SPECTRUM
Vanderbilt University Department of Mathematics Newsletter
*Fall 2017*

# Cosmic Stickiness Favors 'Big Rip' End of Universe

by David Salisbury

The universe can be a very sticky place, but just how sticky is a matter of debate.

That is because for decades cosmologists have had trouble reconciling the classic notion of viscosity based on the laws of thermodynamics with Einstein's general theory of relativity. However, a team from Vanderbilt University has come up with a fundamentally new mathematical formulation of the problem that appears to bridge this long-standing gap.

The new math has some significant implications for the ultimate fate of the universe. It tends to favor one of the more radical scenarios that cosmologists have come up with known as the "Big Rip." It may also shed new light on the basic nature of dark energy.

The new approach was developed by Assistant Professor of Mathematics Marcelo Disconzi in collaboration with physics professors Thomas Kephart and Robert Scherrer and is described in a paper published in 2015 in the journal *Physical Review D.*

"Marcelo has come up with a simpler and more elegant formulation that is mathematically sound and obeys all the applicable physical laws," said Scherrer.

The type of viscosity that has cosmological relevance is different from the familiar "ketchup" form of viscosity, which is called shear viscosity and is a measure of a fluid's resistance to flowing through small openings like the neck of a ketchup bottle. Instead, cosmological viscosity is a form of bulk viscosity, which is the measure of a fluid's resistance to expansion or contraction. The reason we don't often deal with bulk viscosity in everyday life is because most liquids we encounter cannot be compressed or expanded very much.

Disconzi began by tackling the problem of relativistic fluids. Astronomical objects that produce this phenomenon include supernovae (exploding stars) and neutron stars (stars that have been crushed down to the size of cities).

Scientists have had considerable success modeling what happens when ideal fluids – those with no viscosity – are boosted to near-light speeds. But almost all fluids are viscous in nature and, despite decades of effort, no one has managed to come up with a generally accepted way to handle viscous fluids traveling at relativistic velocities. In the past, the models formulated to predict what happens when these more realistic fluids are accelerated to a fraction of the speed of light have been plagued with inconsistencies: the most glaring of which has been predicting certain conditions where these fluids could travel faster than the speed of light.

"This is disastrously wrong," said Disconzi, "since it is well-proven experimentally that nothing can travel faster than the speed of light."

These problems inspired the mathematician to reformulate the equations of relativistic fluid dynamics in a way that does not exhibit the flaw of allowing faster-than-light speeds. He based his approach on one that was advanced in the 1950s by French mathematician André Lichnerowicz.

Next, Disconzi teamed up with Kephart and Scherrer to apply his equations to broader cosmological theory. This produced a number of interesting results, including some potential new insights into the mysterious nature of dark energy.

In the 1990s, the physics community was shocked when astronomical measurements showed that the universe is expanding at

*(continued on page 2)*

*Photo: NASA Hubble*

## INSIDE

## Letter from the Chair

*Mike Neamtu*

Dear Alumni and Department Friends,

Welcome to the 2017 Department of Mathematics newsletter. Since its last edition in 2015, the department has experienced many exciting developments. A newsletter this size can hardly do justice to the diverse activities and achievements of our students and faculty during that time, but I hope it will give you a sense of the vibrancy of our department.

This fall, we will be entering the 143rd year of our department's existence. Over that span, countless students and faculty have helped build the reputation we enjoy today. Two faculty members who recently retired deserve a special mention - Philip Crooke and Daoxing Xia. The combined duration of their association with us has been an impressive 78 years. One of our most formidable challenges ahead will be hiring new faculty to replace these irreplaceable colleagues.

It is with great sadness that I note the loss of Professor Emeritus Bjarni Jónsson, who passed away last fall. He was one of our most renowned scholars, and he contributed considerably to our department's national and international recognition. You can read more about his career elsewhere in this issue, and also in the new History section of our website.

The department has had several noteworthy achievements over the past two years. On the undergraduate education front, these were two of our best years in terms of the number of math majors, with 100 or more students choosing mathematics each year. What is especially exciting is that we continue to attract better students, which is evidenced by them taking more advanced courses. For several years now, we've held the position of the second largest department in the College of Arts and Science, as measured by the number of credit hours taught. We teach more than 3,500 students annually and offer about 150 classes in many different subjects.

As a department, we continue to excel in research and research-related activities. The intriguing work of Assistant Professor Marcelo Disconzi featured on our cover is only one recent example. Our faculty members are leaders in their fields, and they are excellent advisers and dedicated mentors of our students and young researchers. Another trend worth noting is the consistently high quality of graduate students we're attracting and the excellent work they do while here. Our departing Ph.D.'s are successful in finding jobs, and several of them have landed prestigious postdoc positions at top research universities. Our postdoctoral program also continues to draw outstanding young researchers who contribute significantly to the stimulating research atmosphere in our department and to our research successes.

Academic year 2016-17 was my first year as chair, and it has been extremely rewarding to work with the talented and dedicated group of students, faculty, and staff of this department. I am grateful for the opportunity to serve in this new capacity.

Mike Neamtu
*Professor & Chair, Department of Mathematics*
*Vanderbilt University*
*Email: mike.neamtu@vanderbilt.edu*

## COSMIC STICKINESS *(continued from page 1)*

*Marcelo Disconzi*

an ever-accelerating rate. To explain this unpredicted acceleration, they were forced to hypothesize the existence of an unknown form of repulsive energy that is spread throughout the universe. Because they knew so little about it, they labeled it "dark energy."

Most dark energy theories to date have not taken cosmic viscosity into account, despite the fact that it has a repulsive effect strikingly similar to that of dark energy. "It is possible, but not very likely, that viscosity could account for all the acceleration that has been attributed to dark energy," said Disconzi. "It is more likely that a significant fraction of the acceleration could be due to this more prosaic cause. As a result, viscosity may act as an important constraint on the properties of dark energy."

Another interesting result involves the ultimate fate of the universe. Since the discovery of the universe's runaway expansion, cosmologists have come up with a number of dramatic scenarios of what it could mean for the future.

One scenario, dubbed the "Big Freeze," predicts that after 100 trillion years or so the universe will have grown so vast that the supplies of gas will become too thin for stars to form. As a result, existing stars will gradually burn out, leaving only black holes which, in turn, slowly evaporate away as space itself gets colder and colder.

An even more radical scenario is the "Big Rip." It is predicated on a type of "phantom" dark energy that gets stronger over time. In this case, the expansion rate of the universe becomes so great that in 22 billion years or so material objects begin to fall apart and individual atoms disassemble themselves into unbound elementary particles and radiation.

The key value involved in this scenario is the ratio between dark energy's pressure and density, which is called its equation of state parameter. If this value drops below -1, then the universe will eventually be pulled apart. Cosmologists have called this the "phantom barrier." In previous models with viscosity the universe could not evolve beyond this limit.

In the Desconzi-Kephart-Scherrer formulation, however, this barrier does not exist. Instead, it provides a natural way for the equation of state parameter to fall below -1.

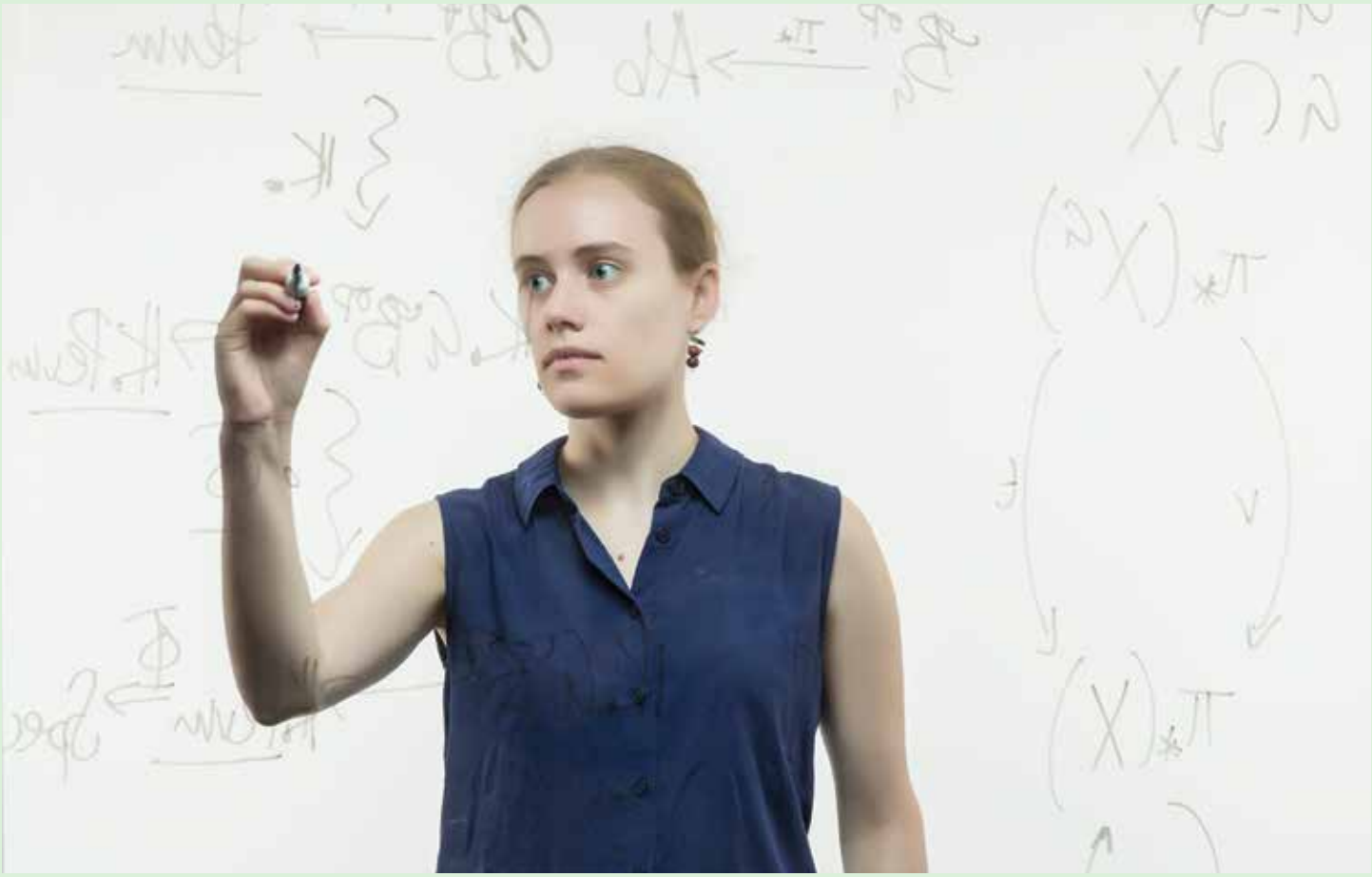
"In previous models with viscosity the Big Rip was not possible," said Scherrer. "In this new model, viscosity actually drives the universe toward this extreme end state."

According to the scientists, the results of their pen-and-paper analyses of this new formulation for relativistic viscosity are quite promising but a much deeper analysis must be carried out to determine its viability. The only way to do this is to use powerful computers to analyze the complex equations numerically. In this fashion the scientists can make predictions that can be compared with experiment and observation.

Disconzi's work has been covered by many general interest and science media outlets, including *The Huffington Post, Wired, The Guardian, The New Statesman*, and BBC Brasil. The research was supported by the National Science Foundation and the Department of Energy.

NEW FACULTY PROFILE

# Anna Marie Bohmann by David Salisbury



*Anna Marie Bohmann*

When Anna Marie Bohmann was growing up in Minneapolis, she enjoyed school in general—and math in particular—but had no idea that making a career in mathematics was even possible.

In high school, however, she took some university math classes and did so well that her high school math teacher suggested that she consider majoring in mathematics when she went to college. "Getting a Ph.D. sounded cool," Bohmann said.

When she was accepted to Massachusetts Institute of Technology as an undergraduate, Bohmann also considered physics as a possible major. "But when I got into levels beyond calculus, I found mathematics to be increasingly compelling," she said. "It's amazing what you can do with nothing but your brain."

Bohmann also learned that she had a talent for languages, so she double majored in math and Spanish language and literature. After graduating from MIT, she got a master's degree in Spanish literature at New York University. "For a while I seriously thought about going into Spanish lit, but I realized I would miss the math. I tried out the other pathway until I knew mathematics was what I wanted to do," she said.

Bohmann enrolled in the graduate program in mathematics at the University of Chicago, earning her master's degree in 2007 and doctorate in 2011. From there, she moved to a postdoctoral fellowship at Northwestern University. In 2014 she also put in a stint as a postdoctoral fellow at the Mathematical Sciences Research Institute in Berkeley, California, before accepting a tenure-track position as assistant professor of mathematics at Vanderbilt in 2015.

Bohmann's research area is called "algebraic topology." Abstract algebra is a major area in advanced mathematics that focuses on generalizing the structures required to manipulate numbers. Topology is concerned with the properties of spaces, particularly those that are preserved under deformations such as bending and stretching.

"Algebraic topology," she explained, "is using algebra to understand spaces, not just familiar three-dimensional spaces but also multidimensional spaces."

Bohmann gives the example of the circular floor plan of the house in which she grew up. If you took a piece of string and unrolled it as you walked around the house, then tied the two ends together, it would be impossible to pull the string out without cutting it.

"That makes the space 'nontrivial' and fundamentally different from the space in a single room," she said. "As long as there aren't any columns in the room, if you lay down a piece of string around the edges and tie them together, you can easily pull the string out. That means the room is a 'trivial' space." By identifying different types of spaces in such a fashion and using algebraic techniques to analyze them, mathematicians like Bohmann can derive a surprising amount of information about how they behave.

"I really enjoy the way that mathematics helps you think about things," Bohmann said. "When you are in school, you know that there are always answers to the problems you are given. That isn't the case in research. You don't know if an answer exists, so it is incredibly gratifying when you find one."

In addition to mathematics, Bohmann enjoys knitting, local cuisine, and old-time and classical music. "I'm really excited to be here," she said. ■

## Faculty Updates

Ioana Suvaina was promoted to associate professor with tenure effective fall 2017.

Anna Marie Bohmann and Spencer Dowdall were reappointed as tenure-track assistant professors effective fall 2018.

Linda Hutchison and Pamela Pigg were reappointed with promotion to the rank of principal senior lecturer in mathematics for a five-year term effective fall 2018.

The department congratulates these faculty members on their continued success.

*We'd love to hear from you!*

*Send us a few lines telling us what you've been up to since leaving Vanderbilt. Write to us at: math.alumni@vanderbilt.edu*

## You can make a difference

Thank you to all alumni, parents, students, faculty, staff, and friends who donate to the Department of Mathematics. You directly impact our department's students and faculty, and play a vital role in supporting a wide range of educational and research activities in our department.

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# Jesse Peterson Named Chancellor Faculty Fellow

Associate Professor of Mathematics Jesse Peterson is one of 12 outstanding Vanderbilt University faculty members named to the 2017 class of Chancellor Faculty Fellows. The class comprises highly accomplished faculty from a wide variety of disciplines across the university. The Chancellor Faculty Fellows program was launched in September 2014 under the Trans-Institutional Programs initiative to support outstanding faculty who have recently received tenure.

*Jesse Peterson*

Peterson will hold the title of Chancellor Faculty Fellow for two years and will be supported by an unrestricted allocation of $40,000 a year for two years beginning July 1, 2017. The funds can be used to support innovative research, scholarship, and creative expression activities that will further propel the career of the awardee. The Chancellor Faculty Fellows also will meet as a group during the course of their awards to exchange ideas on teaching and research, building a broader intellectual community that advances trans-institutional scholarship.

Peterson joined the Department of Mathematics in the fall of 2008. He received his Ph.D. from the University of California, Los Angeles in 2006 under the direction of Sorin Popa. His previous honors include a Liftoff Fellowship from the Clay Mathematics Institute, a National Science Foundation Mathematical Sciences Postdoctoral Research Fellowship, and an Alfred P. Sloan Research Fellowship.

Peterson's primary research interest lies in the area of von Neumann algebras and their applications to related fields such as group theory and orbit equivalence ergodic theory. He is a member of the department's Noncommutative Geometry and Operator Algebras research group and a co-organizer of the weekly Subfactor Seminar. In addition, he was co-organizer of the annual Noncommutative Geometry and Operator Algebras Spring Institute in 2014, 2015, and 2017.

According to Dietmar Bisch, former chair of the department, who nominated Peterson for the Chancellor Faculty Fellows program, "Jesse is a leading researcher in the theory of von Neumann algebras. His contributions to the field are profound and original, and he has already mentored several highly successful postdoctoral fellows and Ph.D. students. We are thrilled to have him as a colleague."

# Denis Osin Invited to Speak at ICM 2018

Professor Denis Osin has been invited to speak at the International Congress of Mathematicians in 2018. Held once every four years, the ICM brings together mathematicians from all over the world to discuss the latest developments in every area of mathematics. An ICM invitation is considered to be one of the most significant recognitions of a mathematician's work.

*Denis Osin*

The 2018 ICM will be held August 1-9, 2018, in Rio de Janeiro. Osin is an invited speaker in the geometry section.

Osin received his Ph.D. from Moscow State University in 1999. He joined the Vanderbilt Department of Mathematics in 2008. His research interests are in the areas of group theory and geometric topology.

Five other current Department of Mathematics faculty members have previously been invited to speak at the ICM: Dietmar Bisch, Vaughan Jones, Gennadi Kasparov, Alexander Ol'shanskii, and Mark Sapir.

The full list of 2018 invited ICM speakers is available at www.icm2018.org. A list of all past invited speakers is available at www.mathunion.org.

NEW FACULTY PROFILE

# Spencer Dowdall

New faculty member Spencer Dowdall joined the Vanderbilt Department of Mathematics in fall 2015 as a tenure-track assistant professor. Dowdall received a B.A. and an M.S. in mathematics as well as an M.S. in physics from the University of Michigan, Ann Arbor, all in 2006. He received a second M.S. in mathematics from the University of Chicago in 2007 and his Ph.D. there in 2011 under the direction of Benson Farb.

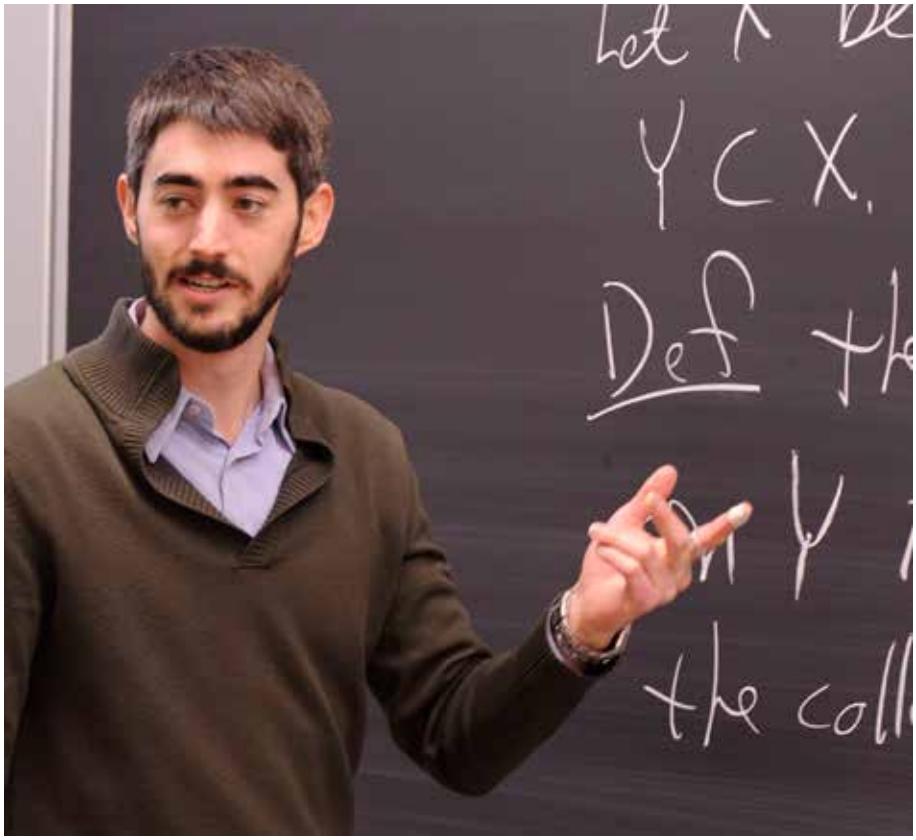
Before joining Vanderbilt, Dowdall was a J. L. Doob Research Assistant Professor at the University of Illinois at Urbana-Champaign from fall 2011 to spring 2015. While there he was also awarded a prestigious National Science Foundation Mathematical Sciences Postdoctoral Research Fellowship to study "Geometry and Dynamics in Surface Topology."

Dowdall's research explores dynamical, geometric, and algebraic aspects of three areas: free group automorphisms, surface homeomorphisms, and Teichmüller spaces. "I think of the first two areas as encoding symmetries of finite graphs and of surfaces," he says, "while the third one parameterizes certain types of geometric structures on a surface. I'm drawn to these topics because they connect in important ways to several branches of mathematics, including dynamics, low-dimensional manifold theory, algebraic geometry and topology, complex analysis, and combinatorial group theory, to name a few."

In June 2017, Dowdall was awarded a three-year NSF research grant for a project entitled "Geometry & Dynamics on Surfaces & Free Group Extensions." It will investigate geometry and dynamics in surface topology and geometric group theory, with a focus on surface homeomorphisms, free group extensions, and Teichmüller spaces.

Dowdall has received a number of other fellowships and awards, including the Lawrence and Josephine Graves Teaching Prize and the McCormick Fellowship while at the University of Chicago, and the Sidney J. and Irene G. Shipman Scholarship while at the University of Michigan. He was twice named to the List of Teachers Ranked as Excellent at the University of Illinois.

Dowdall was the lead organizer of the Conference on Low-Dimensional Topology and Geometry hosted by the Department of Mathematics in conjunction with the 32nd Annual Shanks Lecture from May 15 to 19, 2017 (see separate story on page 11 of this issue).




*Spencer Dowdall*

## Mike Neamtu Named New Chair of the Department

Professor Mike Neamtu has been named the new chair of the Department of Mathematics.

Neamtu received his Ph.D. in 1991 from the University of Twente in the Netherlands. He joined the Vanderbilt Department of Mathematics in 1992. His research interests are in approximation theory, spline theory, computer-aided geometric design, and numerical analysis. His latest research in splines and computer-aided design was featured in the 2015 issue of *Spectrum*.

He has been an organizer and co-organizer of many conferences on approximation theory and its applications, including the International Conference on Approximation Theory and the Conference on Geometric Design and Computing, a flagship conference of the Society of Industrial and Applied Mathematics' Activity Group on Geometric Design that he also chaired.

Neamtu has extensive experience with departmental administration, having served in the past as director of graduate studies, as vice chair, and also as acting chair of the department.

"I am excited to be taking on this role," he said. "In recent years the department has made significant advances in terms of our achievements, visibility, and both national and international reputation, and I look forward to working with the rest of the faculty, students, and staff to continue that momentum."

Neamtu expressed appreciation for the work of former chair Professor Dietmar Bisch, who stepped down after eleven years of service. "We were very lucky to have Dietmar as chair," Neamtu said. "His leadership was the driving force behind the progress the department has made in the past several years."

Professor John Ratcliffe will fill the role of vice chair that is being vacated by Neamtu. Ratcliffe received his Ph.D. from the University of Michigan in 1977. He has been a member of the Vanderbilt Department of Mathematics faculty since 1985. He previously served as vice chair for three years from 2009 through 2012.

Ratcliffe's research interests are in low-dimensional topology, hyperbolic manifolds, and geometric group theory. He is a member of the editorial board of the journal *Advances in Geometry* and the author of *Foundations of Hyperbolic Manifolds*, a popular graduate textbook on the subject.

Neamtu's and Ratcliffe's terms began August 1, 2016.

# Graduate Students Win Teaching & Research Awards

*Chang-Hsin Lee (left) and Timothy Michaels*

Four graduate students were honored for outstanding achievements in teaching and research at the Department of Mathematics annual award ceremony in April 2017.

The 2017 B.F. Bryant Prize for Excellence in Teaching was shared by graduate students Chang-Hsin Lee and Timothy Michaels. The award recognizes graduate teaching assistants who have demonstrated concern for and accomplishments in teaching, qualities that characterized the career of former Professor Billy Bryant. In announcing the award, Associate Professor Alex Powell cited the outstanding ratings Lee and Michaels received on student evaluations.

Lee received his Ph.D. in August 2017 and has accepted a position as a data scientist with Lowe's. Michaels is also expected to graduate in 2017.

The Bjarni Jónsson Prize for Research was awarded jointly to Colin Klaus and Yunxiang Ren. The prize was established in honor of former Distinguished Professor Bjarni Jónsson and is awarded annually to one or more graduate students for exceptional research in mathematics and outstanding research potential.

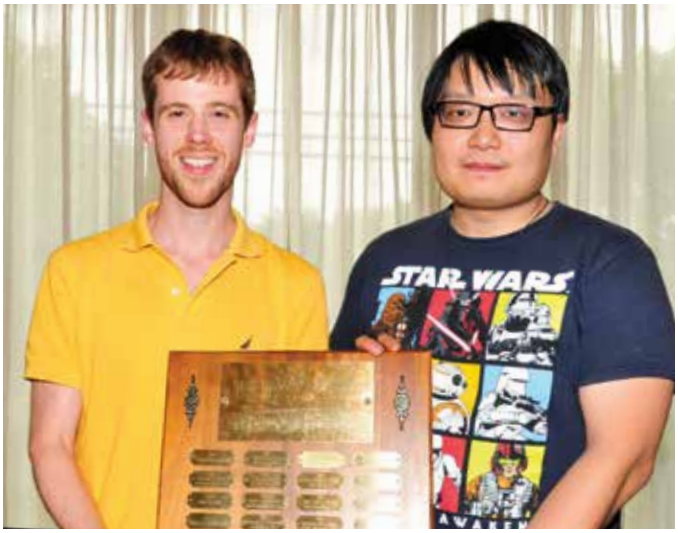
Klaus' research interests are in an area of biomathematics known as visual transduction. Visual transduction is the process by which photons of light get transduced into electrical pulses to be communicated to the brain. His work involves both applied and pure math components.

"In addition to his interest in mathematical biology, Colin was also fascinated with classical analysis issues such as local behavior of degenerate and singular parabolic equations," said Klaus' advisor, Centennial Professor of Mathematics and Professor of Molecular Biology and Biophysics Emmanuele DiBenedetto. "Very few people come to mathematical biology with an expertise in numerical analysis, classical analysis, biochemistry, biophysics, and most of all, the culture of a truly interdisciplinary mindset."

Klaus is the co-author of two published papers, one in the journal *Molecular Biology of the Cell* and the other in *Advances in Calculus of Variations*. He received his Ph.D. in August 2017 and has accepted a postdoctoral position at the Mathematical Biosciences Institute at The Ohio State University.

Yunxiang Ren's research interests are in two different areas: planar algebras and unitary representations of Thompson's groups. "He solved a problem that I had worked on quite hard but was unable to solve and determined the structure of a special planar algebra related to the Peterson graph," said his advisor, Stevenson Distinguished Professor Vaughan Jones. "He also found an elegant reproof of the Golan-Sapir structure of what I call the 'oriented' Thompson group."

Ren is the sole author of a paper that has been submitted to the *Journal of Algebra* and the co-author of a paper that has been submitted to *Quantum Topology*. He received his Ph.D. in August 2017 and is currently a postdoctoral associate at the University of Tennessee, Knoxville.




*Colin Klaus (left) and Yunxiang Ren*

# Michael Montgomery Receives Larsen Award

The 2017 Richard J. Larsen Award for Achievement in Undergraduate Mathematics was awarded to Michael Montgomery. Established in honor of Professor Emeritus Richard Larsen, the award is presented each spring to the senior math major judged by the faculty to have excelled in all aspects of undergraduate mathematics.

Director of Undergraduate Studies John Rafter noted during the award ceremony that the department's honors track math major requires seven courses beyond the core undergraduate courses. "Michael took 17 courses, including all the core graduate courses," Rafter said.

The faculty members are thrilled that Montgomery has joined the Vanderbilt Ph.D. program in mathematics this fall.

*John Rafter, Michael Montgomery, and Richard Larsen*

## New Graduate Students and Recent Graduates

The department welcomes five new graduate students and extends best wishes to five recent graduates.

### NEW PH.D. STUDENTS

**David Chan**
*B.A and M.A., Johns Hopkins University*

**Dumindu De Silva**
*B.S., University of Colombo, Sri Lanka*

**Michael Montgomery**
*B.S., Vanderbilt University*

**Zachary Tripp**
*B. S., Tufts University*

**Sifan Yu**
*B.S., Nankai University, China*

### RECENT GRADUATES

**Sayan Das, Ph.D., 2017**
*Ph.D. Thesis: Poisson Boundaries of Finite von Neumann Algebras*
*Faculty Advisors: Jesse Peterson and Vaughan Jones*

**Colin Klaus, Ph.D., 2017**
*Ph.D. Thesis: Interior Regularity for Parabolic Variational Problems of 1-Laplacian Type and Multi-Scale Homogenization, Finite Element Modeling of Biological Diffusion, Especially of Cone Photoreceptors in Visual Transduction*
*Faculty Advisor: Emmanuele DiBenedetto*

**Chang Hsin Lee, Ph.D., 2017**
*Ph.D. Thesis: Analysis of Signal Reconstruction Algorithm Based on Consistency Constraints*
*Faculty Advisor: Alexander Powell*

**Armenak Petrosyan, Ph.D., 2017**
*Ph.D. Thesis: Dynamical Sampling and Systems of Vectors from Iterative Actions of Operators*
*Faculty Advisor: Akram Aldroubi*

**Yunxiang Ren, Ph.D., 2017**
*Ph.D. Thesis: Skein Theory of Planar Algebras and Some Applications*
*Faculty Advisor: Vaughan Jones*

# New Arenstorf Scholarship Awarded to Select Graduate Students

*Richard F. Arenstorf*

The Richard F. Arenstorf Scholarship is a new endowed scholarship made possible by a generous gift of the late Richard Arenstorf, a professor of mathematics at Vanderbilt University from 1969 to 1997. The scholarship is awarded to one or more primarily incoming graduate students each year to offset educational expenses. The recipients are selected by the department's Graduate Committee.

The first Arenstorf Scholarship was awarded in 2016-2017 to Jun Yang. Yang received his M.S. degree from Nankai University, China, in 2016. The recipient of this year's 2017-2018 scholarship is Dumindu De Silva, who received his B.S. from the University of Colombo, Sri Lanka, in 2016.

After earning his Ph.D. from the University of Mainz in 1956, Professor Richard Arenstorf came to the United States, where he worked first at the Army Ballistics Missile Agency in Huntsville, Alabama, and then with NASA. His work on the "three-body problem" led to his discovery of an 8-shaped orbit around two bodies, which made possible the Apollo missions to the moon. His contributions to the space program earned him the NASA Medal for Exceptional Scientific Achievement in 1966.

Arenstorf left NASA after the first moon landing in 1969 and joined the Vanderbilt Department of Mathematics. His research interests continued to focus on celestial mechanics and analytic number theory. A particular area of interest in number theory was the properties of the Riemann zeta function, which plays a pivotal role in understanding the nature of prime numbers. He introduced and offered several new graduate courses and was an advisor to six graduate students studying number theory.

He was a member of the American Mathematical Society, the Society for Industrial and Applied Mathematics, and the National Space Institute. He retired in 1997 and passed away on September 18, 2014, bequeathing an endowment to fund the Richard F. Arenstorf Scholarship. ■

## *Did you know?*

***The first Ph.D. in mathematics awarded by Vanderbilt was to James Robert ("Bob") Wesson in 1953. Wesson was also a member of the Department of Mathematics faculty from 1957 to 1990. He served as a navigator and bomber in the Army Air Corps during World War II before pursuing his academic career. You can read his biography in the History section of our website.***

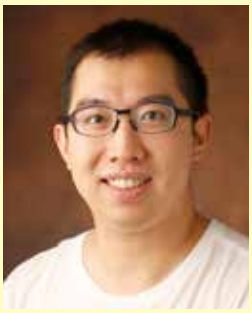
*Bob Wesson*

Photo: George M. Bergman. Source: Archives of the Mathematisches Forschungsinstitut Oberwolfach

# Postdoctoral Fellows

Our postdoctoral program attracts outstanding young researchers from top universities. Most of our postdoc positions are three-year non-tenure track assistant professor appointments with a teaching load of three courses per year. We welcome the following seven postdoctoral fellows who are joining the Vanderbilt Department of Mathematics this fall.

**Valeriano Aiello** received his Ph.D. in 2017 from the University of Rome 3, Italy. His research interests are in the area of operator algebras.



**Chenyun Luo's** research lies in the realm of partial differential equations. In particular, he studies the motion of a compressible liquid with free surface boundary. He received his Ph.D. in 2017 from Johns Hopkins University.

**Scott Atkinson** received his Ph.D. from the University of Virginia in 2016. His research interests lie in operator algebras, operator theory, and functional analysis.

**Andrew Moorhead** received his Ph.D. from the University of Colorado, Boulder in 2017. His research interests are in universal algebra and computer science.

**Matt Haulmark's** research interests are in the field of geometric group theory, specifically boundaries of groups with non-positive curvature. He received his Ph.D. from the University of Wisconsin-Milwaukee in 2017.

**Çağlar Uyanik's** research interests are in geometric group theory, geometric topology, ergodic theory, and dynamics. He received his Ph.D. from the University of Illinois at Urbana Champaign in 2017.

**Wöden Kusner** received his Ph.D. from the University of Pittsburgh in 2014. His research interests are in discrete geometry and optimization.

*Want to go paperless?*

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# Remembering Professor Emeritus Bjarni Jónsson by David Salisbury

Bjarni Jónsson, Vanderbilt's first Distinguished Professor of Mathematics, died Sept. 30, 2016, at the age of 96.

Born in Iceland, Jónsson earned his bachelor's and doctoral degrees from the University of California-Berkeley and also received an honorary degree from the University of Iceland. He was internationally recognized as a leading authority on universal algebra, lattice theory, and algebraic logic.

In his career, Jónsson authored 89 technical papers and served on the editorial board of several major mathematics journals, including *Algebra Universalis*. He presented numerous invited talks at mathematics conferences around the world. In 1974 he was an invited speaker at the International Congress of Mathematicians. In 2012 he was elected an inaugural fellow of the American Mathematical Society. He was also the recipient of Vanderbilt's Harvie Branscomb Distinguished Professor Award in 1974 and the Earl Sutherland Prize for Achievement in Research in 1982.

"Bjarni Jónsson was a remarkable mathematician who made field-defining and path-breaking contributions in universal algebra, lattice theory, and algebraic logic. Anyone who had the fortune to know him admired his integrity, kindness, and immense respect for colleagues and friends. His influence on my personal and mathematical life has been enormous, and it is a great privilege that I have had the opportunity to work with and learn from him," said Professor Constantine Tsinakis, a long-term colleague and a former chair of the Department of Mathematics.

"To me Bjarni will always be a legend, who in his quiet, sincere, unassuming ways continues to inspire uncountably many algebraists, raising questions and re-examining areas that he feels would benefit from an algebraic approach," wrote Peter Jipsen, one of the doctoral students that Jónsson advised, on the occasion of his 70th birthday.

Jipsen, who is a professor of mathematics at Chapman University, added, "While some mathematicians almost revel in stringing together long complex arguments, Bjarni has constantly sought to simplify and illuminate the subjects dear to him."

## Early Days in the Department

Jónsson came to Vanderbilt in 1966 and taught here until his retirement in 1993. When he arrived, mathematics was mostly an undergraduate teaching department. He was instrumental in establishing the department's graduate program, which presently ranks among the top departments in the nation, according to the most recent evaluation by the National Research Council.

Jónsson also formed a research group in algebra at Vanderbilt that attracted mathematicians from around the world and contributed substantially to the high research profile that the department currently enjoys.

Algebra is the study of mathematical objects and the rules for manipulating them. Jónsson made his most important contributions in the area of universal algebra. It is one of the most abstract subfields of algebra because it studies algebraic structures in general, as opposed to specific classes of algebras, such as groups and fields. The importance of his contributions is reflected by the fact that a number of mathematical objects are named for him, including Jónsson and Jónsson-Tarski algebras, Jónsson cardinals, Jónsson terms, the Jónsson lemma, and the Jónsson-Tarski duality.

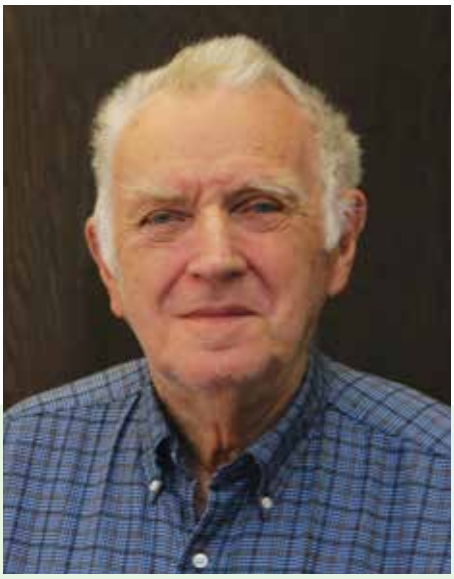
During his career, Jónsson supervised 14 Ph.D. students, eight of them while at Vanderbilt. In letters they wrote for a symposium in honor of his 70th birthday, which took place in Iceland in 1990, his former students all expressed a deep appreciation for him as a "respected mathematical guide and personal friend."

One of the first students he supervised, Steven Monk, now professor emeritus at the University of Washington, recalled advice that he received from Jónsson regarding teaching: "Adventure is not in the guidebook and beauty is not on the map. The best one can hope for is to be able to persuade some people to do some traveling on their own."

The Bjarni Jónsson Prize for Research was established in 1995 in his honor. The prize is awarded each year to a graduate teaching assistant in the Department of Mathematics for exceptional research in mathematics, as well as for outstanding research potential.

In addition, the Vanderbilt Department of Mathematics hosted the 2017 BLAST Conference August 14-18, 2017 in memory of Jónsson. BLAST is a conference series that focuses on Boolean algebras, lattices, algebraic logic, quantum logic, universal algebra, set theory, and set-theoretic and point-free topology.

"Bjarni Jónsson's work and scholarly contributions will have a lasting legacy. His name will forever be interwoven in the history of our department. We are honored to have had him as a colleague," noted Department Chair Mike Neamtu.



*Bjarni Jónsson*

*Bjarni Jónsson was a remarkable mathematician who made field-defining and path-breaking contributions in universal algebra, lattice theory, and algebraic logic.*

# Professor Daoxing Xia Retires

Professor Daoxing Xia retired from the Department of Mathematics in December 2016 after 32 years of service.

Xia graduated from the Research Institute of Mathematics at Zhejiang University, China, under the direction of the influential mathematician Jiangong Chen. From 1952 to 1982, Xia held several positions in the Research Institute of Mathematics and in the Department of Mathematics at Fudan University, Shanghai, including a full professorship from 1978 to 1982.

Beginning in 1957, he spent more than a year in Moscow working with the renowned mathematician Israel Gelfand. In 1980, he was elected a member of the Chinese Academy of Sciences, the highest and most prestigious academic title in China.

In 1982, Xia traveled to the United States, where he was a visiting professor at the University of Iowa in the academic year 1982/83. During that time he also had a part-time visiting position at Stony Brook University. In 1983/84, he was a visiting member of the Institute for Advanced Study at Princeton University and also a visiting professor at The Ohio State University. Xia joined Vanderbilt University as a professor of mathematics in 1984.

Xia's research has been in several areas of mathematical analysis, including functional analysis, complex analysis, operator theory, applied mathematics, modern mathematical physics, the theory of functions, and probability theory. His research was continuously funded by the National Science Foundation from 1985 to1999.

He has produced more than 100 scientific publications, including eight books and research monographs. Some of his achievements include proofs of the so-called Goluzin conjectures, work on quasi-conformal mappings, the development of measure theory on infinite-dimensional spaces and their application to the theory of quantum Boson free fields and Gaussian processes, and his work on hyponormal operators.

During his long and productive career, Xia was invited to give lectures at major international meetings, perhaps the most prestigious being his invited plenary lectures at two consecutive meetings of the International Congress of Mathematical Physics. He served on the editorial boards of several journals, including the *Chinese Annals of Mathematics* and *Integral Equations and Operator Theory*, and he supervised 11 Ph.D. students, six of them at Vanderbilt.

# Professor Philip Crooke Retires

Professor Philip Crooke retired from the Department of Mathematics in August 2016 after 46 years of service.

Crooke earned his B.S. from Stevens Institute of Technology in 1966 and his Ph.D. in applied mathematics from Cornell University in 1970. He joined Vanderbilt University in 1970 as an assistant professor. He was promoted to associate professor in 1976 and to professor in 1986, and received a secondary appointment as professor of education in 1995.

Crooke's research interests evolved over his career to encompass a wide range of subjects, from the use of technology in teaching to biomathematics and mathematical modeling. He has published a large number of papers and other works, including books and book chapters, addressing a variety of problems, including growth properties of the Saffman dusty gas equations, Sobolev inequalities, bifurcations in fermentation processes, parameter estimation in enzyme kinetics, the effects of mergers in auctions, optimization of dialysis networks, and dynamics of mechanical respiratory ventilation. In 2015, a paper he co-authored won the prestigious "Best Paper" award given annually by *Innovations*, the official journal of the International Society for Minimally Invasive Cardiothoracic Surgery.

Recently, his efforts have been directed toward the use of mathematics in translational medicine. His models have been used to optimize mechanical ventilation of critically ill patients, to assess breast cancer risk from estrogen metabolism in post-menopausal women, to predict autoimmune diseases such as MS using the patient's gene expression data, and to design annuloplasty rings for aortic valve repair (his work on which was featured in the fall 2012 issue of *Spectrum*).

Another of his major interests over the years has been the use of technology in teaching. He participated in various programs to integrate technology and instruction, including serving as the departmental coordinator of Mathematica Across the Curriculum, a program funded by the Pew Charitable Trusts, and organizing summer workshops sponsored by the National Institutes of Health for graduate students, postdocs, and faculty on the use of mathematical modeling in cancer growth and invasion. He has co-authored two textbooks: *A Guidebook to Calculus with Mathematica* with John Ratcliffe and *Mathematics and Mathematica for Economists* with Cliff Huang.

Crooke acted as vice chair of the department from 2003 to 2009 and again in 2012. He also served as director of the Biomathematics Study Group from 2002 to 2005. From 2008 to 2016, he served on the Executive Advisory Committee of the Chemical and Physical Biology Program at Vanderbilt. He was the advisor for four Vanderbilt Ph.D. students and co-advisor for an additional three Ph.D. students at Mahidol University in Thailand.

Though retired from teaching, Crooke is continuing his research and his involvement with the Department of Mathematics through a recent appointment as a research professor.

CONFERENCE SPOTLIGHT

# Low-Dimensional Topology and Geometry

*Attendees at the Conference on Low-Dimensional Topology and Geometry*

The Department of Mathematics hosted the Conference on Low-Dimensional Topology and Geometry May 15 to 19, 2017. Held in conjunction with the 32nd Annual Shanks Lecture, the conference focused on the close interrelationships between geometry and topology in low dimensions, such as in the study of surfaces and three-dimensional manifolds (3-manifolds). Emphasis was on the powerful negative curvature and combinatorial techniques that are driving much of the current research in this area.

The inherent connection between geometry and topology pervaded William Thurston's revolutionary work in the 1980s that refocused the field of 3-manifold topology around a handful of bold geometric conjectures. By drawing on the work of many mathematicians and incorporating wide-ranging ideas from ergodic theory, combinatorial geometry, hyperbolic geometry, and group theory, this new paradigm in 3-manifold topology has recently culminated in the proof of Thurston's virtual fibering conjecture.


*Shanks Lecturer Ian Agol*

The Vanderbilt conference revisited some of the ideas that emerged from these developments and examined the tools and techniques that are now being refined and applied to broader contexts. Topics included hyperbolic 3-manifolds, moduli spaces of Riemann surfaces, the geometry and topology of curves on surfaces, surface bundles, Gromov-hyperbolic simplicial complexes, CAT(0) cube complexes, and many others.

This year's featured Shanks Lecturer was Professor Ian Agol of the University of California, Berkeley. Agol received the 2016 Breakthrough Prize in Mathematics for his contributions to low-dimensional topology and geometric group theory, including work on the solutions of the tameness, virtual Haken, and virtual fibering conjectures. He is also the recipient of the 2013 Oswald Veblen Prize in Geometry and the 2009 Clay Research Award. The title of his Shanks Lecture was "Flow and Yamada Polynomials of Cubic Graphs."

The prestigious Shanks Lecture Series is organized annually by the Department of Mathematics of Vanderbilt University, honoring Baylis and Olivia Shanks. The late Professor Baylis Shanks was chairman of the department from 1956 through 1969. A list of previous Shanks Conferences and Lecturers as well as more information about the Conference on Low-Dimensional Topology and Geometry can be found on the department website: as.vanderbilt.edu/math.

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# Math Degree Animates a Disney Career by Mardy Fones

Every day is a Disney day for Vanderbilt Department of Mathematics alumnus Troy Underwood. As a director in the Current Series department for Disney Television Animation, Underwood manages the creative direction on series such as Lucasfilm's "Star Wars Rebels" and Disney XD's hit series "Star vs. The Forces of Evil."

"I'm a facilitator, a problem solver. I ensure the creative team has what they need to do their jobs while keeping an eye on the budget," says the Greenville, Kentucky, native, who received his B.S. in mathematics from Vanderbilt in 1991.

He credits his Vanderbilt years with honing his ability to balance the seemingly divergent priorities that come with working with both business and creative people. "VU taught me to solve problems one step at a time and to work cohesively with others," says Underwood.

Disney is a long way from the mathematics major who got a D in his first calculus class. "The D was a wake-up call," he says. "I had to focus on academics, sharpen my skills, and build study muscles." He regrouped, repeated Calculus I and II, and embraced the counsel of Professor Richard Larsen, who was then the department's director of undergraduate studies.

"Dr. Larsen encouraged me. He pointed out that if I just applied myself I could do it, and he was right," says Underwood. He complemented his analytical prowess with a second major in English. "I love storytelling and writing," he says. "It just seemed to me that majoring in both would provide balance academically and personally."

Post-graduation, Underwood worked in finance in Nashville and New York and was drawn to the independent film industry, eventually working with New York City-based producer, Forensic Films. Via a jump to Los Angeles, he dived into talent representation. There, Underwood fused his financial and problem-solving skills with creativity at AniManagement, an animation-focused talent management company. The next step was The Gotham Group, which represents top animation talent in television, features, publishing, and videogames.

At Disney since 2011, Underwood guides the creative output of multiple series with the goal of making content that kid viewers connect with. In addition to "Star Wars Rebels" and "Star vs. The Forces of Evil," his projects have ranged from the new Disney XD series, "Billy Dilley's Super-Duper Subterranean Summer" to "Fish Hooks" to "TRON: Uprising." While he enjoys the content side of his job, in the future he could see himself in the producer role.

"You never know what paths lay in front of you or what you're really interested in until you're doing it," says Underwood. "That's why I like the direction I got at Vanderbilt — identify your strengths, weaknesses, and what you are drawn to. Then keep making decisions that get you there."