MATH MATTERS

Department of Mathematics Cornell University Ithaca NY December 2015

Letter From The Outgoing Chair

Laurent Saloff-Coste

Our new Chair, Ravi Ramakrishna '88, takes the reins on January 1st 2016. We are very fortunate to have Ravi's leadership moving forward. Exciting challenges and opportunities are plentiful!

Prof. Ravi Ramakrishna

Mathematics departments everywhere must balance the needs created by their far reaching, expanding educational missions with the demands of cutting edge research in one of the most central and competitive fields of study. Cornell, with its considerable commitment to undergraduate education and its ambitious programs spanning an extraordinary range of areas of knowledge, exemplifies this challenge.

With our offering of advanced undergraduate courses, our main challenge going forward is to answer the demand and interest of Cornell students for the mathematics curriculum. We are thrilled that the enrollment in junior and senior mathematics courses has grown 30% over the last seven years. As more students enroll in upper-level mathematics courses, the diversity of their background and interests increases as well. Our goal is to expand the appeal of the advanced mathematics curriculum by increasing the diversity of the areas and subjects we cover while continuing to improve the quality of the overall experience we provide to Cornell mathematics majors.

At the entry level, the challenge is to serve the diverse needs of Cornell students and to help them fulfill their dreams in a world dominated by technology that often requires a higher level of mathematics training and sophistication. Today, pursuing one's interest in the life sciences, economics, information science, the environment and many current aspects of the social sciences requires solid training in mathematics. The use of innovative teaching methods and technology, as well as taking better account of both the past experience of the students (going back to middle and elementary school) and the diversity of their endeavors, are all key elements to tackling these challenges. In the department, Senior Lecturers Kelly Delp and Maria Terrell and Professors Tara Holm, Ravi Ramakrishna,

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Alex Townsend Joins Faculty

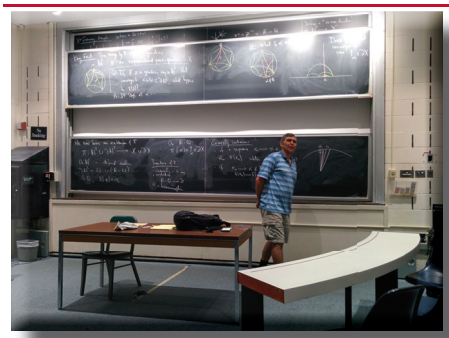
Alex Townsend, a numerical analyst, will be joining our department as a tenure-track assistant professor in 2016. He specializes in using analytic approximation theory to improve the accuracy and efficiency of numerical algorithms.

Alex received his DPhil from Oxford in 2014 (supervised by Nick Trefethen), followed by a two-year postdoctoral position at MIT. He is one of the main contributors to the ChebFun numerical software package.

Alex's work has been recognized by several awards, including two Leslie Fox prizes (2nd place in 2013; 1st place in 2015) in numerical analysis.

His (2015) first-place paper describes the first stable quasi-linear complexity algorithm for computing a two-dimensional Fourier transform with circular symmetry. It is applicable to medical imaging, electromagnetics, and the numerical solution of partial differential equations.

Prof. Alex Townsend



Mladen Bestvina presents at the Topology Festival - photo credit, Tim Riley

Continued from page 1.

Tim Riley and Steve Strogatz have been leading our collective efforts in these directions.

While we are very happy to be part of the College of Arts and Sciences, for all of Cornell's history our department has been the Mathematics Department of Cornell University. From day one, students with very diverse interests have filled our classrooms. In 1874, Cornelia A. Preston earned a Science Bachelor. She later taught history and mathematics in Utica. The same year, George T. Winston graduated with a Literature Bachelor. He was Instructor in mathematics at Cornell, before becoming a Professor of Literature at the University of North Carolina where he was elected president at the age of 39. Also in 1874, Edward Wyllys Hyde graduated as a Civil Engineer. After teaching at Cornell, he became Professor of Mathematics at the University of Cincinnati, made very innovative contributions to vector calculus, and served as president before becoming an actuary.

Cornell Mathematics has a long history of excellence in research. It fulfills a key multifaceted mission at the service of the university and, with your support and that of the entire institution, has a bright future.

The 51st Topology Festival

Tim Riley

The 51st Cornell Topology Festival was held May 8-10, 2015. This annual conference has been a force in the mathematical life of topologists and geometers in the northeastern United States since it was founded in 1963 by Israel Berstein, William Browder, Peter Hilton, Roger Livesay, and Paul Olum. It began as a regional conference, with mostly local speakers, but has grown over the years and is now well-known internationally.

The 2015 meeting featured several one-hour talks in a range of topological topics, with an emphasis on groups acting on negatively curved spaces. The program began with introductory lectures delivered by Mladen Bestvina of the University of Utah and Koji Fujiwara of Kyoto University. Cornelia Drutu of Oxford University then gave the first plenary talk, which also served as the final Oliver Club (that is, Department Colloquium) of the academic year. She discussed issues concerning fixed point properties and proper actions that relate to progress on the Baum-Connes Conjecture. Other speakers were Matthew Strom Borman of Stanford and the Institute for Advanced Study, Talia Fernos of the University of North Carolina, Bob Gilman of the Stevens Institute, Denis Osin of Vanderbilt University, Ori Parzanchevski of Princeton University and the Institute for Advanced Study, former Cornell H.C. Wang Assistant Professor Ana Rita Pires, now of Fordham University, and our own John Hubbard.

Cliff Stoll of Acme Klein Bottles (purveyors of "the finest closed, non-orientable, boundary-free manifolds sold anywhere in our three spatial dimensions") gave a public lecture on creating glass models of Klein bottles and other surfaces.

The Festival also included a banquet, a picnic in Stewart Park, and much conversation about progress in the field.

Planning is underway for the 52nd Topology Festival in May 2016, which will have a concentration of talks in topological combinatorics.

View from the Physical Sciences building - photo credit, Tim Riley

Super Pi Day 3.14.15

Contributing Authors Tara Holm & Steven Strogatz

Super pi Day was globally celebrated on March 15, 2015. It marked the first time in a century that the first five digits of pi were represented sequentially as a calendar date. At 9:26:53am on March 15, 2015, pi was described to 10 digits.

The New Yorker and the *Washington Post* turned to two of our resident faculty, Professors Steven Strogatz and Tara Holm (respectively) to craft opion pieces on the importance of pi day.

Strogatz explained, "The root of fascination with pi is the fact that the ratio of the circle's two simplest measurable quantities – the distance around it and the distance across it – produces a number that is so complicated: its digital expansion continues forever, churning out a sequence of digits with no apparent pattern."

Holm pointed out that ancient cultures have been puzzling over pi for thousands of years, "The Babylonians and the ancient Egyptians were beguiled by pi 4,000 years ago. The Bible tells the story of King Solomon building a circular pool 'ten cubits from the one brim to the other' and 'thirty cubits did compass it round

about,' meaning that the ancient Hebrews understood the number to be close to three. Leonardo da Vinci suggested that ideal human proportions — the full extensions of arms and legs — decipher this divine puzzle."

The obsession with pi in the modern age continues. Strogatz brought us back to why pi still facinates humanity in the modern era, "the contrast between the simplicity of the definition and the complexity of the result has helped turn pi into an iconic cultural symbol. It is a metaphor for the mysteries of mathematics – glorified in many ways, in a song by Kate Bush, a film by Darren Aronofsky and even a perfume by Givenchy."

Why do mathematicians care so much about pi? Strogatz stated, "it puts infinity within reach."

Holm shared, "...in most of the rest of the world, where people put the month after the day when writing dates, there is no 3/14 - it would represent the third day of a nonexistent 14th month. If you'll permit some circular reasoning on my part, that means today (pi day) is as American as apple π."

3.14159265358979323846264338327950288419

Professors Kassabov and Strogatz Named 2016 AMS Fellows

Professors Martin Kassabov and Steven Strogatz have been named 2016 Fellows of the American Mathematical Society (AMS).

Kassabov was invited to join this year's class of AMS Fellows for contributions to the theory of discrete groups and their growth and expansion properties. Strogatz, for contributions to nonlinear dynamics and complex systems, and for the promotion of mathematics in the public sphere.

The department would like to congratulate them both on this honor.

Prof. Martin Kassabov

Founded in 1888 to further mathematical research and scholarship, the 30,000-member AMS fulfills its mission through programs and services that promote mathematical research and its uses, strengthen mathematical education, and foster awareness and appreciation of mathematics and its connections to other disciplines and everyday life. To see other fellows inducted into the AMS in 2016, please visit the AMS website at www.ams.org.

Prof. Steven Strogatz

Levine and Templier Receive NSF CAREER Awards

Assistant Professors Lionel Levine and Nicolas Templier won NSF CAREER Awards in 2015.

The Faculty Early Career Development (CAREER) Program is a Foundation-wide activity that offers the National Science Foundation's most prestigious awards in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research within the context of the mission of their organizations.

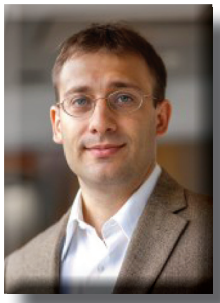
Prof. Lionel Levine

These activities should build a firm foundation for a lifetime of leadership in integrating education and research.

Levine's research looks at landslides, earthquakes, avalanches, wildfires, and financial crises as examples of disaster events in complex systems.

The aim of this research is to prove theorems about mathematical models of these systems, with three particular goals: 1. Quantify the dependence of large-scale observations on small details. Which details actually matter? 2. Develop efficient algorithms to determine whether a given system will stabilize and how long it will take. 3. Examine the threshold state that precedes a large disaster event and what triggers the disaster.

While simulation is an important tool for modeling complex systems, the focus of this research is on mathematical proof. A simulation reveals how a system behaves, but Levine's proof will reveal why.



Prof. Nicolas Templier

Templier received the award for his proposal "Trace formula and geometric analysis of automorphic forms". His research goal is to develop a quantitative theory of special functions, such as characters of representations and generalized Bessel and hypergeometric functions. The outcome is to establish new instances of randomness in number theory. Crucial to these investigations is the mathematical concept of family, that is to assemble objects that share common features and study them together, which is fruitful even if one is ultimately interested in the properties of a single object.

Math for Secondary School Teachers

Mary Ann Huntley

The course MATH 5080 (Special Study for Teachers) consists of four full-day Saturday professional development workshops. During the 2014-2015 academic year, attendance at the workshops ranged from 21-23 people per session. Over the course of the year, 50 different people attended the workshops. This included 33 teachers from 20 different schools, 13 faculty members from three colleges/universities, and four others (a physicist, an engineer, a retired teacher, and an independent consultant). Some of the teachers who attended the workshops are part of the NY State Master Teacher Program.

Throughout the 2014-2015 academic year, workshop presentations were made by four faculty members: Timothy Healey, Ravi Ramakrishna, Steven Strogatz, and Maria Terrell. Two postdocs also gave presentations: Andrew Roberts and Farbod Shokrieh. At another workshop, a session was led by John Macelli (Ithaca College Math Department, retired; M.S. Applied Mathematics, Cornell University, 1968). Cliff Stoll (Acme Klein Bottles) gave the final presentation of the year. This talk, entitled Math in Glass – The Mobius Loop, Klein Bottle, and Torus, was a joint talk for both the MATH 5080 participants and Topology Festival attendees.

Left: Cliff Stoll presents Acme Klein Bottles - photo credit, Tim Riley

The Summer Program for Undergraduate Research

Robert Strichartz

During the summer of 2015, 24 undergraduate students came to Cornell to work on research projects: "Analysis on fractals" directed by Robert Strichartz assisted by graduate students Kelsey Houston-Edwards and Robert Kesler; "Graphs, Chip-Firing Games, and Algebraic Geometry," directed by Farbod Shokrieh, assisted by graduate student Thomas Bååth; "Harmonic Analysis on Stiefel manifolds," directed by Raul Gomez, assisted by graduate student Pok Wai (Victor) Fong.

The SPUR program is a continuation of the REU program that had been supported by the NSF for 21 years.

The students in the Analysis on Fractals group worked on four separate projects. 1. Sharat Chandra (UC Irvine) and Fiora Galzarano (Temple) worked on constructing Laplacians on Apollonian Gaskets that are closely related to the geometry of Apollonian packings, and studying the spectrum of these Laplacians. A surprising discovery they made is that for each Apollonian packing there appear to be several different Laplacians, depending on the way you pass to the fractal limit. They will present their results at a special session on analysis on fractals at the regional AMS meeting in Stony Brook in March 2016. 2. Aaron Chen (Cornell), Max Lipton (Willamette) and Weihang Wang (Cornell) studied self-similar fractals on the Heisenberg group. They found a method to lift self-similar fractals on the plane to the (3-dimensional) Heisenberg group, but the topology of the lift is quite different from the topology of the covered planar fractal. They have created a website (www.math.cornell.edu/aaronchen/heisenberg/fractals.html) that shows some interesting examples of this construction. Max Lipton gave a presentation of this work at the Young Mathematicians Conference at Ohio State University at the end of the summer. 3. Teddy Weisman (Yale), Boya Wen (University of Hong Kong), and Aryah Zax (Cornell) developed a version of the Hodge-deRhan theory of K-forms on products of graphs, with a view toward extending this to products of fractals in the limit. Boya Wen gave a talk on this work at the Chinese University of Hong Kong, and will also give a presentation at the AMS meeting at Stony Brook; in March 2016. 4. Chris Criscitiella (Princeton) and Chris Silvia (Cornell) studied differential equations on infinite blow-ups of the Sierpinski gasket fractal.

The students in the, Graphs, Chip-Firing Games, and Algebraic Geometry group worked on four different projects related to the connections between combinatorics and algebraic geometry.

Louis Brown (Cornell) and Baath worked on various ideals arising from oriented matroids. For cographic matroids, there is an unpublished (due to Farbod) algebraic proof of the Stanley's conjecture. The project was to extend the method of proof to other classes of matroids. They found new methods to test the conjecture on

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Barnes & Benea Recognized for Outstanding Teaching

Recent Ph.D. Cristina Benea, and Ph.D. candidate James Barnes were among the 21 faculty members and teaching assistants who were recognized by Class Councils for outstanding teaching.

Christina Benea

James Barnes

The "Class of" Awards were given by Class Councils at a recognition ceremony held on April 13. Each of the four Councils seeks to recognize students and faculty who have contributed in a meaningful way to the Cornell community and its members, whether through academics, leadership, service, innovation, or outstanding teaching and advising. Jamie Barnes received the '17 award and Cristina received the '16 award.

CORNELL GIVING DAY

Math received **49 gifts** totalling over **$10,000** ranging from **$5** to **$2,500**.

We are grateful for the generosity of our alumni, students, and faculty who contributed.

Thank you for your support!

Johns Hopkins University Center For Talented Youth Family Academic Program

Mary Ann Huntley

On Saturday, March 21, 2015, Cornell University's Department of Mathematics and Center for Applied Mathematics hosted a Johns Hopkins University Center for Talented Youth Family Academic Program. This was the fourth such event hosted at Cornell. The others were held during the fall semesters of the years 2009, 2010, and 2011. The target audience for the event was grades 7-10 students. The keynote talk was given by Prof. Ravi Ramakrishna. The title of his talk was: Exploring Some Mathematical Models.

Graduate students from the Mathematics Department, Center for Applied Mathematics, and Department of Computer Science offered three break-out sessions – Polytopes, Playing with Surfaces, and Cryptography. A program requirement was that every student be accompanied by at least one parent/guardian. Every student and every parent/guardian attended each break-out session. Parallel sessions were offered for students and parents/guardians. That is, as each student cycled through the break-out sessions, their parent/guardian attended the same sessions but in a different room.

Prof. Ravi Ramakrishna uses a Slinky to demonstrate Hooke's Law

Altogether, 109 people attended the event – 55 students and 54 parents/guardians. Of these 109 participants, eight local students and eight parents/guardians attended the event. Participants came from eight states in the Northeast and Mid-Atlantic regions of the US: New York, New Jersey, Pennsylvania, Massachusetts, Connecticut, Delaware, Maryland, and Virginia.

Math Library News Updates

Jill Wilson

The Mathematics library has added to its digital collection, namely ebook collections which include added backfiles. All of these collections and more can be found on our Mathematics Library website (http://mathematics.library.cornell.edu/), and also through the main library catalog (library.cornell.edu). Here are highlights from our page:

SpringerLink E-Books: A growing collection including the archive of over 13,000 titles from 1841-2004. Books in these packages include Mathematics and Statistics (2005-present), and Lecture Notes in Mathematics (1964-present). The 2005-2009 set was purchased with the generous support of an anonymous donor to honor Alex Rosenberg.

Mathematical Surveys and Monographs: We have access to the full AMS e-book collection from 1943. The series of high-level monographs is designed to meet the need for detailed expositions in current research fields.

Graduate Studies in Mathematics: This collection contains graduate-level textbooks from 1993 onward.

Student Mathematical Library: A series of books for undergraduates from 1999 onward.

University Lecture Series: A series for books from 1989 onward focused on important and rapidly developing topics in mathematics.

Any questions or requests regarding collections can be emailed to Mathematics Librarian Steve Rockey (swr1@cornell.edu)

The Math Library, in coordination with the Engineering Library and Physical Sciences Library, held workshops over the spring and early fall on such topics as sharing and organizing data and communicating research through the SPARK Talks series. To find out more about library events, email Outreach Coordinator Jill Wilson (jew248@cornell.edu)

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specific examples, and confirmed the conjecture on some new, small, examples.

Freddie Huang (Cornell) and Matthew Jin (Caltech) proved the "break divisor" subdivision of the "tropical Picard group" in degree g is, in a precise sense, "coherent". This is an important fact for some algebro-geometric applications. They are currently working on writing a paper about this result. Freddie is also continuing his research with Farbod in the fall semester (Math 4900). He has done some impressive work after the summer as well.

Sameer Kailasa (Chicago), Vivian Kuperberg (Cornell) and Nicholas Wawrykow (Yale) proved the following surprising theorem: A "tree of loops" can be Brill-Noether general if and only if the tree is a path! The ideas in the proof are quite original and useful. They are also writing a paper about their results.

Lexie (Xiaoyue) Li (Cornell) and Shruthi Sridhar (Cornell) further studied an algorithm about Jacobians of regular matroids. Last year, two REU students had found a surprisingly simple algorithm to establish bijections between Jacobians and bases. Lexie and Shruthi worked on further extensions of these algorithms, and made some precise conjectures.

The students in the harmonic analysis on Stiefel manifolds project focused on the problem of finding a more intrinsic description of the theory of Stiefel harmonics developed by Gelbart and Strichartz. By the end of the summer, an approach through Geometric Invariant Theory (GIT) was found that can be used to explain not only the results obtained by Gelbart and Strichartz, but also some related results by Knapp.

Alex Frederick (Cornell), Hari Rau-Murthy (NYU), and Kaavya Valiveti (UC Berkeley) focused on describing an $O(m)$-equivariant isomorphism between a particular GIT quotient of the space $O(n)/O(n\text{-}m)$ for n greater than or equal to $2m$ and the space of m by m matrices. In the meantime, Max Halgreen (Cornell), Kendric Schefers (Columbia) and Chris Strohmeier (Cornell) used the aforementioned map to give an alternative construction of the space of Stiefel harmonics. They also extended this result to the unitary case recovering, in this way, some results previously obtained by T.T. That using a different approach.

The two projects are now being merged into a single paper explaining the results obtained during the summer. The SPUR program will continue again in summer 2016.

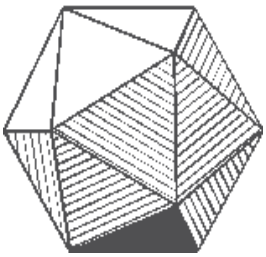
The 76th Putnam Competition

Allen Back

As you read this, our students have just joined (or are about to join) 4500 others nationally in the 76th Putnam Competition. This 6-hour 12-problem exam always falls on the Saturday after the last classes of fall term, so is a good way to celebrate the end of the semester. The problems don't go beyond sophomore level mathematics, but they are tough; last year's median of 3 out of 120 was remarkably high and "only" 34% of participants got a zero.

Cornell students did very well in the 75th Putnam, whose results came out last spring. Freshman Victor Reis was awarded Honorable Mention (top 75 nationally) and four other Cornell students were in the top 210 nationally. There were many other fine performances. Our team of Louis Brown, Vivian Kuperberg, and Lexie Li was 12th nationally, just missing Honorable Mention, despite not having the Cornell high scorer on it. (This is a common problem; the teams of three are chosen in advance of the exam; there was a recent year when MIT had four of the six Putnam Fellows, yet MIT only finished in fourth place!)

We congratulate these excellent performances and their continuance of a long tradition of Cornell related people who have done well on the Putnam. This tradition includes the great physicist



Professor Richard Feynman (a Putnam Fellow at MIT in the second competition and here in the late 40's), current faculty members Professor Bob Strichartz (a Putnam Fellow at Dartmouth in 1962), Professor Ravi Ramakrishna (top 10 nationally while an undergraduate at Cornell in 1987), and current CS Professor Robert Kleinberg (a Putnam Fellow as a math major at Cornell in 1996 as well as part of a second place Cornell team that year.)

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Mathematics Department Endowments & Gifts

We are grateful to alumni, friends, and family for their generosity in supporting our endowments or providing other gifts and donations to the department.

The **Ruth I. Michler Memorial Prize,** established by Gerhard and Waltraud Michler of Essen, Germany, in memory of their daughter, provides funding for the Ruth I. Michler Memorial Prize of the Association for Women in Mathematics. The awardee spends a semester here without teaching obligations.

The **Chelluri Lecture Series** was established by Raju Chelluri's parents in his memory. Funds are used to invite distinguished mathematicians to give annual lectures.

The **Michael D. Morley Senior Prize in Mathematics** is presented annually to an Ithaca High School student who has excelled in mathematics and who has demonstrated originality and innovative power in mathematics.

Teaching Awards for Graduate Students and faculty were created in 2001. Prizes are awarded to graduate students.

The **Colloquium Endowment Fund** was instituted to invite distinguished scientists to speak at the Oliver Club seminars. (See www.math.cornell.edu/~oliver/.)

The **Eleanor Norton York Endowment** was established in honor of Eleanor Norton York to recognize outstanding graduate students in both Astronomy and Mathematics.

The **Faculty Book Endowment** is dedicated to providing the Cornell community with access to one of the world's finest collections of mathematics books and publications.

The **Israel Berstein Memorial Fund** was established in honor of Israel Berstein, a professor in this department from 1962-1991. The memorial fund is intended to help young mathematicians in the field of topology.

The **Logic Endowment** was started with a generous gift from a former Cornell undergraduate to support promising logic students.

The **Robert John Battig Endowment** was established by his parents after his untimely death. Robert was awarded a January 1998 Ph.D. in mathematics. The fund provides an annual prize to an outstanding continuing graduate student in mathematics at Cornell.

If you would like to contribute, please make your check payable to Cornell University, indicate the endowment, or that it is a gift in support of Mathematics, and send it to:

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Gifts can also be made online at
www.giving.cornell.edu