wonderful teacher who pointed me in interesting mathematical directions for many years. Dan Freed and I carried out many projects together and my long-term collaboration with Chuu-Lian Terng took me in unexpected directions. My students have more than paid me back over the years, and my many collaborators allowed me to venture into many different types of mathematics. I have always credited S. T. Yau with finally establishing me in my own view as a real mathematician, not someone lurking on the edges of the subject.

The years I spent at the University of Texas, with endowment funds donated by Peter O'Donnell, gave me the opportunity to help build a major mathematics department and to become involved in many outreach projects. The Institute for Advanced Study gave Chuu-Lian and myself the opportunity to develop the Women and Math mentoring project and has taken me in many times including in my retirement. Finally, I would never have landed in this position without the women activists, those of the first and second waves of feminism as well as the mathematicians who dedicated large chunks of their lives towards opening up the profession to include women. And where would we all be without the women and men who continue on with new contributions to our subject?

Many thanks to all of the above.

Louise Hay Award for Contribution to Mathematics Education

The Executive Committee of the Association for Women in Mathematics (AWM) established the Louise Hay Award for Contribution to Mathematics Education in 1990. The purpose of this award is to recognize outstanding achievements in any area of mathematics education, to be interpreted in the broadest possible sense. While Louise Hay was widely recognized for her contributions to mathematical logic and for her strong leadership as head of the Department of Mathematics, Statistics, and Computer Science at the University of Illinois at Chicago, her devotion to students and her lifelong commitment to nurturing the talent of young women and men secure her reputation as a consummate educator. The annual presentation of this award is intended to highlight the importance of mathematics education and to evoke the memory of all that Hay exemplified as a teacher, scholar, administrator, and human being.

Citation

Erika Camacho

In recognition of her leadership and contributions as a mathematical scholar and educator, the AWM presents the 2020 Louise Hay Award to Dr. Erika Camacho of Arizona State University.

Dr. Camacho has a passion for mentoring, especially the mentoring of underrepresented students. Her mentoring begins with her excitement for mathematics based in her research in mathematical physiology. This research involves developing mathematical models that describe the interactions of photoreceptors in the retina. Dr. Camacho brings graduate and undergraduate students into her research and also finds opportunities for students with other researchers.

She created the Applied Mathematical Sciences Summer Institute and has co-directed both this institute (2004–2007) and the Mathematical and Theoretical Biology Institute (2011–2013). Through these institutes and her other mentoring programs she has impacted over 600 undergraduates, including supervising the research of 89 of these students with 30 receiving conference award recognitions.

Through her work Dr. Camacho changes perceptions. Her own story is an existence proof that someone from an underprivileged and Latina background can earn a Ph.D. in mathematics and be a successful mathematician. In her over 65 plenary and panel presentations, she uses her story to inspire students to persevere and succeed in mathematics. Beyond presenting, Dr. Camacho meets with attendees individually afterwards to learn about their stories and give them advice based on their own interests and passions. By inspiring more women and members of underrepresented groups to continue in their mathematical pursuits, she enlarges of the scope of what we see as successful mathematicians

Response from Erika Camacho

I am humbled to receive the Louise Hay Award for Contributions to Mathematics Education. Dr. Hay was truly a role model for breaking down barriers and creating the supportive environment that allowed many to succeed. Whether in the classroom, mentoring through research, or sharing some of the struggles that I have overcome, I can often empathize with my students and other mentees in my efforts to help them find a good way forward. My mentors have helped me in a similar way, and I have likewise tried to create a nurturing environment for my students and mentees. Beginning with my high school teacher Jaime Escalante, through key professors at Wellesley College (B.A.) and Cornell University (Ph.D.), and finally to those that have helped me navigate an often-challenging academia, I have needed each of them to succeed (and fail!) and help make me into who I am. Dr. Hay's personal story is so inspiring, and I thank the AWM for creating this award to help honor her legacy. Her lifelong commitment to nurturing the talent of young women and men exemplified her desire to build scientific capacity long before the phrase became popular. Creating a truly inclusive mathematical workforce is a goal all of us should have and one of my lifelong passions.

M. GWENETH HUMPHREYS AWARD FOR MENTORSHIP OF UNDERGRADUATE WOMEN IN MATHEMATICS

THE award is named for M. Gweneth Humphreys (1911–2006). Professor Humphreys graduated with honors in mathematics from the University of British Columbia in 1932, earning the prestigious Governor General's Gold Medal at graduation. After receiving her master's degree from Smith College in 1933, Humphreys earned her Ph.D. at age twenty-three from the University of Chicago in 1935. She taught mathematics to women for her entire career, first at Mount St. Scholastica College, then for several years at Sophie Newcomb College, and finally for over thirty years at Randolph–Macon Woman's College. This award, funded by contributions from her former students and colleagues at Randolph–Macon Woman's College, recognizes her commitment to and her profound influence on undergraduate students of mathematics.

CITATION

Margaret Robinson

Margaret Robinson has been a mainstay of caring and thoughtful teaching and mentoring for many years at Mount Holyoke College, an institution whose mission is to educate women. Her focus is not just on the top students but on making a meaningful (and joyful) mathematical intervention for all the generations of learners that have crossed her path. As one student put it, "she saw me in a way that no mathematics teacher had before." Her impactful involvement in the Carleton Summer Math Program and the resounding response from a range of former mentees speak to her effectiveness and her ability to forge personal connections. We are pleased to honor her with the M. Gweneth Humphreys Award for Mentorship of Undergraduate Women in Mathematics.

Response from Margaret Robinson

I am greatly honored and delighted, and also somewhat overwhelmed, to receive the M. Gweneth Humphreys Award for Mentoring. My phenomenal department and students at Mount Holyoke College have inspired me throughout my career. I would also like to thank Deanna Haunsberger and Stephen Kennedy for inviting me to teach in the Summer Mathematics Program at Carleton College and for introducing me to so many wonderful women who have enriched my mathematical life over the past 10 years. An award of this type sends the message that the AWM acknowledges and values the importance of mentoring, and I offer my heartfelt thanks to the 2020 Humphreys Award Committee.

MICROSOFT RESEARCH PRIZE IN ALGEBRA AND NUMBER THEORY

THE Executive Committee of the Association for Women in Mathematics established the AWM-Microsoft Research Prize in Algebra and Number Theory in 2012. First presented in 2014, the prize is awarded every other year. The purpose of the award is to highlight exceptional research in some area of algebra by a woman early in her career. The field will be broadly interpreted to include number theory, cryptography, combinatorics and other applications, as well as more traditional areas of algebra. Candidates should be women, based at US institutions who are within ten years of receiving their Ph.D., or having not yet received tenure, at the nomination deadline.
The AWM-Microsoft Research Prize serves to highlight to the community outstanding contributions by women in the field and to advance the careers of the prize recipients. The award is made possible by a generous contribution from Microsoft Research.

CITATION

Melody Chan

The 2020 AWM-Microsoft Research Prize in Algebra and Number Theory is presented to Professor Melody Chan, in recognition of her spectacular advances at the interface between algebraic geometry and combinatorics.

Melody Chan received her doctorate in 2012 from University of California, Berkeley. She is currently an Assistant Professor at Brown University and a Sloan Research Fellow, after holding an NSF Postdoctoral Fellowship at Harvard University.

Chan is known for an exceptional combination of strength in both combinatorics and algebraic geometry, as well as her ability to fearlessly digest difficult techniques from other fields of mathematics. Chan has proved numerous conjectures across tropical geometry, graph theory, and algebraic geometry. In Chan's recent work with Galatius and Payne, they showed that the top degree cohomology of the moduli space of genus g curves grows exponentially in g, an astounding result which contradicts conjectures of Kontsevich and Church-Farb-Putman that said this cohomology should vanish. This breakthrough comes from a deep study of moduli spaces of tropical curves. Chan's foundational work on the moduli of metric graphs and tropical curves, both solo and with several co-authors, is central to the field, already having important applications, and is expected to continue to lead to further work far beyond the original papers. Chan's work with Pflueger, López Martín, and Teixidor i Bigas proves beautiful new results on the expected number of turns in a random Young tableau and then applies them to give explicit topological information on Brill-Noether varieties that seemed beyond reach before their work. Other researchers call Chan a "leader" and a "major force" and are impressed by both her insights and her technical prowess. AWM congratulates Melody Chan for her well-deserved AWM-Microsoft Research Prize.

Response from Melody Chan

I am happy to receive the 2020 AWM-Microsoft Prize in Algebra, and I thank the AWM and Microsoft for their generosity in recognizing my work. I have learned so much from my close collaborators: Renzo Cavalieri, Soren Galatius, Sam Payne, Nathan Pflueger, Martin Ulirsch, and Jonathan Wise. I'm also grateful for the support and mentorship of Dan Abramovich, Matt Baker, Lucia Caporaso, Joe Harris, Diane Maclagan, and especially my Ph.D. advisor Bernd Sturmfels, and many other mathematicians, including my many supportive colleagues at Brown.

Getting to do research in mathematics is a privilege. After all, basic research in math and science is a long game: we get to study fundamental questions that may have no applications right now but, in totality and over the course of history, make an outsized impact in ways we couldn't have predicted. And we get to have fun while doing it, too. But that whole calculus is predicated on having time, having breathing room, to think about the long game at all. Right now, I'm less and less sure that we have that room. We have a climate crisis on our hands, crises of civil rights and human rights, crises of democracy and disenfranchisement, entire crises of empathy. Our country is taking children from their parents. I've never been more concerned for my country and my community than I am now.

Being a math professor is, I think, still the best thing I personally know how to do. It's getting harder to carry out basic math research—like research on the combinatorics and geometry of moduli spaces, say—with any moral certainty. But there are many parts of the job that do have an immediate impact. We must train students well and find ways to support and include more of them in the first place; we must be role models, while interrogating our role as scientists; we must make more noise altogether. Let's work together on prioritizing these aspects of the profession, even while we push on our foundational research.

SADOSKY RESEARCH PRIZE IN ANALYSIS

THE Executive Committee of the Association for Women in Mathematics established the AWM-Sadosky Research Prize in Analysis in 2012. First presented in 2014, the prize is awarded every other year. The purpose of the award is to highlight exceptional research in analysis by a woman early in her career. The field will be broadly interpreted to include all areas of analysis. Candidates should be women, based at US institutions who are within ten years of receiving their Ph.D., or having not yet received tenure, at the nomination deadline.

The AWM-Sadosky Research Prize serves to highlight to the community outstanding contributions by women in the field and to advance the careers of the prize recipients. The award is named for Cora Sadosky, a former president of AWM and made possible by generous contributions from Cora's husband Daniel J. Goldstein, daughter Cora Sol Goldstein, friends Judy and Paul S. Green and Concepción Ballester.

CITATION

Mihaela Ignatova

The 2020 AWM-Sadosky Research Prize in Analysis is awarded to Mihaela Ignatova, Temple University, in recognition for her contributions to the analysis of partial differential equations, in particular in fluid mechanics. Ignatova received her Ph.D. in 2011 from the University of Southern California and has held appointments at the University of California-Riverside, Stanford University, and Princeton University. She works on challenging analytical questions motivated by problems rooted in applications. The breadth of her work is impressive, spanning from unique continuation properties to fluid-structure interaction problems to non-local models in electroconvection. For example, her work with Kukavica and Ryzhik extends considerably the validity of Harnack inequality to second-order operators with rough drifts. Her remarkable technical abilities are evident in several of her works, in particular in her study, joint with Peter Constantin, of the critical Surface-Quasi-Geostrophic equation in bounded domains. Ignatova developed a new approach to deal with boundaries, which provides also an alternative approach for the case without boundaries. Ignatova's work on fluid-structure interaction problems, joint work with Kukavica, Lasiecka, and Tuffaha, establishes well-posedness of a system coupling the fluid equations with a wave equation for an elastic structure with a moving free interface, and it is highly non-trivial. This work again highlights Ignatova's outstanding analytical skills, her unusual creativity, and her taste for physically-based problems. Ignatova is among the most talented young analysts in fluid mechanics and partial differential equations and is poised to become a leader in the field. She deserves the recognition that the AWM-Sadosky Prize entails.

Response from Mihaela Ignatova

I am truly honored to receive the AWM-Sadosky Research Prize in Analysis. The area of my research, analysis of PDEs, relies much on the methods of harmonic analysis, the field of Cora Sadosky, and it is a privilege to be recognized among the many excellent people who work in analysis. It's particularly gratifying to be awarded this prize by AWM, an organization whose support for women in mathematics is of great importance to society.

I would like to take this opportunity to thank some of the people who helped me become a research mathematician. My master's thesis advisor, Emil Horozov, impressed me with his knowledge and brilliance and encouraged me to pursue a career in math. I am greatly indebted to Igor Kukavica, who was my doctoral advisor and continues to be my collaborator, for his honest, uncompromising, and deep approach to mathematical research, and I thank him for his kind and thoughtful mentorship over the years.

I very much appreciate the opportunities I have had to work with powerful and creative collaborators in the area of analysis of PDEs originating from fluid mechanics and physics. I also wish to thank the leading mathematicians working in my area with whom I interact and from whom I have learned a lot and who continue to inspire me.

AMERICAN MATHEMATICAL SOCIETY
MATHEMATICAL ASSOCIATION OF AMERICA
SOCIETY FOR INDUSTRIAL AND APPLIED MATHEMATICS

FRANK AND BRENNIE MORGAN PRIZE FOR OUTSTANDING RESEARCH IN MATHEMATICS BY AN UNDERGRADUATE STUDENT

THE Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student recognizes and encourages outstanding mathematical research by undergraduate students. It was endowed by Mrs. Frank Morgan of Allentown, PA.

CITATION

Nina Zubrilina

The recipient of the 2020 AMS-MAA-SIAM Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student is Nina Zubrilina, for "her research in the areas of analysis and analytic number theory... characterized by her independent vision, her creativity, and her technical abilities." She was selected from a list of nominees with stellar accomplishments to their credits. Zubrilina is described as a researcher with unusually mature vision, who has obtained beautiful and surprising results that shocked leading experts in the field. Zubrilina has written six papers and preprints (with more forthcoming), all solo authored, which makes her early contributions to several areas of mathematics all the more impressive. Her published papers appear in *Discussiones Mathematicae* and *Discrete Mathematics*, with further papers under revision at the *International Journal of Number Theory* and the *International Mathematics Research Notices.*

In her earlier works, Zubrilina studied the number of connected components of ranges of divisor functions, and gave lower and upper bounds for the number of such, for a subclass of divisor-zeta functions with a real parameter. This work has prompted C. Defant to introduce the term "Zubrilina numbers," and to conjecture the infinitude of such. She also addressed part of a conjecture of Grimmett–Strizaker regarding the expected value of maximal bets in the Labouchere system; classified all the pairs of elements of $SL(\mathbb{N}_0)$ whose corresponding Möbius transformations map the right upper half plane into disjoint sets, answering a question of Nathanson; answered two open questions of Kalanc, Tretnik, and Yero concerning the edge dimension of a graph; and found an asymptotic formula for the edge metric dimension of the Erdős-Rényi graph with constant p.

In her most recent work, Zubrilina contributed substantially to the theory of sphere packings. Viazovska's breakthrough results in dimensions 8 and 24 were based on the properties of the zero sets of the optimal Cohn–Elkies function. Zubrilina focused on properties of the zero sets of optimal Cohn–Elkies functions in other dimensions. In her work, she has proved—under a very plausible regularity hypothesis—a fifteen-year-old conjecture of H. Cohn and N. Elkies regarding the relationship between best known bounds for packing density of spheres in high dimensions and an uncertainty principle for signs of functions. As an expert writes, "This [regularity] hypothesis seems difficult to remove, but Nina's argument amounts to greater progress than anyone else has made in the last fifteen years, and it gives the first conceptual reason why the conjecture should be true." The committee felt that Zubrilina's contributions to active research areas were original, numerous, and impactful. Her development as an independent thinker and mathematician shines through her work, which will undoubtedly continue to produce results appreciated by leading experts.

Zubrilina graduated from Stanford University with departmental honors and is now a Ph.D. student in mathematics at Princeton University. She has been awarded the Barry M. Goldwater Scholarship, The Paul & Daisy Soros Fellowships for New Americans, the Hertz Foundation Graduate Fellowship, the NSF Graduate Fellowship, the Princeton Centennial Fellowship, and an honorable mention for the Alice T. Schafer Mathematics Prize.

Biographical Note

Nina Zubrilina grew up in Moscow, Russia. She became interested in mathematics and started participating in math olympiads at an early age, and later attended the math magnet Moscow State High School #57. Nina earned her undergraduate honors math degree at Stanford University. In undergrad, she participated in the Duluth REU twice and spent a summer at Microsoft Research New England. Nina is currently pursuing a Ph.D. in mathematics at Princeton University. Apart from mathematical research, she enjoys playing music, making films and writing film scores, lifting, and reading.

Response from Nina Zubrilina

It is a great honor and a privilege to receive the 2020 Frank and Brennie Morgan Prize. I want to thank Mrs. Morgan as well as the AMS, MAA, and SIAM for supporting and encouraging undergraduate mathematical education.

I am incredibly grateful to Professor Thomas Church for the colossal work he has done to support me and other underrepresented undergraduates in the Stanford math department. Learning and working with Professor Church was the most rewarding part of my undergraduate career, and his unwavering support and mentorship gave me the desire and confidence to continue doing math in graduate school.

I am very thankful to Joe Gallian for the two wonderful and prolific summers in the Duluth REU, and his continued mentorship over the years. I would like to thank Henry Cohn for a very productive summer at Microsoft Research, and for contaminating me with his deep scientific curiosity about the world. Summer research experience was foundational to my decision to pursue a research career, and I am very thankful to Professor Gallian and Professor Cohn for creating such superb environments to try it out.

I want to thank my advisor Kannan Soundararajan, and all my excellent undergraduate professors and mentors, including but certainly not limited to Brian Conrad, Jacob Fox, Persi Diaconis, Daniel Bump, Lenya Ryzhik, Ravi Vakil, and Simon Rubinstein-Salzedo, as well as my mathematical friends and peers Ann Dmitrieva, Ben Gunby, Colin Defant, Tony Feng, and Levent Alpoge.

I would also like to thank all my educators at the Moscow High School #57, especially to Professors Sergeev, Gordin, and Timashev. The world-class mathematical education I got in this excellent school cemented my fascination with research mathematics.

Lastly, I want to give special thanks to my family. My parents have supported and advised me every step of the way, and I am so very grateful to have them.

Citation

Ashwin Sah, Mehtaab Sawhney, and David Stoner

The team of Ashwin Sah, Mehtaab Sawhney, and David Stoner is recognized with an Honorable Mention for the 2020 Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by Undergraduate Students for their prolific research collaborations on a wide range of topics in discrete mathematics, ranging from extremal graph theory to combinatorial number theory and discrete geometry. Among the three of them, they have worked on 18 papers, four of which include all three students as co-authors, and five others have two of the trio as co-authors. Papers have appeared in the *SIAM Journal of Discrete Mathematics*, the *Mathematical Proceedings of the Cambridge Philosophical Society*, and the *Journal of Combinatorial Theory, Series B*, among many others.

In joint work, they found an elegant inequality on the number of independent sets of a graph in terms of the degrees of the vertices of the graph. Using some of the ideas of that paper, they solved several open problems in the area of extremal problems for bounded degree graphs, including maximizing the number of proper q-colorings of a d-regular graph.

Sah and Sawhney are currently undergraduates at MIT, expected to graduate in 2020. Stoner graduated from Harvard University and is currently in the Ph.D. program in mathematics at Stanford. Sah has been awarded a Goldwater Scholarship and was a Putnam Fellow, and Stoner was a two-time Putnam Fellow and received the Friends Prize from Harvard and an NSF graduate fellowship.

Biographical Note

Ashwin Sah was born and raised in Portland, Oregon. In high school, he won a gold medal at the 2016 International Mathematical Olympiad as a member of the winning US team. Ashwin is currently an undergraduate studying mathematics at the Massachusetts Institute of Technology. Other than combinatorics, Ashwin is also interested in pursuing analytic number theory and Fourier analysis.

Beyond math, Ashwin spends his time helping organize math contests and participating in the effective altruism community. He is also interested in economics, game theory, and artificial intelligence.

Biographical Note

Mehtaab Sawhney grew up in Commack, New York. Mehtaab Sawhney is currently an undergraduate studying mathematics at the Massachusetts Institute of Technology. In addition to combinatorics Mehtaab is interested in statistics and probability.

Outside of math, Mehtaab enjoys playing table tennis, playing poker, and watching classic Hollywood movies. He is also interested in economics, theoretical machine learning, and finance.

Biographical Note

David Stoner grew up in suburban Aiken, South Carolina. As a high schooler, he won a gold medal at the 2015 International Math Olympiad as part of the winning US team. David received his A.B. in mathematics and S.M. in computer science from Harvard University, where he graduated summa cum laude and Phi Beta Kappa. During his undergraduate years, David published joint papers in combinatorics at the Cornell and Duluth REUs.

Currently, David is enrolled in the math Ph.D. program at Stanford University. He plans to continue his studies in combinatorics there. Outside of mathematics, David also enjoys puzzles, competitive gaming, and graphical art.

Response from Ashwin Sah, Mehtaab Sawhney, and David Stoner

It is a tremendous honor to receive Honorable Mention for the 2020 Frank and Brennie Morgan Prize. We extend our deepest gratitude towards Mrs. Morgan and the AMS, MAA, and SIAM for promoting and supporting undergraduate mathematical research. We would also like to sincerely thank two of our research mentors, Professor Yufei Zhao from the MIT math department and Professor Joseph Gallian from the Duluth REU, who have each been instrumental in our mathematical endeavors.

Ashwin Sah would like to thank his older brother Varun for support in all his pursuits, and to thank Dr. John Gorman for playing a key role in guiding him towards higher mathematics. He also thanks Professor Ken Ono and Professor Jesse Thorner for their mentorship and support at the 2019 Emory REU. Mehtaab Sawhney would like to thank Mr. Robert Minott, Mrs. Barbara Gerson, and Mr. Richard Kurtz for helping cultivate an interest in mathematics and research more broadly. He also thanks Dr. Per Alexandersson and Professor Jonathan Weed for their mentorship in his initial steps into research; especially in their guidance regarding how to broadly approach mathematical research.

David Stoner would first like to thank his older brothers Ben and Michael for being his earliest math teachers, and for motivating him to pursue his passions at an early age. He also thanks Richard Rusczyk for his helpful guidance when David was first learning about research, and Professor Florian Frick for his mentorship at the 2016 Cornell REU. Mehtaab and David both thank Richard Moy for his assistance in their collaboration at Duluth.

Finally, and most importantly, we would each individually like to thank our parents for their incredible support and encouragements all along our mathematical adventures.

Citation

Murilo Corato Zanarella

Murilo Corato Zanarella is recognized with an Honorable Mention for the 2020 Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student. He has made important contributions to difficult problems in number theory, specifically to the Iwasawa theory of elliptic curves and to the theory of Kolyvagin systems for conjugate self-dual Galois representations. Zanarella proved Howard's Main Conjecture for many elliptic curves, and showed that the primitivity of the Heegner point Kolyvagin system is equivalent to Howard's Main Conjecture and the p-indivisibility of the Tamagawa numbers. In his work, he "found something in the well-mined theory of Euler and Kolyvagin systems that had been missed by all the 'experts.' " Zanarella is commended for "his willingness to think deeply about an important problem, to probe the boundaries and the technical details of prior work, and to grapple with obstacles over an extended period of time."

On the basis of this research, Zanarella was awarded the Middleton Miller Prize at Princeton University for the best independent work. He also received the Class of 1861 Special Prize from Princeton University. He graduated from Princeton with highest honors in mathematics, and is currently a Ph.D. student at MIT.

Biographical Note

Murilo Corato Zanarella was born in Brazil and raised in the countryside of São Paulo. During middle and high school, he represented his country in several international mathematics olympiads. He then attended Princeton University, where he received an A.B. in mathematics, graduating with highest honors. His undergraduate studies motivated him to further pursue research in mathematics, and he is currently a Ph.D. student at MIT. His interests are in number theory and arithmetic geometric, and especially in the study of the arithmetic of elliptic curves and abelian varieties.

Besides research, Murilo is also passionate about teaching. He was recognized by Princeton's computer science department for his service as a course assistant, and consistently helps with the preparation of Brazil's team for the International Mathematics Olympiad.

Response from Murilo Corato Zanarella

It is an honor and privilege to receive Honorable Mention for the 2020 AMS-MAA-SIAM Frank and Brennie Morgan Prize. I am grateful to Mrs. Morgan, the AMS, MAA, and SIAM for promoting undergraduate research in mathematics. I am extremely thankful to Professor Chris Skinner for the countless hours of advisement throughout my undergraduate years. He was exceedingly kind and caring, and his commitment to promoting undergraduate research at Princeton is remarkable. I would also like to thank Professor Francesc Castella for advising my junior paper and for all his generosity. They both played pivotal roles in my undergraduate, and have been great sources of inspiration. I extend thanks to my Princeton professors and the mathematical community there, and in particular to Daniel Kriz for his patience on answering many of my questions. Finally, I thank my family and friends for their enduring support.

JOINT POLICY BOARD FOR MATHEMATICS

COMMUNICATIONS AWARD

THE JOINT POLICY BOARD FOR MATHEMATICS (JPBM) established its Communications Award in 1988 to reward and encourage journalists and mathematicians who, on a sustained basis, bring mathematical ideas and information to non-mathematical audiences. The award recognizes a significant contribution or accumulated contributions to the public understanding of mathematics, and it is meant to reward lifetime achievement. JPBM represents the American Mathematical Society, the American Statistical Association, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics.

CITATION

Christopher Budd

The 2020 JPBM Communications Award is presented to Christopher Budd, OBE, for his passionate popularization of mathematics.

Through his positions at Gresham College, the Royal Institution of Great Britain, and the Institute of Mathematics and its Applications, his books, and his work with science festivals and schools, he inspires audiences of all ages.

Biographical Note

Christopher Budd obtained his degree in mathematics at the University of Cambridge in 1982 where he was Senior Wrangler, graduating top in his year. He then moved to the University of Oxford where he obtained his Ph.D.. He stayed at Oxford as the CEGB Fellow in Numerical Analysis, before moving to the University of Bristol in 1989. He then moved to his present position as Professor of Applied Mathematics at the University of Bath in 1995, where he is also the Deputy Director of the Institute for Mathematical Innovation. His career has centered on applying mathematics to problems in the real world, with a particular passion for working on problems coming from industry. He has worked in problems as diverse as microwave cooking, weather forecasting and climate change, electrical power generation, food manufacture, medical imaging, laser dynamics, and saving the whales. He has also applied mathematics to analyze (and create) folk dances and Celtic Knot patterns. He is also a passionate communicator of mathematics. Since 2000 he has been the Professor of Mathematics at the Royal Institution in London, where he helps to coordinate the mathematics master class program for young people. This includes giving regular talks and workshops to schools, both on his own, or with his students. He is the current Gresham Professor of Geometry (the longest established chair of maths in the UK) and delivers regular public lectures in this role, which he repeats all over the world. He founded, and continues to direct, the award winning Bath Taps Into Science Festival. Not only does this showcase maths and science to thousands of young and older people, it also acts as a vital means of training undergraduate students to be the maths communicators of the future. Indeed he runs a module called "Communicating Maths" which trains many such students each year. He has also served as the Education Officer of the London Mathematical Society and the Vice President for communication of the Institute of Mathematics and Its Applications. Until recently he was chair of the United Kingdom Mathematics Trust, and was an organizer of the 2019 International Mathematics Olympiad at Bath. He has written many academic papers, books, and popular articles, including a regular series of internet articles for the Plus Maths magazine. He is married with a son, a daughter, and two dogs, and they like nothing better than going for long walks together in the mountains.

Response from Christopher Budd

I am very greatly honored to receive the Communications Award from the JPBM. As an applied mathematician, I love both doing maths, and applying maths to the real world. But I think that it is equally important that we, as a community, communicate maths as widely as we possibly can. Mathematics plays a role in everyone's lives in many ways, and with the growth of the Internet, Big Data, and the increasing use of algorithms, its importance is going to expand without measure. It is truly the case that our modern technology is very much a mathematical technology, whether this is the Smart Phone, the Driverless Car, or a medical scanner. Our future relies on equipping the next generation with mathematical tools, and motivating them to appreciate, understand, and use them. For my whole career I have been passionate about doing this, both showing as many people as I can the power of mathematics, and also demonstrating (by getting them involved) that actually doing maths can be a lot of fun. I think strongly that everyone can enjoy maths if given the right motivation. I try to achieve this by starting from a real life application (such as how to cure cancer), demonstrating the way that maths gets involved and makes a difference, and finally giving them a chance to do some of the maths themselves. Communicating maths is very much a team effort, and it is a pleasure to acknowledge the many wonderful maths communicators that I have worked with over the years, and especially all of my "Communicating Maths" students, who I hope, and expect, will be the maths communicators of the future. It is a special pleasure to me that one of the supporters of this award is SIAM. I am a great admirer of SIAM and regularly attend its conferences, and publish in its journals. It is a wonderful organization and I am honored that they acknowledge my work in communicating maths with this amazing prize.

CITATION

James Tanton

The 2020 JPBM Communications Award is presented to James Tanton for global leadership in high school mathematics instruction. Through his “G’Day Math!” online courses, MAA Curriculum Inspirations, numerous textbooks, and the Global Math Project, he is inspiring millions to learn, and teach, math in wonderful new ways.

Biographical Note

James Tanton (Ph.D., Princeton 1994, mathematics) is an author, a consultant, and an ambassador for the Mathematical Association of America, currently serving as their Mathematician-at-Large. He has taught mathematics both at university and high-school institutions. James is absolutely committed to promoting effective and joyful mathematics thinking, learning, and doing at all levels of the education spectrum.

Response from James Tanton

Thank you, members and friends of the Joint Policy Board for Mathematics, for this terrific honor. We each, as teachers, doers, lovers, writers, sharers, thinkers, and creators of mathematics, are part of a stunning global community united by the unbridled awe our beautiful subject can bring. Let’s together help one and all on this planet, child and adult, personally experience the soaring joy, the human connection, and the uplifting wonder genuine mathematics offers!

CHAUVENET PRIZE

THE Chauvenet Prize is awarded to the author of an outstanding expository article on a mathematical topic. First awarded in 1925, the Prize is named for William Chauvenet, a professor of mathematics at the United States Naval Academy. It was established through a gift in 1925 from J. L. Coolidge, then MAA President. Winners of the Chauvenet Prize are among the most distinguished of mathematical expositors.

CITATION

Vladimir Pozdnyakov and J. Michael Steele

"Buses, Bullies, and Bijections," *Mathematics Magazine* **89** (2016), no. 3, 167–176, DOI: 10.4169/math.mag.89.3.167.

"Want insight? Consider a bijection!" This bold claim seems hyperbolic, but the authors deliver. Who knew that one of the simplest, most fundamental notions in mathematics holds so many powerful surprises?

Pozdnyakov and Steele show the remarkable utility of bijections by considering seating assignments on a bus. Everyone has a designated seat, but all except the last passenger take seats at random. Then the final passenger—a bit of a bully—boards, not only wanting his own seat, but demanding that each subsequently displaced person finds his correct seat as well. What is the probability that the first person to board will need to change seats?

The authors obtain the answer via a brute-force combinatorial argument, but then find the solution in an easier, more revealing way by making elegant use of permutation cycles. The authors then use bijections to derive even more surprising and beautiful results including the mean and variance of the number of cycles in a random permutation. This well-crafted paper, which introduces the reader to the theory of permutation patterns, flows naturally and easily, providing a journey that is interesting and insightful. This bus is available for all—professor and student alike—delighting the rider with the simple power of bijections.

Biographical Note

Vladimir Pozdnyakov received his Ph.D. in statistics in 2001 from the University of Pennsylvania under the supervision of his co-awardee J. Michael Steele. Since that time he has taught at the University of Connecticut, where he is currently

Professor of Statistics and Director of the Applied Financial Mathematics graduate program. His research is mostly in applied probability, and he has a particular interest in the discovery and exploitation of martingale tricks. He is a recipient of the 2006 Abraham Wald Prize in Sequential Analysis (jointly with Joseph Glaz) and the 2017 Carl B. Allendoerfer Award (jointly with J. Michael Steele). Vladimir is an elected member of the International Statistical Institute, and since 2007 he has served on the editorial board of the *Journal of Mathematical Analysis and Applications.*

Biographical Note

J. Michael Steele received his B.S. in Mathematics from Cornell University in 1971 where he had the opportunity to study with the probabilistic and statistical greats Frank Spitzer, Harry Kesten, and Jack Kiefer. He went on to Stanford University and completed his Ph.D. in mathematics in 1975 under the direction of Kai Lai Chung, whose love of mathematical exposition has had a lifelong effect. After appointments at the University of British Columbia, Stanford, and Carnegie Mellon, he became Professor of Statistics at Princeton University. In 1990 he moved from Princeton to the Department of Statistics of the University of Pennsylvania, where he served as C. F. Koo Professor of Statistics until moving to Emeritus status in 2018.

Steele is an elected Fellow of the American Statistical Association and the Institute of Mathematical Statistics for which he also served as President. He is a winner of the Wilcoxon Prize in Applied Statistics (with R. DeVeaux) and the Allendoerfer Prize of the MAA (with V. Pozdnyakov). He is the author of several books including the very accessible Cauchy-Schwarz Master Class published by the MAA.

Response from Vladimir Pozdnyakov and J. Michael Steele

We are beyond delighted to join the very distinguished list of winners of the Chauvenet Prize. From early ages we have both been wide-ranging readers of mathematical expositions. Naturally, those papers that have been acknowledged with the Chauvenet Prize have often zoomed to the top of our reading list, even when—perhaps especially when—they offer the chance to learn some mathematics outside of our work-a-day world.

We are probabilists at heart, and probability theory has the very pleasing feature of intersecting with many parts of pure mathematics, applied mathematics, and statistics. Starting with a simple story, our paper “Buses, Bullies, and Bijections” aims to give readers an introductory peek into one of the most fecund notions of modern combinatorial theory—the construction of a bijection between two notably different sets. The simplest consequence of such a bijection is that the two sets must have the same cardinality, and this easily snaps one back into the land of probability. Specifically, if the two sets also happen to form a partition of some set, then under the natural model of random selection from that set, we find ourselves looking at another face of the classic coin-flip, or 50/50, chance event. Nothing could make a probabilist happier.

DAVID P. ROBBINS PRIZE

THIS prize was established in memory of David P. Robbins by members of his family. Robbins, who died in 2003, received his Ph.D. in 1970 from MIT. He was a long-time member of the Institute for Defense Analysis Center for Communication Research and a prolific mathematician whose work (much of it classified) was in discrete mathematics. The Prize is for a paper that reports on novel research in algebra, combinatorics, or discrete mathematics, has a significant experimental component, and is on a topic which is broadly accessible. The paper shall provide a simple statement of the problem and clear exposition of the work. This Prize is awarded every three years.

CITATION

Aubrey D.N.J. de Grey

"The Chromatic Number of the Plane is at least 5," *Geombinatorics* **XXVIII** (2018), no. 1, 18–31.

What is the minimum number of colors needed to color the points of the Euclidean plane so that no two points at distance exactly 1 have the same color? This minimum number, known as the chromatic number of the plane, is denoted by $\chi(E^2)$. This question appears to have first been considered by the late Princeton mathematician Edward Nelson in 1950 while he was a student. It is easy to see that $4 \leq \chi(E^2) \leq 7$. It is often known as the Hadwiger–Nelson problem; Hadwiger, several years earlier and for other reasons, had been the first to discuss the simplest coloring of the plane that demonstrates the upper bound.

A compactness argument of P. Erdős and R. Rado shows that there is always a finite subset of the plane which achieves $\chi(E^2)$. Therefore, the problem is equivalent to determining the (usual) chromatic number of a unit distance graph in the plane, i.e., a finite set of points in which all the edges have length 1. In spite of substantial efforts by combinatorial mathematicians over the subsequent nearly 70 years, these bounds on $\chi(E^2)$ remained unchanged. Thus, it was quite unexpected when Aubrey de Grey announced an improvement of the lower bound from 4 to 5. What de Grey managed to do is to discover a very ingenious hierarchy of juxtapositions of 4-chromatic subgraphs to build a large 5-chromatic unit distance graph. The first graph de Grey constructed had 20,425 vertices. He then improved this to a smaller 5-chromatic graph with only 1581 vertices. The record now stands at 529 vertices, and conceivably the smallest such order could be as small as 100. In any case, this breakthrough has spurred renewed hope that the bounds on $\chi(E^2)$ can be tightened even further. In particular, it raises the question as to whether $\chi(E^2) \geq 6$.

Biographical Note

Aubrey D.N.J. de Grey is a biomedical gerontologist based in Mountain View, California, and is the Chief Science Officer of SENS Research Foundation, a California-based 501(c)(3) biomedical research charity that performs and funds laboratory research dedicated to combating the aging process. He is also VP of New Technology Discovery at AgeX Therapeutics, a biotechnology startup developing new therapies in the field of biomedical gerontology. In addition, he is Editor-in-Chief of *Rejuvenation Research*, the world's highest-impact peer-reviewed journal focused on intervention in aging. He received his B.A. in computer science and Ph.D. in biology from the University of Cambridge. His research interests encompass the characterization of all the types of self-inflicted cellular and molecular damage that constitute mammalian aging and the design of interventions to repair and/or obviate that damage. Dr. de Grey is a Fellow of both the Gerontological Society of America and the American Aging Association, and sits on the editorial and scientific advisory boards of numerous journals and organizations. He is a highly sought-after speaker who gives 40–50 invited talks per year at scientific conferences, universities, companies in areas ranging from pharma to life insurance, and to the public.

Dr. de Grey's interest in mathematics has hitherto been only recreational, but he looks forward—with substantial, and increasing, confidence—to a post-aging world in which it can be his main occupation.

Response from Aubrey D.N.J. de Grey

I am immensely honoured to be awarded the MAA's Robbins prize. In my youth I had the great privilege to have friends at Cambridge who are among the most talented combinatoricists of their generation and who are also wonderful people. The result is that for most of my life I have been hooked on combinatorics, and especially graph theory. This field, while never having been my source of income, has given me perpetual joy, and I want to express my gratitude to those old friends who provided that gift. The Hadwiger-Nelson problem has the rare feature of being both comprehensible and seductive not only to the mathematics undergraduates whom this prize seeks to inspire, but even to those with much more elementary mathematical experience. I therefore hope that this contribution by a recreational mathematician will serve to encourage a new generation to explore this infinitely rich abstract universe.

EULER BOOK PRIZE

THE Euler Book Prize is awarded annually to the author of an outstanding book about mathematics. The Prize is intended to recognize authors of exceptionally well-written books with a positive impact on the public's view of mathematics and to encourage the writing of such books. The Euler Prize, established in 2005, is given every year at a national meeting of the Association beginning in 2007, the 300th anniversary of the birth of Leonhard Euler. This award also honors Virginia and Paul Halmos, whose generosity made the award possible.

CITATION

Tim Chartier

Math Bytes, Princeton University Press (2014)

Math Bytes gives readers a taste of the mathematics and computing applications that underlie many aspects of everyday life. With a wide array of topics—including fractals, fonts, tweets, basketball, Google, digital images, movies, and more—the book exposes readers to a satisfying assortment of mathematical ideas, many of which will be new to non-mathematical audiences. That said, even more mathematically-inclined readers should find plenty of interesting material, including new ways of thinking about and applying familiar mathematical concepts.

Chartier's exposition is clear, accessible, and fun. Regular challenge problems encourage readers to explore for themselves the ideas introduced in the text. All in all, Math Bytes is an engaging and stimulating read that is sure to broaden horizons and increase appreciation for the ubiquitous and invaluable role of computational mathematics in modern society.

Biographical Note

Tim Chartier is a Professor of Mathematics and Computer Science at Davidson College. As a researcher, Tim collaborated with both Lawrence Livermore and Los Alamos National Laboratories on the development and analysis of computational methods targeted to the lab's supercomputers, which were among the fastest in the world. He specializes in numerical linear algebra, with his recent work focusing on data science. He frequently fields analytics questions, which have included consultation on problems for ESPN, the New

York Times, the US Olympic Committee, and teams in the NBA, NFL, and NASCAR. Tim serves as Section Representative to the MAA Congress for the MAA's Southeastern Section and has served as Vice President of the MAA. Tim was the first chair of the Advisory Council for the National Museum of Mathematics. In K–12 education, Tim has worked with Google and Pixar on their educational initiatives. Tim is also a performing artist having trained in mime at Le Centre du Silence mime school and in master classes with Marcel Marceau. Along with his wife Tanya, Tim has performed their mime presentation that introduces mathematical ideas throughout the United States and in Holland, Japan, Panama, and South Korea.

Response from Tim Chartier

Math Bytes began when I met Vickie Kearn of Princeton University Press. Art Benjamin, knowing a long-time vision Vickie had for a playful, popular math book that would introduce readers to areas of applied mathematics, recommended she hear me speak. Our meeting was transformative: in her vision, I saw a book I quickly dreamed of writing. On that day, while many of the decisions about how to shape the book lay ahead, we took our first steps on a delightful journey with *Math Bytes* being an eventual destination. For Vickie's friendship and mentorship, I am continually grateful. Art, thank you for facilitating that first meeting and for inspiring me to teach in and beyond the classroom.

Math Bytes became a collection of ways I engage students and strangers when they ask about mathematics. Play Angry Birds? Let's talk about parabolas. Have a bag of M&Ms? Let's integrate! Like sports? How much time do you have?

While I was certainly speechless when I learned of this award, many might say that's common for me as a professionally trained mime. So, I'll also note that I was motionless, without any intention of being so. The Euler Prize has been awarded for transformative books; each unfolded new mathematical landscapes to be explored by the public. It's an unexpected honor to receive this award and deeply meaningful since making math accessible and inspiring has been a foundational part of how I teach, inside and outside of the classroom.

Math Bytes is dedicated to my children. I thank them for reading sections of the drafts, enabling me to see if adults could turn to children in experiencing "ah-ha!" moments with math. I thank my sister, who read the first draft of my book; given that she struggled with math, her energy about my writing fueled my work throughout the publication process. I thank my parents, who encouraged me to take math during college as my back-up for a performing arts career; before long, I'd learned the artistry and creativity of the field, which became my major and area of graduate study.

Tanya Chartier, thank you for encouraging me to write the book that I sensed was yet unwritten. Thank you for encouraging me to hone my whimsical mathematical voice which could make my “art friends” laugh and engage in a field that might have seemed otherwise mysterious to them from the outside, finding in it imagination and joy akin to their own creative work. The best stories of life are the ones we create together.

Thanks to Davidson College. I appreciate the students who have repeatedly affirmed my storytelling, continually spurring me on to find that next story to tell. I appreciate my colleagues who surround me with excellence and dedication.

Finally, I want to thank the MAA, as an organization and as a body of members, for the many ways you have encouraged me to engage in the association. From my early days of membership, I have heard the call to find my place, however unique. The MAA has helped me reach for the stars that I see from where I stand.

I hope *Math Bytes* helps readers taste the joys and creativity of mathematics. For those who’ve read the book, I await the stories of your own infinite discoveries.

DEBORAH AND FRANKLIN TEPPER HAIMO AWARDS FOR DISTINGUISHED COLLEGE OR UNIVERSITY TEACHING OF MATHEMATICS

IN 1991, the Mathematical Association of America instituted the Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching of Mathematics to honor college or university teachers who have been widely recognized as extraordinarily successful and whose teaching effectiveness has been shown to have had influence beyond their own institutions. Deborah Tepper Haimo was president of the Association, 1991–1992.

CITATION

Federico Ardila

Prof. Ardila inspires students from all walks of life to recognize and realize their potential in mathematics via his work inside and outside of the classroom at San Francisco State University (SFSU), nationally, internationally, and in the popular media. He serves as a leader in the movement to broaden and deepen diversity in research mathematics.

Students in all of his classes at SFSU routinely describe Prof. Ardila's classes with words that boil down to "life changing." He has provided exceptional research mentorship to 50 undergraduate-thesis students, Master's students, Ph.D. students, and postdocs from SFSU, UC Berkeley, and various universities in his native Colombia. The majority of his US advisees are women, and the majority come from underrepresented ethnic groups.

Prof. Ardila has provided multifaceted leadership as the Director of Mathematical Sciences Research Institute–Undergraduate Program (MSRI–UP) for the past five years. He was selected for that position through a national search for a mathematician singularly committed to access, diversity, and inclusion. The program is the largest Research Experience for Undergraduates (REU) in the country and the mathematics REU that serves the largest number of underrepresented students. Most of the students join Ph.D. programs. Prof. Ardila's colleagues describe his striking ability to recognize mathematical talent among students who may not always rate highly by traditional measures of mathematical ability—measures that often discriminate against students from underrepresented communities.

To cultivate a global scientific community that reflects world demographics, Prof. Ardila conceived and spearheads the SFSU-Colombia Combinatorics Initiative. Through the initiative, he developed seven new courses that promote international scholarly collaboration among undergraduates and Master's students, including many women, African Americans, Latinx, and Pacific Islanders at SFSU and Universidad de Los Andes. Of the 200 students who have taken classes simulcast from the two continents in the joint venture, more than 50 have continued to Ph.D. programs in mathematical sciences. Of the 21 students in his first joint course in 2008, 18 went on to additional degrees in mathematics, and 13 are now tenure-track faculty.

This initiative also features a biannual summer school in Colombia. Encuentro Colombiano de Combinatoría energizes an international audience.

In point of fact, Prof. Ardila has provided students (especially those from underrepresented groups) too many entry points into mathematics for comprehensive citation here. These activities include publishing a wide range of expository articles in English, Spanish, and German, in addition to publishing his own research prolifically, editing several journals, and earning a CAREER grant. His YouTube channel contains more than 240 hours of freely available advanced mathematics, and his viewers come from over 150 countries. He gives frequent invited public lectures, for example from Nightlife at the California Academy of Sciences, the Society for Advancement of Chicanos/Hispanics and Native Americans in Science, and the Numberphile Youtube channel, on which his contributions have had over 600,000 views.

In "Todos Cuentan: Cultivating Diversity in Combinatorics," published in the *Notices of the AMS* in November, 2016, Prof. Ardila outlines his principles for building mathematical spaces that serve every interested participant. Colleagues around the country have posted Prof. Ardila's maxims on their office doors and websites as a concise manifesto for creating an inclusive classroom and a diverse body of mathematicians. One student speaks for many others from a variety of backgrounds in describing Prof. Ardila as a mentor who "allowed me to turn off all stereotypes I faced growing up about Latinos in mathematics and helped plant a seed of determination and curiosity, which bloomed into the passion I have for both math and research."

The MAA recognizes the great role Prof. Ardila has had in expanding, diversifying, and enriching the mathematics community domestically and globally. The MAA is honored to present him with the Deborah and Franklin Tepper Haimo Award for Distinguished College or University Teaching of Mathematics.

Biographical Note

Federico Ardila received his Ph.D. from MIT in 2003, and is Professor of Mathematics at San Francisco State University and the Universidad de Los Andes. He is a Fellow of the American Mathematical Society, an NSF CAREER Awardee in the US, and a recipient of the Premio Nacional de Ciencias and Premio Nacional de Matemáticas in his native Colombia. His research is in combinatorics and its connections to geometry, algebra, topology, and applications. Federico is constantly working towards fostering an increasingly diverse, equitable, and welcoming community of mathematicians. With that goal, he founded the SFSU-Colombia Combinatorics Initiative, he co-directs the MSRI-UP undergraduate research program, and he hosts more than 200 hours of combinatorics lectures on YouTube. He has advised more than 50 students; the majority of his US advisees are women, and the majority are members of underrepresented ethnic groups. These days, when he is not at work, he is probably reading, playing fútbol, playing records, or playing marimba de chonta.

Response from Federico Ardila

It is an enormous honor to receive this recognition.

I will confess that I sometimes feel guilty about being a mathematician. It is a tremendously privileged life: I spend my days searching for beauty and understanding, and I call that my job, and I get paid for it. But society has many deep problems; next to them, the mathematical endeavor can feel like an unjustified luxury.

It has taken me decades at the job to understand that we can have a positive impact on society through mathematics and education; that perhaps this is where I am best positioned to do this work. I owe this lesson to my wonderful students in San Francisco, in Colombia, and in many other places; they are my best teachers. Their diverse, critical, and generous perspectives have completely transformed my world view and my understanding of our work as educators. Working with them keeps my spirit young and my heart full.

Awards are often given to individuals, but our work can only be carried out in community. My work is only a small part of a fertile ecosystem of initiatives, within and outside of mathematics, which I have had the honor and joy to collaborate with and learn from.

In mathematics, these include MSRI-UP, SF BUILD, the Olimpiadas Colombianas de Matemáticas, SACNAS, and Latinx in Math, among many others. In the Mathematics Department at San Francisco State University and the Comunidad Colombiana de Combinatoria, I have found my mathematical homes.

Outside of mathematics, my loving community of educators, community organizers, political activists, journalists, artists, and futbolistas in Oakland and

LA constantly challenge me, teach me, and inspire me. Mi querida familia me enseã que con convicción, dedicación, e integridad, uno puede lograr lo que se proponga. May-Li Khoe is my partner, my role model, my best friend. Anyone who knows her will recognize her huge influence on my work. She is a constant source of knowledge, inspiration, wisdom, and energy to always keep growing and (in her words) joyfully subverting the status quo.

This award is all of theirs as much as it is mine.

CITATION

Mark Tomforde

Prof. Tomforde has had a deep and positive impact at all levels of mathematics education. He has promoted the participation of members of underrepresented groups in mathematics and has increased interest in mathematics engagement and college attendance in middle and high schools surrounding the University of Houston (UH). He has empowered students at UH to become "stewards of the discipline," teaching by example that service is an integral component of a STEM career and that an advanced degree carries a responsibility to the wider community.

An exceptional teacher, prolific scholar, and advisor of numerous undergraduate-research projects, Master's tutorials, Ph.D. theses, and an NSF postdoc, Prof. Tomforde has won teaching awards at UH and from the MAA Texas Section. He has recruited, retained, and mentored members of underrepresented groups spectacularly at all levels, including by enrolling over 70 UH students in the Math Alliance, an organization whose goal is to make sure every underrepresented or underserved American student with talent and ambition has the opportunity to earn a doctoral degree in a mathematical science. Through the Math Alliance he has mentored undergraduates at other institutions. He has found funding to double the number of UH students who can attend the organization's annual Field of Dreams conference and has given invited talks at the conference. In addition, Prof. Tomforde is a co-founder and co-organizer of Gulf States Math Alliance (GSMath), one of seven regional alliances, comprised of members of the Math Alliance in Texas, Louisiana, and Mississippi. He facilitates and promotes associated opportunities in the Gulf Coast region.

At the local level, Prof. Tomforde reached out to Houston's Third Ward, Sunnyside, and East End communities when he developed and directed the Cougars and Houston Area Math Program (CHAMP). For six years, Prof. Tomforde worked in collaboration with neighborhood high schools and middle schools to provide a wide variety of mathematical activities. Ms. Tai G. Ingram, Principal and School Leader at KIPP Liberation Middle School, brings CHAMP's impact to life when she writes, "Simply put, Dr. Tomforde has helped to make math cool at KIPP Liberation... As our students found success with math, they were able to wipe away their fears and develop a growth mindset. The same kids who once held the mantra of 'Math is hard!' now remind me that 'Math is the universal language.' This critical mindset shift around math was groundbreaking for students who had failed the Texas-mandated math STAAR exam numerous times in their past." She continues that "As an inner-city middle school principal, it has been really hard to find programs interested in working long-term with my building full of brilliant black and brown children. I greatly appreciate Dr. Tomforde's consistent desire to serve as a thought partner, supportive neighbor, and coach to my math teachers and students. Notably, I have always appreciated his intentionality in the selection and pairing of strong CHAMP mentors with my students. It has been extremely powerful for my students to meet and work with their math mentors who look like them, share similar backgrounds, and often have grown up in neighborhoods surrounding my school. These connections have shown my scholars that with hard work, college is a reality and math can lead to their preferred career." CHAMP has received local accolades as well as two major national awards: the AMS Award for Mathematics Programs that Make a Difference and a Phi Beta Kappa award for Broadening Participation in STEM, both in 2018.

Prof. Tomforde has encouraged and supported students and colleagues in other ways too numerous to mention exhaustively. As examples, he has built a multifaceted collaboration between UH and Texas Southern University (TSU), an HBCU in Houston. He has recruited faculty from UH to serve as Math Alliance mentors. He has revitalized, established, and led student organizations, serves on MAA committees and as a Project NExT consultant, and disseminates a wide variety of materials on multiple web sites to guide faculty and students. More than one student described how their interactions with Prof. Tomforde changed and facilitated their career trajectories. One spoke for many when she wrote, "I never would have had the courage to take a graduate course without Dr. Tomforde's encouragement, and I am grateful that he saw the ability in me that I did not see in myself."

The MAA recognizes the great positive impact Prof. Tomforde has had on students in his city and neighborhoods, at his own institution, in his region, and in the national mathematics community. The MAA is honored to present him with the Deborah and Franklin Tepper Haimo Award for Distinguished College or University Teaching of Mathematics.

Biographical Note

Mark Tomforde was raised in the small town of Lake City, Minnesota, which is nestled in the scenic Mississippi River Valley. He earned a BA in mathematics from Gustavus Adolphus College, and went on to obtain an M.A. and Ph.D. in mathematics from Dartmouth College. He was an NSF postdoc at the University of Iowa for three years, and subsequently taught for one year at the College of

William and Mary. He is currently a professor at the University of Houston. He was also a Project NExT Fellow (sky dot, 2002) and a Project NExT Consultant (2014–2015). Dr. Tomforde has been greatly influenced by the liberal arts educations he received at Gustavus and Dartmouth, and he attributes many of his successes in research, teaching, and outreach to the training and mindset provided by this background. Although now at a large public university, he strives to infuse the educations of his students with these same liberal arts values, as he encourages students to think critically, gain multiple perspectives, and approach learning as a life-long process.

Response from Mark Tomforde

I am incredibly honored to receive the Haimo award. In my life I have had the good fortune to be taught, trained, and mentored by several excellent professors. There are too many to thank here, but I do wish to express my gratitude to four that I found particularly influential: my undergraduate professors, Jeff Rosoff and John Holte; my Ph.D. advisor, Dana P. Williams; and my postdoctoral advisor, Paul Muhly. Each of these individuals exemplifies the ideal of the teacher-scholar, and I have made great effort to emulate them as I strive to integrate the multiple roles and responsibilities of a successful mathematician. I also thank the excellent teachers, colleagues, peers, and friends I have had, many of whom have influenced me much more profoundly than they realize. Finally, I thank the students I have known throughout the years. They have taught me at least as much as I have taught them. I am particularly grateful for the numerous students who have volunteered to help with various outreach activities I have organized and led. Their willingness to get involved has been the driving force behind much of what I have accomplished.

CITATION

Suzanne L. Weekes

Prof. Suzanne L. Weekes has had an extraordinary impact on the mathematics community via superlative teaching, advising, and mentoring of students and faculty at Worcester Polytechnic Institute (WPI), regionally, and nationally. Her work has dramatically changed the lives of many students. She serves as a leader in enhancing the mathematical sciences: identifying and developing overlooked potential, broadening the pipelines into both Ph.D. programs and industrial mathematics, and training faculty in how to prepare students for careers in business, industry, and government (BIG).

At WPI, Prof. Weekes provides an outstanding education to students in the classroom and mentors newer faculty as a “model teacher.” Her superb work with individual students and the WPI SIAM chapter earned her a 2013 campus Advisor of the Year award. Prof. Weekes also won the 2019 Humphrey Award from the Association for Women in Mathematics for mentoring undergraduate women.

In local and regional outreach, Prof. Weekes designed and organized the Applied and Industrial Mathematics Institute for Secondary Teaching at WPI which offers workshops for high school mathematics teachers. As a member of the Math Advisory Group of Transforming Post-Secondary Education in Mathematics (TPSE Math), Prof. Weekes co-organized and hosted the New England Regional Meeting on Upper-Division Pathways at WPI, now a model for such workshops in other regions.

Prof. Weekes is a national leader in connecting students and faculty with research problems from industry and in guiding student teams through such projects. At WPI, she directed the Center for Industrial Mathematics and Statistics and also directed its WPI REU Program in Industrial Mathematics and Statistics. Prof. Weekes has personally mentored 76 undergraduate students, as well as master's and Ph.D. students.

Prof. Weekes is a founding director of tremendously impactful national programs. One is the Mathematical Sciences Research Institute Undergraduate Program (MSRI-UP) which she collaborated to establish in 2007. The high stature summer-research program has engaged over 200 students, of whom 90% are from racial or ethnic groups underrepresented in the mathematical sciences, and 46% are female. Over 80% have continued on to graduate programs, with over 70% of those to Ph.D. programs. Another such national program is the MAA's Preparation for Industrial Careers in Mathematical Sciences (PIC Math) program which trains faculty members and provides resources for them to teach courses at their own colleges or universities focused on students working in small groups on research problems coming directly from BIG. Faculty and students around the country now benefit from Dr. Weekes' expertise in working with partners in BIG. In the process, PIC Math is increasing awareness among mathematical sciences faculty and undergraduates about non-academic career options and preparing students for industrial careers.

In its first three years, PIC Math has engaged almost 1400 undergraduate students at 101 participating universities and colleges. Participants have collectively produced 147 research reports and papers, and over 150 conference presentations. PIC Math's participating institutions include six HBCUs and ten HSIs; participating students include 40% women, and 21% come from historically underrepresented groups. These numbers don't occur by chance: they result from intentional work and the supportive atmosphere Prof. Weekes creates.

The MAA recognizes the great power and impact of Prof. Weekes' teaching and advising in applied and industrial mathematics, her cultivating of and advocating for diverse student populations in the discipline, and her mentoring of mathematics faculty, all at WPI, regionally, and nationally. The MAA is honored to present her with the Deborah and Franklin Tepper Haimo Award for

Distinguished College or University Teaching of Mathematics.

Biographical Note

Suzanne L. Weekes grew up in the Republic of Trinidad and Tobago and then went to Indiana University as an international student and received her B.S. in Mathematics. She moved to Ann Arbor, MI, and earned her Ph.D. in mathematics and scientific computing from the University of Michigan in 1995. She held a Visiting Assistant Professor position in the Department of Mathematics and the Institute for Scientific Computing at Texas A&M for three years and then took up a position at Worcester Polytechnic Institute (WPI) in 1998. She is Professor of Mathematical Sciences at WPI and is now the Associate Dean of Undergraduate Studies ad interim.

Suzanne was honored and grateful to receive the 2019 Humphreys Award for the Mentoring of Undergraduate Women from the Association for Women in Mathematics (AWM) last year.

Her research work is in numerical methods for differential equations including applications to spatio-temporal composites/dynamic materials and cancer growth. She is involved in several initiatives connecting the academic mathematics community to mathematics and statistics work done in business, industry, and government, and with broadening the participation and success of students in mathematical sciences.

Response from Suzanne L. Weekes

I am honored and humbled to have been nominated and selected for this award. My gratitude goes out to the MAA and to the people who took the time and effort to write letters in support of my nomination. I am fortunate and thankful to work with and learn from collaborators, students, mentors, and leadership with adventurous, creative, and inspiring spirits. Thank you to the many people who have allowed me the opportunity to experiment with them or on them, and to the National Science Foundation, the National Security Agency, the Sloan Foundation, the Department of Defense, the Clare Boothe Luce Foundation, the GE Fund, and other agencies that have supported efforts that I have been involved in.

Several of my colleagues in the Department of Mathematical Sciences at WPI started the Center for Industrial Mathematics in 1997. The embrace of industrial connections along with WPI's emphasis on undergraduate research led me to the decision that WPI was the right choice for me and I have never regretted that choice for a moment. I remain grateful to Art Heinricher and Bogdan Vernescu for being the mavericks and mentors that they are and for always making a place for me at the table.

About thirteen years ago, Duane Cooper, Ricardo Cortez, Herbert Medina, and

Ivelisse Rubio took a chance on a stranger and with the support of David Eisenbud and the MSRI leadership, we put together MSRI-UP. It has been a treasure to work with you all and with Mercedes, Federico, Rebecca, and our fantastic research leaders and staff. May the students that we serve always know that there is a place for them in the mathematical sciences community and that they are able, wonderful, and deserving. May our mathematical sciences community be welcoming and open to them and may our students have opportunities and support to dream big and to flourish.

I am blessed to have met Michael Dorff several years ago and to have developed PIC Math with him, the MAA, and SIAM. It has been wonderful working with Michael and we have fun dragging each other into new ventures. Thank you to Michael for thinking highly enough of me to have nominated me for this award. Michael, you have already left your mark with your generosity, kindness, and all that you do to help others.

In measure >> 0, thank you to Burt, Cedric, Darren, Marcel, Merle, Luca, Naima, Rhonda, Samara, and Trent.

YUEH-GIN GUNG AND DR. CHARLES Y. HU AWARD FOR DISTINGUISHED SERVICE TO MATHEMATICS

THE Gung and Hu Award for Distinguished Service to Mathematics, first presented in 1990, is the endowed successor to the Association's Award for Distinguished Service to Mathematics, first presented in 1962. This award is intended to be the most prestigious award for service offered by the Association. It honors distinguished contributions to mathematics and mathematical education—in one particular aspect or many, and in a short period or over a career. The initial endowment was contributed by husband and wife, Dr. Charles Y. Hu and Yueh-Gin Gung. It is worth noting that Dr. Hu and Yueh-Gin Gung were not mathematicians, but rather a professor of geography at the University of Maryland and a librarian at the University of Chicago, respectively. They contributed generously to our discipline, writing, "We always have high regard and great respect for the intellectual agility and high quality of mind of mathematicians and consider mathematics as the most vital field of study in the technological age we are living in."

CITATION

Gerald J. Porter

The Gung & Hu Award Committee recommends to the MAA Board of Directors Gerald J. Porter as the recipient of the Yueh-Gin Gung and Dr. Charles Y. Hu Award for Distinguished Service to Mathematics.

Jerry's service has been in teaching, teacher education, research, MAA administration, and, most importantly of all, in leading the profession, especially the MAA, to value racial and gender diversity in all activities. Those who have served on the MAA Board of Governors and/or Executive Committee with Jerry know that he is a strong advocate for diversity in all committee appointments. During Jerry's four years on the Committee on Committees and Councils, he led that group to completely rethink the committee appointment process and to insist on a diverse membership on all committees. The MAA considered a double-blind review system for many years but it is because of Jerry Porter's persistence that the Board agreed to implement such a system.

As chair of the Council on Prizes and Awards (2010–2014), Jerry served ex-officio on the Committee on Committees and Councils. His service in these positions illustrates how Jerry exercised his responsibilities in the Association. He did not simply maintain the status quo but carefully examined every activity for which these committees were responsible, seeking improvements and, where appropriate, increasing diversity. In the case of prizes and awards, he led the Council to review every prize and award that MAA gives, the timing of appointments to committees, membership and terms for these committees, and the nomination process for all the awards. This multi-year process led us to a much improved, more inclusive, system.

Jerry served as Treasurer of MAA from 1992 to 2001. During those years he maintained a complete set of the MAA financial records so that he could understand the MAA finances without relying on the staff. This was necessary because there was a high turnover of staff during that period. Jerry not only understood the Board-approved operating budget, but also knew the details of the MAA funds that supported prizes, awards, lectures, and specific programs. When the Executive Committee sought funds to increase an award or for some specific need not covered in the budget, it was Jerry who provided information about donor restrictions and the amount in the fund not being spent. Even after his time as Treasurer and Chair of the Investment Committee (1986–2001), Jerry, as a Governor, would remind staff of various funds. Jerry's considerable financial expertise served the MAA well.

Since first serving on the Executive Board of the Eastern Pennsylvania and Delaware Section in 1975 (it was then called the Philadelphia section), Jerry Porter has spent decades in service to the MAA. His service in terms of years and variety at the national level is extensive but his service and care for the organization goes far beyond the lengthy list of committees on which he served and positions he has held. His is the service that, while not appearing on any list, has made the difference in the MAA and our profession. He pursued this service while providing strong support to Executive Directors, learning and sharing his great expertise, and being a change agent in the areas in which he was involved. He has been a mentor to many young mathematicians and has nominated them for awards and committees, welcomed them at both section and national meetings, and shown by example the importance of inclusivity. For many years he was the only male member of the Joint Committee on Women; as always, Jerry strengthened MAA's role on this committee. Jerry welcomed the women and minorities who attend our meetings and encouraged them to take an active role in the Association.

Jerry has been a faculty member at the University of Pennsylvania since 1965. In 1968 he began using computing in his introductory calculus course to enhance student learning. Following the introduction of desktop computers, Jerry was asked to serve as Associate Dean for Computing Services and Facilities for the School of Arts and Sciences at Penn with the goal of introducing instructional computing throughout the curriculum. He served in this position for ten years

(1980–1990). In the MAA, Jerry was the first chair of the MAA Committee on Computers in Mathematics Education.

The Interactive Mathematics Text Project (IMTP) was funded by IBM and NSF and was directed by Jerry and Jim White. IMTP funded the creation of six computer laboratories that were used to host workshops to encourage the creation of computer-based algebra materials in teaching. This was an early exploration of what today is called "active learning." Two of the laboratories were located in two-year colleges and one was in an HBCU. A second NSF grant funded similar workshops for high school math teachers. Participants from the workshops made presentations of the materials they developed at national meetings of the MAA, NCTM, and AMATYC. Jerry "ate his own cooking" and joined with David Hill to author: *Interactive Linear Algebra: A Laboratory Course Using MathCAD,*, one of the first laboratory-based math courses.

Jerry has contributed to mathematics and the mathematical community for many years by publishing substantive papers, being on the forefront of teaching calculus with computing, and writing a pioneering book using active learning. His research papers in algebraic topology explored the topology of spaces now known as "polyhedral products." His foundational research was built upon by others to include applications such as toric varieties in algebraic geometry, Stanley-Reisner rings in combinatorics, and right-angled Artin groups in geometric group theory.

He has published papers and made presentations on using computers in undergraduate mathematics instruction with a focus on teaching calculus and linear algebra. He collaborated with Doris Schattschneider to create computer materials to accompany the show on Periodic Ornamental Designs that she curated at the Allentown (PA) Museum of Art. At Penn, Jerry assumed responsibility for a multi-school consortium to encourage mathematics and its applications throughout the curriculum. To disseminate the products of this consortium he created an online journal, *Journal of Mathematics and its Applications* (JOMA). The MAA agreed to assume responsibility for JOMA when the grant funding the consortium was over. JOMA became a component of MathDL and was eventually integrated into Loci.

Jerry has been a member of AMS and MAA since 1959. He is a life member of MAA, AMS, and NAM and has also been a member of SIAM, AWM, and AMATYC. He and his wife, Judy, are members of the MAA Icosahedron Society and have endowed the AMS-MAA-SIAM Gerald and Judith Porter Public Lecture, given annually at the Joint Mathematics Meetings since 2010. Their support of MAA includes the tiled entrance at the MAA headquarters in Washington, DC, a pentagonal tiling designed by Marjorie Rice. Nominated by the Eastern Pennsylvania and Delaware Section, Jerry was recognized with a Certificate of Meritorious Service in 2011.

Jerry's deep feelings of social justice are reflected in his work and play; his website `www.math.upenn.edu/~gjporter/` reflects this. As an Association, MAA is stronger and a model for others because Jerry Porter's insistence that we be fair, inclusive, and welcoming has expanded our community with mathematicians who respect and include all. This is distinguished service from which MAA and the profession will long benefit.

Biographical Note

Gerald J. Porter grew up in Rahway, New Jersey. His parents could not afford to attend college themselves and were very proud of the education they were able to provide for their sons.

Jerry was an undergraduate at Princeton where he was a math major and had the opportunity to learn from Emil Artin, William Feller, Norman Steenrod, and other legendary mathematicians. He first studied algebraic topology in a course taught by Lee Sonneborn.

During a summer job in 1955 he was introduced to digital computing. The next summer he worked for IBM writing programs for the IBM 360 library. His senior thesis involved a comparison of two computation methods for solving the transportation problem. One was proposed by his advisor, Harold Kuhn, and one proposed by Ford and Fulkerson. The comparison was done using the von Neumann computer at the Institute for Advanced Study. This was, perhaps, the first Princeton senior thesis written using a digital computer and Jerry was, most likely, the first person to program the Ford-Fulkerson algorithm on a digital computer.

He attended graduate school at Cornell University and chose to specialize in algebraic topology because of the strong group of faculty in that field including Paul Olum, Peter Hilton, Israel Berstein, and his thesis advisor, Bill Browder. His thesis involved the study of higher order Whitehead products. Following Cornell, he spent two years at MIT as an instructor and an additional year as an ONR postdoc at Brandeis. During these years he continued his study of the topology of spaces now known as "polyhedral products."

Jerry arrived at Penn in 1966 and has been a member of that faculty since then. He retired from teaching in 2006 but is still involved in advising students. During the period from 1958 to 1968, Jerry had no involvement with computing. In 1968, following a chance conversation with Herb Wilf, Jerry and Herb began using digital computing in their undergraduate courses. Jerry's subsequent work using digital computers to improve undergraduate learning in mathematics has been a major focus of his academic career. At Penn, in addition to serving as Associate Dean for Computing in the School of Arts and Sciences, he has also chaired the Faculty Senate and has served as President of the Penn Emeritus Association.

Jerry's long career of service in the MAA began in the mid-1970's following an invitation from David Rosen to teach a topology course at Swarthmore. Rosen, who was the Governor of the (then called) Philadelphia Section nominated Jerry to serve on the Executive Committee of the Section. A few years later he was elected to the MAA Board of Governors representing his section. He was elected Treasurer of the MAA in 1992 and served in that position until 2001.

Response from Gerald J. Porter

During my years in the MAA I have served with many of the previous award recipients: Lynn Steen, Ken Ross, Jerry Alexanderson, Len Gillman, Lida Barrett, and Martha Siegel to name a few. It is an incredible honor to join them as a recipient of this award. Those of us who serve mathematics and the mathematics profession do so because we think that it is important work that needs to be done. As Emerson wrote, "The reward of a thing well done is having done it." External recognition is not expected but when it is received, it is warmly appreciated. I have had four or five different academic careers, I am appreciative of the support I have received at the University of Pennsylvania that enabled me to change jobs without changing employer. My wife, Judy, had a long career as Professor of Sociology at Bryn Mawr College. As an "academic couple" we realized many years ago that it was important to support each other. Without her support and love I would not be receiving this award today. Finally, as I noted in my biographical statement, there are numerous seemingly random events that change the course of one's life. Take to heart the words of the American philosopher, Yogi Berra, who said: "When you come to a fork in the road, take it."

Summary of Awards

For AMS

- **Award for Distinguished Public Service**: David Eisenbud
- **Bôcher Memorial Prize**: Camillo De Lellis, Lawrence Guth, and Laure Saint-Raymond
- **Chevalley Prize in Lie Theory**: Huanchen Bao and Weiqiang Wang
- **Frank Nelson Cole Prize in Number Theory**: James Maynard
- **Leonard Eisenbud Prize for Mathematics and Physics**: Kevin Joseph Costello
- **Levi L. Conant Prize**: Amie Wilkinson
- **Joseph L. Doob Prize**: René Carmona and François Delarue
- **Leroy P. Steele Prize for Mathematical Exposition**: Martin R. Bridson and André Haefliger
- **Leroy P. Steele Prize for Seminal Contribution to Research**: Craig Tracy and Harold Widom
- **Leroy P. Steele Prize for Lifetime Achievement**: Karen Uhlenbeck

For AWM

- **Louise Hay Award for Contribution to Mathematics Education**: Erika Camacho
- **M. Gweneth Humphreys Award for Mentorship of Undergraduate Women in Mathematics**: Margaret Robinson
- **Microsoft Research Prize in Algebra and Number Theory**: Melody Chan
- **Sadosky Research Prize in Analysis**: Mihaela Ignatova

For AMS-MAA-SIAM

- **Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student**: Nina Zubrilina; Honorable mention: Ashwin Sah, Mehtaab Sawhney, and David Stoner; Honorable mention: Murilo Corato Zanarella

For JPBM

- **Communications Award**: Christopher Budd and James Tanton

For MAA

- **Chauvenet Prize**: Vladimir Pozdnyakov and J. Michael Steele
- **David P. Robbins Prize**: Aubrey D.N.J. de Grey
- **Euler Book Prize**: Tim Chartier
- **Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching of Mathematics**: Federico Ardila, Mark Tomforde and Suzanne L. Weekes
- **Yueh-Gin Gung and Dr. Charles Y. Hu Award for Distinguished Service to Mathematics**: Gerald J. Porter

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