Indiana University Department of

Mathematics Alumni Newsletter

College of Arts & Sciences Alumni Association

Chair's Corner

Elizabeth Housworth

As I write this, I have not yet been Chair for a year, but it is getting close! My heartfelt thanks and appreciation go out to all the faculty, staff, students, parents, alumni, and donors who make being Chair so rewarding. In this newsletter, you will read about their numerous accomplishments. In this corner, I will focus on events and accomplishments that may not appear elsewhere.

The first year of the department-sponsored Bloomington Math Circle was a great success. We created two groups, the Primary Circle for children who know multiplication, roughly grades 3-6, and the Secondary Circle for children who know algebra, roughly grades 7-10. We met for nine Saturday afternoons during each of the Fall and Spring Semesters. Tracy Whelan organized the Primary Circle in the Fall and Shabnam Kavousian organized it in the Spring. Andrew Dabrowski organized the Secondary Circle the entire year. Guest speakers included Professor Michael Larsen, Professor Moon Duchin visiting us from Tufts University, Professor Michael Damron, yours truly, Erica Isaacson, Jim Hendrickson, several of our graduate students, as well as the organizers themselves. Students in the Primary Circle learned about binary expansions (and expansions in other bases) through dots and boxes, the properties of random numbers, dynamical systems, the mathematics of spirographs, and mathematical games, among other things. Students in the Secondary Circle explored infinity, mathematical paradoxes, random walks, card tricks, and topology through cutting and taping strips of paper. While we have some issues to work through, the Circles were generally a success. This summer, Will Orrick and Shabnam Kavousian will participate in Bob and Ellen Kaplan's Math Circle Summer Teacher Training Institute, and the team of Bloomington Math Circle organizers will include Erica Isaacson next year. We also created a linked 1-credit undergraduate service learning course so the undergraduate students can get course credit for helping with the Math Circle, learning the mathematical typesetting program LaTeX, and typing up the Circle activities for posterity.

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? Problem Corner

Problem: The king of Babylon has three prisoners and randomly places on their heads either a blue hat or a green hat. None of them may see their own hat, but they see the others. They cannot communicate in any way. The king charges them that one or more of them must guess their own hat color, and all guesses (or the option to pass on guessing) must occur simultaneously. If all the guesses that are made are correct, then they all go free. However, if any of the guesses are wrong, or no guesses are made, then they are all executed. The prisoners were forewarned the night before of the challenge and therefore have had a chance to strategize. Find the strategy that maximizes their chance of survival. What is that chance?

T-Shirts!

Where has your departmental T-Shirt been? Look for the new T-Shirt and contest rules at: http://www.math.indiana.edu/Outreach/TShirts2015

One of the e-mails I sent out to my faculty had the subject line "101 Bureaucratic Efficiencies." I must have a bit of the parents in *Cheaper by the Dozen* in me because this is one of the aspects of being Chair I find most fun and rewarding. One bureaucratic efficiency I made was to obtain a secure-print printer for the mailroom with the accompanying benefits including no worries about printing an exam off where a student might see it - the printer only prints when the document's owner is present and enters a private code; less paper and toner usage - if a document is misprinting, for instance, so that it is all black, the owner is there to cancel the job; the old printer room, Rawles Hall 368, is now an 18-student seminar room complete with tables, chairs, and a blackboard! A generous donor provided the department with some fancy erasers and eraser (vacuum) cleaners to cut down on the chalk dust from our old-fashioned (and highly valued) use of blackboards. I will mention one efficiency I made more before you fall asleep reading: the College Information Technology Office provided the department with a secure file server for departmental documents, helping my successor find and modify departmental documents, like this newsletter!

Gioia Di Cari's monologue Truth Values: One Girl's Romp through M.I.T.'s Male Math Maze came to the Wells Metz Theatre on April 28. The monologue and the discussion panel afterwards were both hits. Continuing with this math/arts combination, David Fisher has worked to bring Counting from Infinity: Yitang Zhang and the Twin Prime Conjecture, a Zala Films documentary, to the IU Cinema on November 9, 2015. In Fall 2016, the College's Themester program will be "Beauty" and the department will try to bring the Mosaic Math and Art Exhibit that the Mathematical Sciences Research Institute sponsors to campus that semester. On the purely mathematical side, we are still looking forward to hosting a Sectional Meeting for the American Mathematical Society April 1-2, 2017.

We are working on documenting the department's history for the upcoming IU Bicentennial in 2020. Former departmental chair John Ewing already documented the department's first 100 years for our move into Rawles Hall. Here are two *facts* from Professor Ewing's **Indiana University Mathematics: The first 100 years (1820-1920)**:

Fact: In 1930, more members of the American Mathematical Society had received their undergraduate training at Indiana University than at any other university, except Harvard.

Fact: During the twenty years from 1888 to 1908, out of 2084 students who received their A.B. degree from Indiana, one eleventh had majored in mathematics.

There are many other important accomplishments made by the faculty, staff, students, alumni, donors, and friends of the department, some that will fill the pages of this Newsletter, but many that cannot be included. I thank you all for making the department such a special place.

About the Newsletter

Thanks go to Chris Connell, Michael Damron, Chris Judge, Darrell Haile, Michael Larsen, Russ Lyons, Linda McKinley and Kevin Pilgrim for their contributions to this newsletter. Special thanks go to Peter Sternberg, who has taken over the bulk of the editing and formating duties.

Student News

From DUGS Kevin Pilgrim:

The past academic year has been very exciting and full of news. More clubs, courses, majors, and students...

More students than ever are taking math at IUB. For math majors, this led to more course offerings. Resurrected are now Math-M 436 Introduction to Geometries, taught for the first time in 20+ years last Fall 2015 by Matthias Weber, and Math-M 420 Metric Space Topology, taught by Dylan Thurston. Newly created were Math-G 201 Service Learning in Mathematics. This past year, seven math majors received credit for assisting in and developing materials for our new Math Circles 3rd-10th grade Outreach Program.

Also new is Math-M 298 Careers in Mathematics, which brought IU math alums *Lonnie Nicholson '86 (Kimball International)*, *Robert O'Connell '09 (Epic)*, and *Frances Richert '12 (ACES Excellence in Energy)* into our classroom to share their insights. If you would like to be involvedâĂęclick the "share your story" link!! We'd love to hear from you!! Spring '15 also saw five teams of undergraduates working on applied projects in our Math-M 490

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Fields Medal Colloquia

The 2014 Fields Medal was given out to four mathematicians, Artur Avila Cordeiro de Melo, Maryam Mirzakhani, Manjul Bhargava and Martin Hairer. As part of this year's Departmental Colloquium series, three faculty from within our Department, Kevin Pilgrim, Chris Judge and Michael Larsen gave lectures describing the remarkable achievements of these mathematicians and they provided the summaries you find below. (A former IU post-doc and now Assistant Professor at Virgina Tech, Nathan Glatt-Holtz, gave the lecture on the work of Martin Hairer in the area of stochastic partial differential equations.)

Artur Avila Cordeiro de Melo

Brazilian-French mathematician Artur Avila Cordeiro de Melo received one of the four Fields Medals at the 2014 International Congress of Mathematicians. He is the first Latin American mathematician to receive this prize. The medal recognizes his outstanding contributions to several areas of mathematics, including dynamical systems and analysis.

Here is one (of many) dynamical systems that Arthur Avila analyzed. Start with the unit interval $[0,1]$. Cut it into several non-overlapping pieces, and rearrange them to form again the unit interval $[0,1]$. The resulting transformation $f : [0,1] \to [0,1]$, although discontinuous, is defined everywhere except at a finite set of points, and it preserves lengths. This is an example of an *interval exchange transformation* (IET). These come up in a variety of places in mathematics nowadays, including in research of IUB faculty members *Matthew Bainbridge* and *Christopher Judge*. A major result of Avila asserts: *almost every IET is weakly mixing*. That is, if one picks an IET "at random", then iterates of f mix things up, in a certain technical average sense. More precisely: weak mixing means that for any subintervals $A, B \subset [0,1]$,

$$\frac{1}{n}\sum_{i=1}^{n} \left| \mu(f^{-n}(A) \cap B) - \mu(A)\mu(B) \right|$$

approaches zero as n tends to infinity. Here $\mu(J)$ denotes the length (Lebesgue measure) of a subset of $[0,1]$. The concept of weak mixing appears in the branch of mathematics known as *ergodic theory*. Ergodic theory features in work of IUB faculty members Ciprian Demeter, Marlies Gerber, and Russell Lyons.

Another milestone achievement is his solution to the so-called *Ten Martini problem*. The name comes from mathematician Mark Kac, who offered 10 martinis to the person who could solve this problem. The problem asks to show that the spectrum of a certain specific operator is a Cantor set. The spectrum of an operator is kind of like a generalization of the set of eigenvalues of a square matrix to an infinite-dimensional setting. The spectral theory of operators is studied by IUB faculty member Hari Bercovici.

The notion of *renormalization* appears in much of his work. Here is an example of renormalization. Suppose $f : [0,1] \to [0,1]$ is an IET and $J \subset [0,1]$ is a sub-interval. Pick $x \in J$ and apply f over and over again until $f(x) \in J$. Since f preserves μ, this happens with probability 1. This gives a new function $g : J \to J$. It often happens that

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Faculty News

Michael Mandell

Professor Michael Mandell has been named a Fellow of the American Mathematical Society. Mandell is an algebraic topologist, and he joins previously named fellows from our Department Eric Bedford, Hari Bercovici, David Fisher, Robert Glassey, Michael Larsen, Russell Lyons, Peter Sternberg, Roger Temam, Shouhong Wang and Kevin Zumbrun.

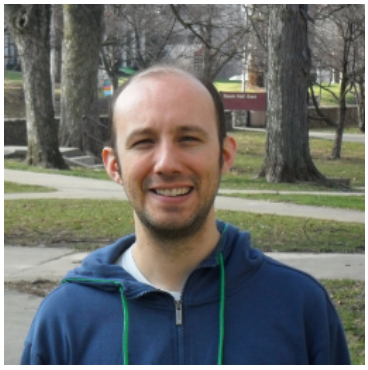
Tracy Whelan

Dr. Tracy Whelan, a senior lecturer in the Math Department, was inducted into the Faculty Colloquium on Excellence in Teaching (FACET) in Spring, 2014, joining Professors Elizabeth Housworth and Peter Sternberg as members from the Department of Mathematics. FACET is a community of Indiana University faculty members who are committed to being – and helping others to be – exceptional teachers.

Russell Lyons

Professor Russell Lyons gave an invited address at the annual joint meeting of the American Mathematical Society and the Mathematical Association of America in San Antonio. His talk was titled "Random orderings and unique ergodicity of automorphism groups."

Noah Snyder



Professor Noah Snyder was the recipient of a prestigious NSF Career Award, and will begin receiving more than $455,000 over five years to advance the study of quantum groups and subfactors, a form of theoretical mathematics with potential applications in areas such as physics and quantum computing. In addition to advancing knowledge in the field, Snyder's grant will support the development of new curriculum based on his work – which employs a technique known as higher dimensional algebra – for high school students at Canada/USA Mathcamp, an elite mathematics summer program. The grant will also fund dissertation fellowships for graduate students with an established record of extraordinary education and outreach in mathematics, with a strong emphasis on underrepresented groups, as well as support undergraduate research and the establishment of a math club for mathematics education majors at IU Bloomington.

Roger Temam

Professor Roger Temam has been selected for membership in the American Academy of Arts and Sciences, one of the nation's oldest and most prestigious honorary societies. Temam has made fundamental contributions to several large areas of applied mathematics, including numerical computation of fluid flows, slow dynamics and inertial manifolds, turbulence theory, and climate modeling. He is one of the top experts in mathematical models for climatology and a leading expert worldwide in nonlinear partial differential equations and their applications. He has received numerous international honors and awards and is a fellow of the Society for Industrial and Applied Mathematics, the American Association for the Advancement of Science and the American Mathematical Society.

Kevin Zumbrun

Professor Kevin Zumbrun has been promoted to distinguished professor, the highest academic rank the university can bestow upon its faculty. He joins Professors Michael Larsen and Roger Temam in this distinction. Zumbrun works in the area of nonlinear partial differential equations, having made deep contributions to the understanding of stability of shocks. He has published over 150 articles in his career.

Fields Medalists

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$g : J \to J$ is again an IET, and then g is called a *renormalization* of f.

Noteworthy is that most published work of Arthur Avila has been co-authored, and that he proved his first major result on renormalization at the age of just 19!

Maryam Mirzakhani

Maryam Mirzakhani of Stanford University became the first woman and the first Iranian to win the Fields Medal.

Periodic phenomena is often the most striking and the most useful. The ancients discovered the periods of the moon, the sun, and the stars. In a chaotic universe, the rare examples of periodicity provide us with frames of reference in time and space. Most of the work of Mirzakhani concerns estimating the time—the *period*—it takes for some object to return to a previous state. For example, the Earth takes one (Earth) year to revolve around sun. Saturn takes about thirty years. Uranus takes eighty-four years. If the Sun were the only star, one might imagine an infinite sequence of planets at farther and farther distances all orbiting the sun. Mirza-

khani would be interested in the asymptotics of the associated sequence of periods.

An example closer to home is found in playing billiards. Imagine the motion of a billiard ball on a frictionless square pool table, the ball bouncing off the sides but otherwise following straight paths. One can create a periodic orbit by shooting the ball in a direction perpendicular to one of the sides. Indeed, since the table is rectangular, the ball will bounce off this side, retrace its path in the opposite direction, bounce off the opposite side, and finally return to its original state in both position and velocity. Since the table is frictionless, the period depends only on the initial velocity.

One could do fancier shots that yield periodic orbits. For example, one can shoot the ball at angle that is forty-five degrees from a side. In fact, one choose any direction that has rational slope where we imagine the sides of our table parallel to standard coordinate axes. Because there are infinitely many rational numbers, there are infinitely many possible periods.

Even if Gauss were not a pool player, he would have understood that if $N(x)$ is the number of periods of size less than x, then

$$\lim_{x\to\infty} \frac{N(x)}{x^2} = \frac{\pi}{2^3 \cdot s^2}. \quad (*)$$

Indeed, it's not hard to see that the set of periods is essentially the set of lengths of vectors of the form $(2s \cdot n_1, 2s \cdot n_2)$ where m_1 and m_2 are integers s is the sidelength of the table. The number of such vectors inside the disc of radius x was first estimated by Gauss, and the search for better estimates is known as the *Gauss circle problem*.

One can also play billiards on tables made from exotic shapes such as triangles, pentagons, hexagons...For these exotic tables, much less is known. In fact, we don't even know whether for each trianglular table there exists a periodic billiard trajectory!

For polygonal tables for which each angle is a rational multiple of π, Howard Masur showed that infinitely many periods do exist and that there exists a constant c so that $c \cdot x^2 \leq N(x) \leq c^{-1} \cdot x^2$ for x large. On the other hand, an asymptotic formula like $(*)$ is unknown for so-called 'rational' tables.

With her collaborator, Alex Eskin, Mirzakhani proved that for any rational table T there exists an explicitly computable constant $c(T)$ such that

$$\lim_{x\to\infty} \frac{1}{x} \int_0^x \frac{N(e^s)}{(e^s)^2}\, ds = c(T). (**)$$

The constant $c(T)$, introduced earlier by William Veech, involves the volumes of moduli spaces and elementary combinatorial invariants associated to the polygon T and is known to be a rational multiple of some power of π. Formula $(**)$ should be regarded as an averaged version of $(*)$. The proof is a tour de force involving techniques from dynamical systems, geometry, and probability.

The elusive analogue of Gauss' asymptotic $(*)$ for exotic tables awaits a future Fields Medalist.

Manjul Bhargava

Manjul Bhargava of Princeton received the Fields Medal for his work in number theory. He is the first person of Indian descent to win this most coveted prize in mathematics.

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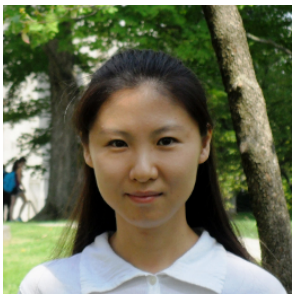
New Faculty

Nam Le

Professor Nam Le (Ph.D. Courant Institute, NYU, 2008) joined the faculty of the Math Department during the academic year 2014-15. Le received his Ph.D. from the Courant Institute at NYU and previously held a post-doctoral appointment at Columbia University. He received the prestigious Scientific Prize of the Institute of Mathematics at the Vietnam Academy of Science and Technology in 2013. Professor Le works in the area of nonlinear partial differential equations and the calculus of variations.

Three new lecturers joined the Math Department faculty in the fall of 2014. All three earned either graduate or undergraduate degrees in mathematics at IU Bloomington.

Zhixu Su



Zhixu Su did her graduate work in the Mathematics Department studying under Jim Davis. She completed her Ph.D. in geometric topology in the fall of 2009, and was

a member of the mathematics faculty at Rose Hulman University from 2009 until 2012. Just prior to returning to Bloomington, she held a lecturer position in mathematics at the University of California, Irvine.

Erica Isaacson

Erica Isaacson, a Bloomington native, studied as an undergraduate at IUB and earned a B.S. in mathematics and a B.S. in Physics in the spring of 2006. She studied under Jon Wilkening at University of California, Berkeley and completed her Ph.D. in applied mathematics in 2012. After returning to Bloomington, Erica taught as a visitor in the IUB Math Department for several semesters before she was appointed as a lecturer last fall.

Jim Hendrickson

Jim Hendrickson graduated from the University of Wisconsin-Parkside, where he majored in psychology and history. He rediscovered a love for math late in his undergraduate career and took an extra year to complete a B.S. in mathematics. From there, he entered our graduate program, graduating with an M.A. in mathematics in 2002. After that, Jim was the Director of the Math Learning Center for three years. Since then, Jim has been a frequent visiting instructor in the Math Department and brings a wealth of experience with large sections of finite math and calculus to his new position. The appointment of Erica, Jim and Su brings the number of lecturers in the Department up to eleven. A primary responsibility of the lecturers is to teach most of the Department's large (270-student) sections of our service courses. As a group, lecturers touch the academic lives of the majority of IU undergraduates as they seek to meet their general education requirements. During fall semester of 2014, for example, the total number of students enrolled in our lecturer-taught classes was nearly 3500. Lecturers may also be asked to do course coordination, participate in curriculum development, and take on a variety of service activities.

Fields Medalists

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Fermat's "Two Squares" theorem says that a positive integer can be written as x^2+y^2, where x and y are integers, if and only if it is a product of primes $p \not\equiv 3 \pmod 4$ and expressions p^2, $p \equiv 3 \pmod 4$. A key part of the argument is the identity

$$(x^2+y^2)(u^2+v^2) =$$

$$(xu-yv)^2+(xv+yu)^2.$$

Conversely, if m and n are relatively prime and mn can be written as a sum of squares, one can run this backward to write m and n as sums of squares. This generalizes to some other cases; for instance, there is a completely analogous criterion for integers of the form x^2+xy+y^2. However, the argument breaks down in most cases. For instance, 2 and 3 are relatively prime integers and $2 \cdot 3$ is of the form x^2+5y^2 while 2 and 3 are not. Gauss devoted much of his classic number theory treatise *Disquisitiones Arithmeticae* to exploring this phenomenon. He developed a theory of composition of binary quadratic forms of the same discriminant. For instance, $2x^2+2xy+3y^2$ and x^2+5y^2 are both of discriminant -20, and the formula

$$(2x^2+2xy+3y^2)(2u^2+2uv+3v^2) =$$

$$(2xu+xv+yu-2yv)^2+5(xv+yu+yv)^2$$

explains why 6 factors into two integers of the form $2x^2+2xy+3y^2$. Later, it was understood that this phenomenon occurs for number rings where unique factorization into irreducible factors breaks down: in the ring $\mathbb{Z}[\sqrt{-5}]$, 6 has two distinct factorizations: $2 \cdot 3$ and $(1+\sqrt{-5})(1-\sqrt{-5})$. The group of forms of a given discriminant is a special case of an ideal case group. It was understood that this was the end of the story.

However, Bhargava discovered a new and unexpected continuation, a completely different direction in which the theory of composition of binary quadratic forms can be extended. There are a number of kinds of forms of higher degree which have a composition law analogous to the one developed by Gauss. Bhargava classified them, using ideas from the theory of Lie groups. Just as it is hard to count the forms of a single discriminant but easy to estimate the number of forms of discriminant less than some given bound, so it is possible to use Bhargava's theory to count various objects of interest to number theorists, for instance quintic fields of bounded discriminant.

Retirements

Rick Bradley

Born in Berkeley, CA in 1950, Richard C. Bradley, Jr., comes from a long and distinguished line of professors. He grew up in Ithaca, New York and Colorado Springs, Colorado and his interest in mathematics dates back to elementary school. By 8^{th} grade, playing Parcheesi and other games of chance, Rick already became fascinated by probability. Later, when he entered MIT as an undergraduate in 1968, he had a course on probability from the legendary teacher Gian-Carlo Rota and this course solidified his interest in the field.

After graduating from MIT, Rick was looking for adventure and took a break from school. He worked for a year as a cowboy after college, herding cows on horseback and even helping cows give birth. Ready to resume school in 1974, he entered UCSD and left with a Ph.D. in probability in 1978. During that time, his advisor, Murray Rosenblatt, gave him a paper to read by Ibragimov on strong mixing conditions, and posed several questions for Rick to work on. This field grabbed Rick's interest, and it remained his principal area of research for the rest of his career.

Before coming to IU, Rick spent two postdoctoral years in the statistics department of Columbia University. However, New York felt unsafe, and getting mugged did not help. He moved to IU in 1980; driving out of New York for the last time, he said, felt like getting out of prison.

What is his chosen field of strong mixing about? Suppose one throws dice or tosses coins repeatedly, shaking them very well each time. Then each outcome is independent of the others, and there is a well-developed theory to describe what happens. For example, if one tosses a coin 2000 times, then one expects to get around 1000 heads, but not exactly 1000; the distribution of the number of heads is given approximately by the famous bell curve. However, suppose that one shakes the dice only a little each time. Then the outcomes are dependent, but outcomes that are far separated in time should be almost independent. How does this affect the bell curve for the dice average? This sort of question about limit behavior (laws of averages) is the basis of the theory of strong mixing, which is of interest not only mathematically, but also in a wide area of applications.

Rick is recognized as one of the top people worldwide in this field. He is especially noted for constructing ingenious examples or counterexamples and for proving structural properties, all of which elucidate the relationships among various kinds of mixing conditions. He also wrote a masterful 3-volume "Introduction to Strong Mixing Conditions" totaling 1681 pages. For his work, he was honored with election as a Fellow of the Institute of Mathematical Statistics.

Rick regularly gives invited talks in the US and Europe. Ever retaining his adventurous spirit, in the summer of 1982, between meetings in Hungary, France, West Germany, and Romania, he climbed to the top of the Matterhorn. A few years later, in 1986, he was invited to the First World Congress of the Bernoulli Society, in Tashkent, USSR. This Congress was especially memorable because 50 of its 1000 participants had to be hospitalized due to poor local sanitation. Rick felt lucky that his assigned roommate gave him good advice on how to cope with the conditions.

Along with all of Rick's success at IU over the years, he has contributed in so many ways to the Mathematics Department. He won departmental awards for teaching and has been a favorite among graduate students to serve on doctoral exams. He is known as a conscientious colleague and one who always carries out his work with efficiency and thoroughness. For example, while serving as Director of Graduate Studies, he discovered that it was very hard to know all the rules and regulations that students needed to follow. Consequently, he prepared a 50-page document so that all future Directors would not have to learn on their own like he did. Rick has also been a very patient and effective advisor, directing seven doctoral theses and successfully mentoring three undergraduates in summer research. Beyond service to IU, he also served the profession as Probability Editor of the "Proceedings of the American Mathematical Society" for 8 1/2 years. His name is well known and his work is admired by both theoretical and applied researchers.

Rick has been a wonderful colleague in every respect. His fellow faculty and students will miss him for his remarkable energy, conscientiousness, devotion, and selfless integrity.

by Russ Lyons

Jiri Dadok

Jiri Dadok is retiring this semester after spending the last thirty-five years as a vital member of the Department of Mathematics. Jiri has been a wonderful colleague who is known for his quick and powerful mathematical insights and his equally quick wit and generous laugh.

Jiri was born in Brno, Czechoslovakia in 1950. He and his family traveled to the United States in 1968 during the Prague Spring, a period when his father Josef was conducting research at Carnegie-Mellon. With the subsequent Soviet invasion of Czechoslovakia, the family decided to remain in the United States. Jiri's father joined the faculty of Carnegie-Mellon and Jiri enrolled there as an undergraduate, finishing his bachelor's degree in mathematics in 1972.

Jiri went to MIT for graduate work, completing a PhD under Sigurdur Helgason in 1977 with a dissertation titled, "Fourier Transforms of Distributions on Symmetric Spaces." After holding a one-year visiting position at the University of Connecticut, Jiri went on to take a post-doctoral position as a G.C. Evans Instructor at Rice University from 1977-1980. There he began a fruitful collaboration with Reese Harvey that eventually spanned two decades.

In 1980 he arrived in Bloomington, serving the last twenty years at the rank of Full Professor. Jiri's mathematical interests have always been very broad. His influential contributions include work on harmonic analysis of Lie groups and homogeneous spaces, several complex variables, differential geometry, calibration theory and partial differential equations.

As a mathematician, he is known for his ability to cut through complex problems to see the essence of the difficulty and most especially for his ability to arrive at elegant solutions to seemingly messy or even intractable mathematical situations. The breadth of Jiri's mathematical interests are also reflected in the impressive array of high level courses he has volunteered to teach, including 400-level classes in geometry, complex analysis, algebra, real analysis, number theory, partial differential equations, probability and statistics. For over three decades, Jiri has remained one of the Mathematics Department's most popular teachers. Students delight in his ability to convey complicated and often abstract notions through a few key pictures and short calculations, without the clutter of messy details. In recognition of his talents in the classroom, Jiri received the Mathematics Department's Rothrock Teaching Award in 2011.

While retirement for some may seem a daunting transition, for a person of Jiri's wide interests, there can be no such qualms. Jiri and his wife Carolyn Begley are enthusiastic bird watchers, participating frequently in bird counts throughout the surrounding forests. He is an accomplished photographer, always volunteering for the role of family photographer at the numerous family events surrounding his sons, daughters and grandchildren, in whose lives he plays a central role. He is equally content to hike a trail or listen to classical music and he plays some classical guitar himself when seeking a moment of tranquility.

So many of us in the Mathematics Department who value his friendship and the always lively conversation that accompanies any walk with Jiri to the coffee shop hope that he will still spend plenty of time in Rawles Hall in the coming years.

by PETER STERNBERG

Student News

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Problem Seminar course. One team, led by graduate student Ozan Yolasigmaz, worked with IU Physical Plant. The problem: to design a model that determines the optimal dorm assignments for students in summer programs and classes at IU so as to save money on electricity. Ozan's work this summer is supported by a $2,000 grant from the IU Office of Sustainability.

For non-majors, in order to meet anticipated demand for interesting General Education mathematics courses in Fall 2016, faculty members Andrew Dabrowski, Jim Hendrickson, Shabnam Kavousian, Will Orrick, and Bruce Solomon are developing topics in areas like art, game theory, groups and symmetry, music, and voting. This will be a unique and valuable addition to our already diverse offerings.

New also was the founding of our first student chapter of the Association for Women in Mathematics, led by senior Lea Beneish, now bound for the PhD program at Emory University. *(continued on p. 10)*

Obituary

Vinay Deodhar

This year marked the passing of long-time colleague Vinay Deodhar. Vinay Deodhar was born in Bombay, India, on December 3, 1948. He attended Bombay University, where he received his doctoral degree in 1974 studying under M. S. Raghunathan. He came to Indiana University in 1981 from a faculty position at the Tata Institute of Fundamental Research, one of the great centers of mathematics in the world, which remained for him the standard of excellence. Prior to his position at the Tata Institute, he spent three years at the Institute for Advanced Study and one at the Australian National University in Canberra.

Vinay has made fundamental contributions to mathematics, particularly Lie theory. While still a student, he wrote a highly influential set of notes based on lectures by Robert Steinberg. In 1978 he was awarded the Young Scientist Award from the Indian National Academy. Vinay is also one of the developers of Kazhdan-Lusztig theory (and in fact, he coined the term) and has done important work on the geometry of flag varieties. In 1992 he edited a volume of the AMS series Contemporary Mathematics on the subject. He also has made important contributions to the theory of Bruhat orderings on Coxeter groups. During his last sabbatical at Indiana University he started on an entirely new project with Israel Gelfand, one of the greatest Russian mathematians, who was by then in the United States. Vinay was quite enthusiastic about the project but Gelfand died before it reached fruition.

Vinay wrote several highly influential papers on the (weak) Bruhat order on Coxeter groups. In the motivating case of symmetric groups this can be understood as follows. The length of a permutation A is the minimal number of times a consecutive pair of elements must be exchanged in order to achieve A. There may be several different ways to realize A by consecutive transpositions in this smallest possible number of steps. All the permutations obtained as intermediate steps along any of these sequences are considered to be less than A. His work on the Bruhat order is inextricably connected with the development of the Kazhdan-Lusztig polynomial, which plays a central role in modern representation theory.

Vinay was also a very popular teacher, highly organized and known for his clear exposition. In 1998 he earned our highest teaching award, the Rothrock Teaching Award. He stamped his personality on two of our courses, Lie Groups and Lie Algebras. He also supervised three Ph.D. students, all of whom remain academic mathematicians: Dijana Jakelic, at UNC Wilmington; Wansoon Kim, at Hoseo University, in South Korea; and Yi Ming Zou, at UW Milwaukee, who has given Vinay the distinction of having mathematical grandchildren.

Vinay served a term as director of graduate studies, a job he took very seriously, especially in the selection of new graduate students. He also played a major role in running the teaching mentor program for the Math Department.

Vinay was greatly devoted to his family, his wife, Vineeta, and his two children, Abhijit and Aditi, both of whom have been students here at IU. In the last several years of his life, he exhibited exceptional courage dealing with illness while still continuing his distinguished teaching and mentoring. We all indeed count it as a privilege to have been his colleague.

by DARRELL HAILE

Around the Department

Undergraduate Awards

These first-year students won awards and scholarships: Andrew Henderson and Jordan Lenchitz (Thelma Abell Prize).

These second-year students won awards and scholarships: Jennifer Huang and Samuel Pilgrim (Thelma Abell Prize); Sarah Butchko (Ruth E. Gilliatt Memorial Scholarship); Taylor Ball (Cora B. Hennel Memorial Scholarship); and Ben Briggs (Marie S. Wilcox Scholarship).

These third-year students won awards and scholarships: William Bowman, Christopher Farris and Jared Wentz (Cora B. Hennel Memo-

rial Scholarship); and Max Zhou (Ciprian Foias Prize).

These fourth-year students won awards and scholarships: Kevin Miloshoff and Mary Pasquale (Thelma Abell Prize); Jennie Lipson (Ruth E. Gilliatt Memorial Scholarship); Luke Andrejek (Trula Sidwell Hardy Scholarship); Eva Loveland, Sarah Reifeis, Chloe Urbanski, Zachary Wampler, and Zhengang Zhang (Marie S. Wilcox Scholarship); and Lea Beneish (Rainard Benton Robbins Prize).

Shelby Kruse won the M118 Undergraduate Intern Award.

Fourth-year scholarship winners Sarah Reifeis, Chloe Urbanski and Eva Loveland.

Graduate Awards

The following graduate students won awards and scholarships: Tim Lai and Brady Thompson (Hazel King Thompson Fellowship); Patrick Chu, Gregory Cook, Derek Donner, Sailaja Gajula, Dong Han, Jordyn Harriger, Jacob Herlin, Sarah Hoban Halvorsen, Jandos Jayikbaev, Luke Kwiakowski, Aranya Lahiri, Geunho Lim, Didac Martinez-Granado, Jihye Park, Min Woo Park, Kaluthanthrige Perera, Kursat Sozer, Kevin Switzer, Pengfei Tang, and Cong Zhou (College of Arts and Sciences Fellowship); Pengfei Tang (Robert E. Weber Memorial Award); Kelvin Guilbault and Pengfei Tang (James P. Williams Memorial Award); Ruiyu Yang (Muriel Adams Stahl Graduate Fellowship); Marco Hernandez and Wai Kit Lam (William B. Wilcox Mathematics Award); Ashley Lightfoot (College of Arts and Sciences Travel Award); Eduardo Fischer, Deniz Kutluay, Rafael Monteiro da Silva, Pawan Patel, Xuqiang Qin, Andrew Tapay, Shida Wang, Calvin Woo, Shizhuo Zhang, and Yining Zhang (Glenn Schober Memorial Travel Award); Rafael Monteiro da Silva (College of Arts and Sciences Dissertation Year Award); Rafael Monteiro da Silva (Outstanding Thesis Award); Samantha Allen, Nikhil Gupta, Matthew Heimerdinger, Zachery Lindsey, Thang Nguyen, Michael Novack, Eunhee Park, and Ranjan Rohatgi (David A. Rothrock Associate Instructor Award).

Faculty Awards

Ayelet Lindenstrauss received the Rothrock Mathematics Faculty Teaching Award. Marlies Gerber, Kevin Pilgrim and Tracy Whelan won the IU Trustees Teaching Award.

Ayelet Lindenstrauss

Student News

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Goldwater Scholars

Mathematics majors took two of this year's three Goldwater Scholarships awarded to IUB students. Thomas Dauer is a junior from Newburgh, Indiana. He plans to pursue a Ph.D. in physics, conduct research in theoretical condensed matter physics and quantum information, and teach at the university level. Joshua Foster is a junior from Carmel, Indiana. He also plans to pursue a Ph.D. in physics. Both Thomas and Joshua were members of our 2014 Putnam Competition team.

Accolades and Awards

Outgoing Math Club president Timothy Zakian received a prestigious Clarendon Scholarship to study at Oxford University. Rising junior Taylor Ball attended the prestigious Director's Summer Program at the National Security Agency. Math majors won numerous campus awards too, including Wells Scholar Jonathan Hawkins '15, recipient of a Kate Hevner Mueller Outstanding Senior Award, who is now headed to the PhD program in Economics at Yale University. Eighteen of our majors were elected to Phi Beta Kappa honor society.

Putnam Team

Our Putnam Team this year, with members Thomas Dauer, Joshua Foster, and Max Zhou, placed 35th in the nation. This is an exam where the median score is often 0! These students trained for the exam under Professor Hari Bercovici.

REU

Expanding the frontiers of knowledge since 1966, our Research Experience for Undergrad-

uates (REU) program has been regularly funded by grants from the National Science Foundation for the last few decades. Thanks to the leadership of faculty member Chris Connell, we're pleased to report we have NSF funding for summers '16-'18, inclusive. A "gap year" this summer led to a temporary downsizing of our program and to a cohort coming exclusively from IUB students. I thank faculty mentors Matthew Bainbridge, Chris Connell, Dylan Thurston, and Zorn postdoctoral professor Jeffrey Meier for keeping the program running this year. Five students will work very hard in this eight-week program; the experience is invaluable preparation for the rigors of graduate studies. Other current students are at REU programs around the country.

Actuary Club, AWM Chapter, and Math Club

Founded just this past Fall 2014, our new chapter of the Association for Women in Mathematics has had a busy year. An outstanding lineup of visitors, including Cornelia van Cott '08, (U. of San Francisco) and Moon Duchin (Tufts), gave inspiring presentations. Events included networking with alumna Frances Richert during her Careers class campus visit, viewing the one-woman hit play *Truth Values*, and outreach to the local chapter of Girls Inc. I look forward to working with new president LeeAnn Sager this coming year!

Under the leadership of senior Neelan Scheumann (now headed to OneAmerica in Indianapolis), our Actuary Club continues to thrive. The year was busy, with Club members holding study sessions, technical training sessions, and attending networking events to help members gain valuable industry contacts. Past Club president Bradley Hipsher '14 is now a recruiter for AllState and we hope to see him on campus someday soon! Incoming president Cheng Shi and I are already corresponding about logistics for Fall '15.

Did you know Disney has a math research group? They do–and the math behind the snow in the hit movie *Frozen* was discussed during a Math Club presentation by Michael Dorff from Brigham Young University. In addition to numerous cool talks by IU Mathematics faculty, the Club also had panel discussions on REU programs, problem solving sessions, and the occasional game of Mathematics Pictionary.

Field Trip

In a first-ever formal collaboration, the Departments of Economics and Mathematics supported a group of 24 mathematics and economics majors on a trip to St. Louis, MO February 19-21, 2015, led by Gerhard Glomm (Econ) and myself, Kevin Pilgrim '89 (Math). Our first event was a stop at the Federal Reserve Bank of St. Louis for an alumni mixer event and a speech by President James Bullard (PhD '90, Economics). The next day saw panel discussions with several varied business leaders in two locations: Brown Shoe Company and Buckingham Financial. At the latter event, we met Sharol Brickman '86. Now an associate partner at Aon Hewitt, she shared valuable perspectives about the business world, work ethic, and the power of mathematics. The trip also included a theatrical play, a trip to the St. Louis Art museum, and a stop at the Cahokia Mounds State Historic Site.

We thank Anne Koehler, whose generosity supported this trip for several Mathematics majors from our new Careers in Mathematics course.

Perspectives on careers

"We're looking for smart and creative types." "We're looking for solid performance in analytical courses." "The algorithmic thinking of math majors is valuable to us." "We have no quota for IUB math majors." I've heard this from several recruiters over the past two years. This would seem to refute the myth that a Liberal Arts degree is less valuable than a professional degree. To help get this word out, I've been drawing on the wisdom shared by 38 of you IU math alums in our "Share your story" survey. This has helped a lot when discussing the value of math degrees with potential recruits and their families and potential majors. Thanks to all who have responded!!
by KEVIN PILGRIM

Groups Program

Groups 2015 problem-solving students with Associate Instructor Emily Walther

The summer of 2015 will mark nearly 50 years of Mathematics Department participation in the Groups Scholars Summer Experience Program. The Groups Program is expecting at least 384 students (its largest class ever) to come to campus in June for six weeks of intensive academic preparation. The Program's participants are Indiana residents who are "first generation college" or from low-income families. They will all enroll in composition, critical reading and mathematics courses, and many will also elect

to study business, chemistry or participate in a musical theater production. There is no cost to the students for the summer program. Nearly all will return to IUB fall semester to formally begin their academic careers.

The Groups Program was founded in 1968 as a means of increasing diversity at IUB. A large network of recommenders in high schools and community groups throughout the state was put in place to seek out well-qualified students and help them apply to the program. The recommender system is still used today and ensures access to the program for students in rural areas and small towns as well as the large urban high schools in Indianapolis, Fort Wayne, Evansville, South Bend and Gary. Each entering Groups class includes students of African American, Hispanic, White, Asian and mixed ethnicities. In addition, in the last two years alone, the Groups Program has welcomed students who were born in more than 30 different countries including Afghanistan, Bosnia, Yemen, Bangladesh, Iran, Pakistan, Mexico, Ecuador, Ghana, Zimbabwe, Fiji and Thailand.

The Mathematics Department has been a major participant in the Groups Summer Program since its inception. Dan Maki and Maynard Thompson were involved in designing the original summer math curriculum, which targeted preparation for entering the School of Business. In the early years, the Mathematics Department hired faculty specifically to teach algebra and computer science classes for the Groups students. As the number of program participants has grown, the teaching responsibilities have shifted to graduate students, and the curriculum has also evolved to meet the needs of the students. We currently offer four courses during the summer program: pre-algebra, algebra, introduction to problem solving and an honors version of the problem-solving course. This summer we are hoping to hire 21 associate instructors and 7 undergraduate tutors to staff the summer classes.

Mathematics is the only academic area that also offers classes specifically for Groups students during the academic year. Our J113 (brief calculus) class, for example, meets daily in very small sections to maximize student-teacher contact hours and provide students with a more structured and supportive learning environment than they might have in a large lecture class. The close relationship between entering Groups students and instructors is an important factor in the students' ultimate success in the University. We can be very proud of the hundreds of mathematics graduate students who have so positively affected the lives of first generation students over the last five decades.

by LINDA MCKINLEY

Giving

The Department of Mathematics is grateful for all of the support it receives from its generous donors. The Department has several funds to which you can give. Donations may be made using the attached Indiana University Foundation Donation Form or through the Give Now link at http://www.math.indiana.edu/

- Mathematics Enrichment Fund (I380008688): Gifts to this fund will be used for the general support of the Mathematics Department, in the College of Arts and Sciences.
- Mathematics Alumni Lecture Fund (I380012139): Gifts to this fund are used to cover the direct costs of presenting guest lectures each year on the Bloomington campus for the benefit of our undergraduate students, for example, by bringing Alumni back to speak to students in our new Careers in Math course. This fund was recently established with the generosity of faculty support.
- Glenn Schober Memorial Fellowship Fund (I380008692): Gifts to this fund support outstanding advanced graduate students, including travel and registration fees for national meetings.

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