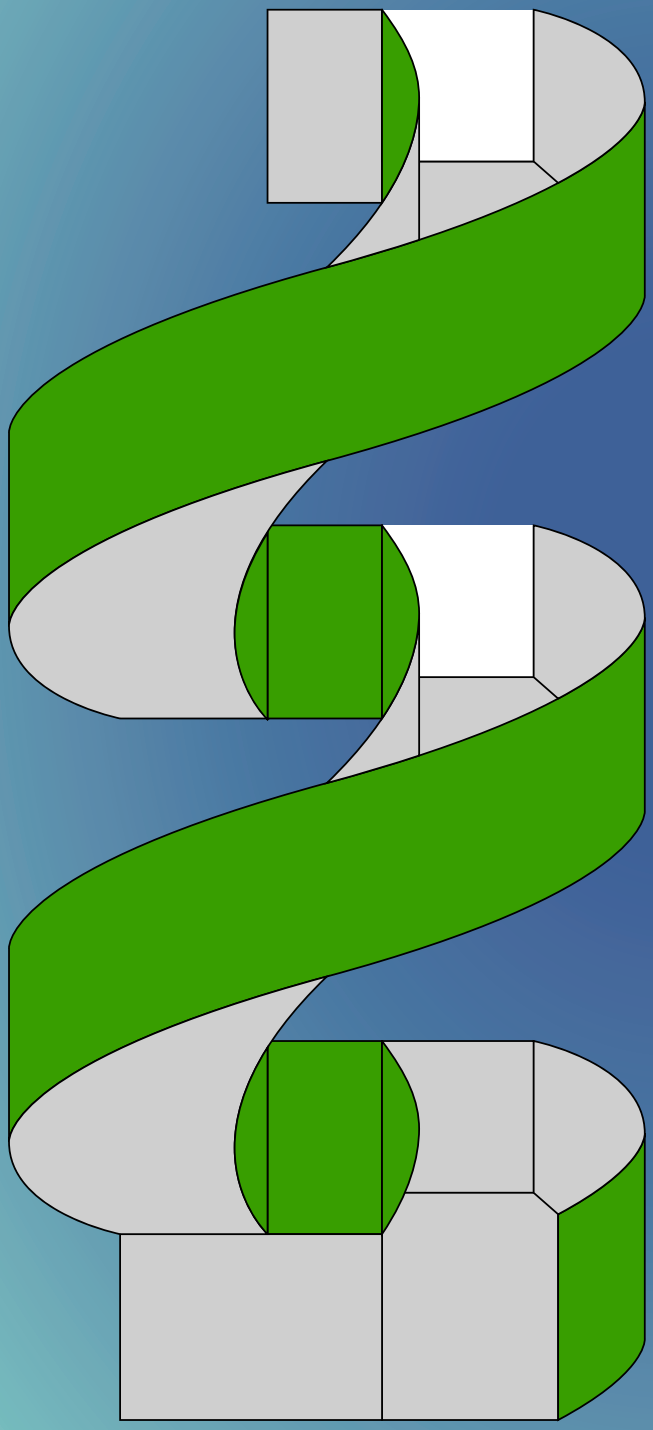
FIELDS NOTES

VOLUME 17:2 - Summer 2017

THE FIELDS INSTITUTE FOR RESEARCH IN MATHEMATICAL SCIENCES

+ The Human Part of the Equation
+ Patterns in Art and Mathematics
+ Spotlight On: Sigma Analysis



THE FIELDS INSTITUTE TURNS 25

Excerpts from the anniversary book

FIELDS NOTES

VOLUME 17:2 - Summer 2017

DIRECTOR
Ian Hambleton

DEPUTY DIRECTOR
Huaxiong Huang

MANAGING EDITOR
Malgosia Ip

DISTRIBUTION COORDINATOR
Tanya Nebesna

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CONNECT WITH US
Questions? Comments?
E-mail communications@fields.utoronto.ca

@fieldsinstitute

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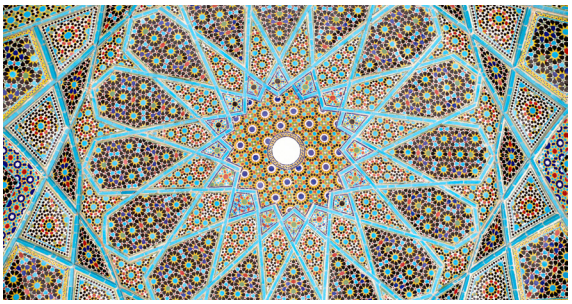


In every issue

Message from the Director

"We've showcased the diversity of programming that Fields supports and the beauty and breadth of mathematics research".

The Fields Institute is twenty-five years old and over those years it has seen ten different Directors and nine different Deputy Directors; it has named 117 Fields Fellows; it has put on countless thematic programs, focus programs, workshops, seminars, and summer schools. No one person could possibly remember all the details. That's why we've collected stories from 32 different people that have seen the Institute grow and develop from before its inception to the present, and put them together into a twenty-fifth anniversary book. We hope you enjoy reading excerpts from the book in this issue of Fields Notes.

This twenty-fifth anniversary issue of Fields Notes also celebrates other milestones, including the 10th Annual Keyfitz Lecture in Mathematics and the Social Sciences, and the 10th anniversary of Sigma Analysis and Management's "graduation" from our start-up program.

Additionally, we've showcased the diversity of programming that Fields supports and the beauty and breadth of mathematics research. Read our feature "Patterns in Art and Mathematics" to see four different perspectives on the connections between mathematics and art from the Waterloo Bridges Lecture Series. Explore the life and mathematical philosophy of Jean-Marie De Koninck, winner of the 2016 Margaret Sinclair Memorial Award for excellence in mathematics education, in our story "The Human Part of the Equation". Search the issue for "25 Facts about Fields" – you might learn some things you didn't know about the Institute.

Finally, save the date for the 2017 Fields Medal Symposium featuring the work of Martin Hairer (October 16-19). This year the event will be held at MaRS and with a public lecture, a student night, and an exciting scientific program, there will be something for everyone.

I am proud to have seen the Fields Institute grow and develop over the two years that I've spent as Director, and I hope you'll follow along to see it thrive for many more.

Ian Hambleton
Director

News

Maryam Mirzakhani, 2014 Fields Medal Winner, Dies at 40

Mirzakhani was the first woman and first Iranian-born to win the prestigious mathematics prize.

MARYAM MIRZAKHANI, IRANIAN MATHEMATICIAN and professor of mathematics at Stanford University, passed away on July 14, 2017 after a long battle with cancer. Mirzakhani was the first woman and first Iranian-born to win the prestigious Fields Medal.

She will be remembered for her research in moduli spaces, Teichmüller theory, hyperbolic geometry, Ergodic theory, and symplectic geometry, but also for her fearlessness tackling problems that others would not attempt.

Mirzakhani will continue to be an inspiration to women everywhere who are pursuing or thinking of pursuing careers in math and science. ❖

Ryerson Becomes Fields' Ninth Principal Sponsoring University

The nine Principal Sponsoring Universities are essential for the success of Fields' mission to enhance mathematical activity in Canada.

THE FIELDS INSTITUTE IS VERY PLEASED to welcome Ryerson University as its ninth Principal Sponsoring University (PSU). The connections formed with Ryerson over the past few years as a Fields Affiliate University have now reached a new level, which we recognize and celebrate with this PSU agreement.

"The Fields Institute is excited to increase its ties with such a geographically close neighbour. Ryerson's commitment to research excellence as well as its focus on community engagement will certainly result in an array of interesting programming within and beyond the mathematical sciences community," says Ian Hambleton, Director of the Fields Institute.

The mission of the Fields Institute is to enhance mathematical activity in Canada by bringing together mathematicians from all around the world.

"Ryerson is delighted to be furthering our partnership with the Fields Institute as a Principal Sponsoring University. The application of knowledge in the area of math sciences continues to grow at an unprecedented pace as computational technology and access to data and analytics are present in nearly every field of study," says Professor Steven Liss, Vice-President, Research and Innovation, Ryerson University. "Our ongoing collaboration with the Fields Institute reaffirms our commitment to mathematical studies and contribution to fundamental knowledge and its applications."

The Fields Institute aims to expand the impact of mathematics in modern society by promoting contact and collaboration between professional mathematicians and the increasing numbers of users of mathematics.

The nine Principal Sponsoring Universities are essential for the success of this mission. Together we provide a wide variety of opportunities through the excellence of our research programs to benefit the mathematical sciences community across Canada. ❖

2017 Fields Institute Fellows

Five inductees were honoured for their outstanding contributions to the Fields Institute and its activities.

HENRI RENE DARMON (MCGILL): Darmon is the winner of the 2017 CRM-Fields-PIMS Prize and a well known mathematician specializing in number theory. He was elected to the Royal Society of Canada and will receive the 2017 AMS Cole Prize in Number Theory "for his contributions to the arithmetic of elliptic curves and modular forms." He is currently a James McGill Professor of Mathematics at McGill University.

NASSIF GHOUSSOUB (UBC): Ghoussoub is a founder of BIRS (Banff International Research Station) and has been its Scientific Director since 2004. He was also the founding Director of PIMS (Pacific Institute for the Mathematical Sciences) for the period 1996-2003, a cofounder of the Mitacs Network of Centres of Excellence (Mathematics of Information Technology and Complex Systems). He was elected Fellow of the Royal Society of Canada in 1993, and was appointed Officer of the Order of Canada in December 2015. Ghoussoub is currently a Professor of Mathematics and a "Distinguished University Scholar" at the University of British Columbia.

MATHEUS GRASSELLI (MCMASTER): Grasselli was the Deputy Director of the Fields Institute from 2012 to 2016. He is Managing Editor of Springer Briefs in Mathematical Finance, Associate Editor of the International Journal of Theoretical and Applied Finance, and Associate Editor of the Journal of Banking and Finance. Grasselli is currently a Professor of Financial Mathematics working with the PhiMac group in the Department of Mathematics and Statistics at McMaster University.

DONNA KOTSOPOULOS (WILFRID LAURIER): Kotsopolous is an Ontario Certified Teacher (OCT) and the founding and current co-editor of the Fields Mathematics Education Journal. She was recently awarded the Hoffman-Little Award for Faculty for excellence in teaching, research, and professional endeavor. Currently, Kotsopoulos is a professor in the Faculty of Education, cross-appointed to the Department of Mathematics in the Faculty of Science at Wilfrid Laurier.

ROBERT PRICHARD (TORYS LLP, BANK OF MONTREAL, METROLINX): Prichard was the thirteenth president of the University of Toronto from 1990 to 2000. During his ten years as president, the U of T's endowment rose to $1.4 billion, the most of any Canadian university. Prichard is currently the Chairman of the Board of the Bank of Montreal as well as the chair of the board of Metrolinx and Penguin Group Canada, and the chair of Toronto law firm Torys LLP. ❖

Zhangxing (John) Chen Wins the 2017 CAIMS-Fields Industrial Mathematics Prize

The CAIMS-Fields annual industrial mathematics prize is awarded to a researcher in recognition of exceptional research in any branch of industrial mathematics.

THE CANADIAN APPLIED AND INDUSTRIAL MATHEMATICS SOCIETY and the Fields Institute are pleased to announce that Professor Zhangxing (John) Chen has been awarded the 2017 CAIMS-Fields Industrial Mathematics Prize for his seminal contributions to industrial and applied mathematics, computational science, and modelling of flow in porous media.

Dr. Chen is a Professor in the Department of Chemical and Petroleum Engineering at the University of Calgary and currently holds the NSERC Industrial Research Chair in Reservoir Simulation and the AITF (iCORE) Industrial Chair in Reservoir Modeling. His group uses modelling and simulation to develop new, more economical, and more sustainable ways to recover heavy oil and oil sands resources.

Throughout his career, Dr. Chen has led many collaborative projects with industrial partners including Suncor, Nexen Energy, Petróleos Mexicanos, China National Petroleum Corp., and Computer Modelling Group. His research has had major impact on practical applications in the oil and energy sectors, as evidenced by his 15 patents.

Dr. Chen's publication record is stellar, with 16 books and over 500 refereed journal papers covering problems ranging from existence-uniqueness theory, finite element approximations, homogenization, and parallel algorithms, with applications to multi-phase porous media flow, CO_2 sequestration, and semiconductor device simulations. Dr. Chen has also made major contributions to training, having supervised over 100 graduate students and post-docs in industrial applications of mathematics and advanced computing algorithms.

Dr. Chen holds a PhD (1991) from Purdue University and held positions at Xi'an Jiaotong University, Peking University, the University of Minnesota, Texas A&M University, Mobil, and Southern Methodist University (SMU), before arriving at the University of Calgary in 2007.

As part of the award, Dr. Chen will be invited to deliver a lecture at the CAIMS Annual Meeting taking place in Halifax from July 17 to 21, 2017. ❖

2010 Fields Medallist, Cédric Villani, Elected to French National Assembly

Villani won 69% of the vote in the 5th constituency of Essonne, south of Paris.

CÉDRIC VILLANI, PROMINENT MATHEMATICIAN and Director of the Institut Henri Poincaré in France, was elected to the French National Assembly last month as a representative of Emmanuel Macron's party, "La République En Marche!" Villani won 69% of the vote in the 5th constituency of Essonne, south of Paris.

In an interview with Science Magazine, Villani said that "it is important that scientists step in and become part of the political process."

In 2014, Villani was awarded the Fields Medal, one of the highest honours of mathematics, "for his proofs of nonlinear Landau damping and convergence to equilibrium for the Boltzmann equation." He was honoured at the 2014 Fields Medal Symposium hosted at the Fields Institute. In the Winter 2015 issue of Fields Notes, Villani described himself as a "militant European federalist", perhaps foreshadowing his future political career.

Villani now plans to leave his Directorship at the Institut Henri Poincaré to focus on his political duties. We wish him the best of luck in this new role. ❖

Calendar

2017 Fields Medal Symposium: Martin Hairer, October 16-19

WORKSHOPS AND CONFERENCES

Conference on Quantum Information and Quantum Control VII August 28 to September 1 The Fields Institute

Workshop on Wave Transport of Ionic Species August 28 To September 1 The Fields Institute

Workshop on Waves in Neural Media September 5 - 8 The Fields Institute

Workshop on Global Sensitivity Analysis and Parameter Estimation September 11 - 15 The Fields Institute

Conference on Big Data and Information Analytics September 18 - 22 The Fields Institute

4th Industrial-Academic Workshop on Data Science and Optimization in Finance and Risk Management September 25 - 26 The Fields Institute

Training Workshop on Diffusive Processes in Physiological Media September 25 - 29 The Fields Institute

Workshop on Graph Classes, Optimization, and Width Parameters (Grow 2017) October 10 - 13 The Fields Institute

Symposium on Computational Thinking in Mathematical Education October 13 - 15 University of Ontario Institute of Technology

SPECIAL LECTURES

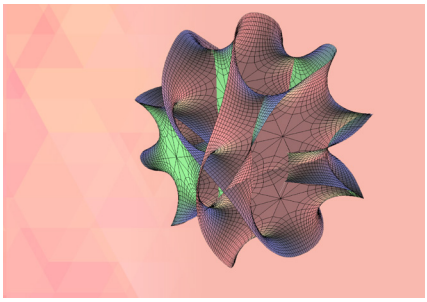
Public Lectures: James Sneyd September 11, 5:00 p.m. The Fields Institute

CRM-Fields-PIMS Prize Lecture: Henri Darmon September 13, 4:10 p.m. The Fields Institute

Department of Statistical Sciences Anniversary Lectures: David Bellhouse September 14 5:30 p.m. The Fields Institute

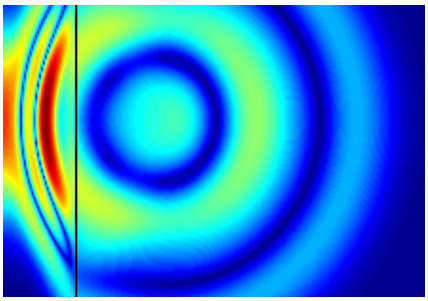
Public Lectures: Bill Ziemba September 20, 5:30 p.m. The Fields Institute

Distinguished Lecture Series: Panagiota Daskalopoulos October 3-5 The Fields Institute



THEMATIC PROGRAM

Geometric Analysis
June – December, 2017



FOCUS PROGRAM

Multi-scale Modelling of Wave Structures in Tissues
August 28 – October 6, 2017

2017-2018 Distinguished Lecture Series in Statistical Sciences: Raymond Carroll October 4 - 5 The Fields Institute

Department of Statistical Sciences Anniversary Lectures: Art Owen October 12 5:30 p.m. The Fields Institute

Department of Statistical Sciences Anniversary Lectures: Victoria Stodden October 26 5:30 p.m. The Fields Institute

Coxeter Lecture Series: Tobias Colding November 15 - 17 The Fields Institute

Life at Fields

Fields-China Industrial Problem Solving Workshop in Finance

THE INDUSTRIAL PROBLEM Solving Workshops (IPSW), organized through the Fields Commercial and Industrial Mathematics Program (CIMP), are an opportunity to make connections between academic and non-academic circles. Academics learn about interesting, real-world research problems and industries get access to some of the top mathematical modellers and problem-solvers.

This year's workshop was focused on challenges in finance and included problems from **The TMX Group, Scotiabank, The China Futures Exchange, and the China Securities Index Co., Ltd.** After one week of working in small groups, the participants presented their progress on each problem.

"The best part of the workshop is the cooperation," said one of the participating students.

The IPSW has a long-standing tradition—the Pacific Institute for Mathematical Sciences (PIMS) started organizing such events almost twenty years ago. Now the workshops are organized jointly by the Fields Institute, the Centre de Recherches Mathématiques in Montréal, PIMS, and the Canadian Institute for Statistical Sciences (CANSSI).

Shige Peng, a Professor at China's Shandong University and one of Fields 2017 Research Fellows, thinks the IPSW is "a wonderful opportunity, especially for our students."

Mathematical tools are increasingly important in our data-driven society. By creating connections between mathematicians and industry, the CIMP hopes to support technological advancement and innovation. ❖

— Malgosia Ip

Fields Thesis Competition

ON APRIL 18TH, The Fields Institute held its inaugural thesis competition in collaboration with TEDxUofT. Doctoral students studying any form of mathematics from across Ontario competed to see who could best present their thesis topic within three minutes.

The audience laughed and cheered as they heard presentations on financial math, elliptic curves, L-functions, big data, medical imaging, and more.

Judges Pierre Roquet from TEDxUofT, Jean-Marie De Koninck from Université Laval, Arvind Gupta from the University of Toronto and UBC, and Tom Salisbury of the Fields Institute and York University, had such a hard time choosing the three winners that they added three honourable mentions. Though all the presentations were interesting, the judges felt that "the winners were able to present complex mathematical concepts in a particularly engaging and accessible manner."

Winners will have the opportunity to expand their talks for a TEDxUofT salon later this summer. ❖

— Malgosia Ip

Winners

Grey Kuling,York University: How Texture Will Change the Course of Multiple Sclerosis

Thomas Bury, University of Waterloo: Predicting Critical Transitions in Nature and Society

Tyrone Ghaswala, University of Waterloo: Pac-Man and Donuts

Honourable Mentions

Helen Cheyne, York University: Improving Quantitative Credit Estimates with Big Data

Anton Mosunov, University of Waterloo: Theory of Elliptic Curves. A History in Portraits.

Sawitree Boonpatcharanon, York University: Digestion Data by Clustering

FOCUS PROGRAM

From May 29 to June 23, 2017, the Fields Institute hosted graph theorists, probabilists, theoretical computer scientists, social scientists, and researchers in network systems and security for a focus program on Random Graphs and their Applications to Complex Networks. This program represents a major emerging area that requires the collective efforts of multiple disciplines.

RANDOM GRAPHS AND APPLICATIONS TO COMPLEX NETWORKS

The theory of random graphs was founded by Erdős and Rényi in 1959 after Erdős discovered that the probabilistic method is useful in attacking problems of extremal graph theory. Shortly afterwards, Gilbert introduced the random model of the Gilbert disc, nowadays known as random geometric graphs. Both models are simple, but they do not address all the characteristics of complex networks. For example, the famous chain experiment by Milgram showed that there are at most six degrees of separation between any two people in the world. This phenomenon of small diameter is nowadays reflected in online social networks such as Facebook, and none of the classical models reflect this appropriately. More recently, new random graph models, such as the Preferential Attachment Model or the Spatial Preferential Attachment Model, have been designed. These models have been used to give theoretical insight into the propagation of epidemics, the activity of neurons in neural networks, and the connections in protein-protein interaction networks, to mention a few.

Thanks to the availability of more and more data in bigger networks and because of their relevance to a multitude of applications, these models have been the subject of sustained research effort over the past five decades.

This particular Focus Program included a Summer School on Random Graphs and Probabilistic Methods (May 29 to June 9, 2017) with more than 80 participants and 4 invited experts in the field; the 14th Workshop on Algorithms and Models for the Web Graph, WAW2017 (June 15 - 16, 2017); a panel on complex networks in industry and academia (June 16, 2017); and a Workshop on Random Geometric Graphs and Their Applications to Complex Networks (June 19 - 23, 2017).

Panel on complex networks in industry and academia

A highlight of the program was the panel discussion featuring four experts (Jeannette Janssen, Jure Leskovec, Yuval Peres, Andrei Raigorodskii) who gave a personal view of career options, challenges, and opportunities in both academia and industry for professors and students. Following the panel discussion, attendees had an opportunity to meet and network with the panelists over a casual lunch sponsored by an NSERC Connect grant.

— Pawel Pralat

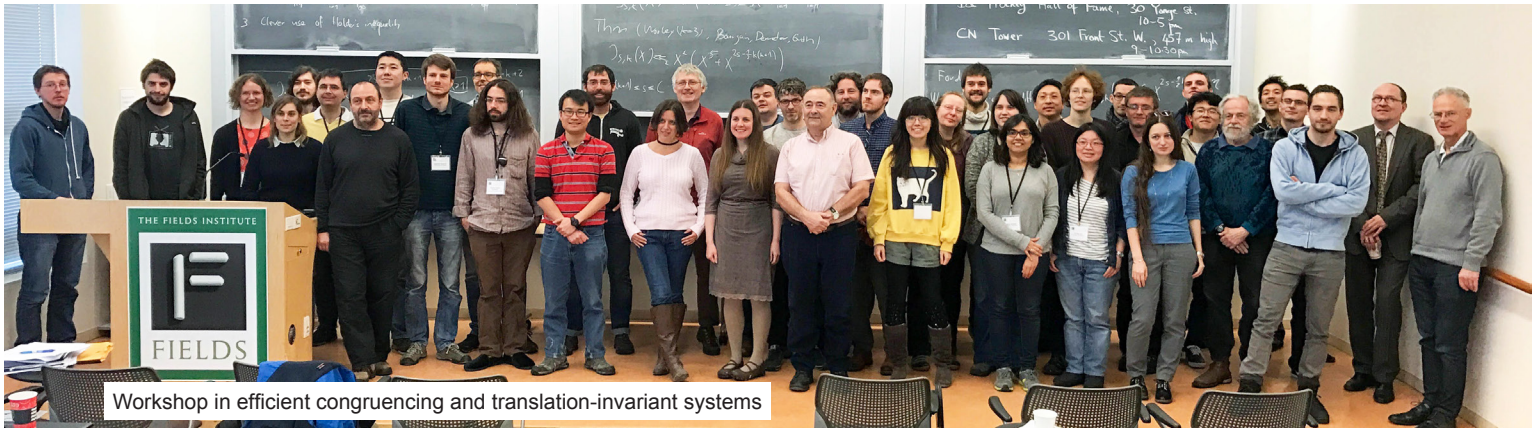
THEMATIC PROGRAM

UNLIKELY INTERSECTIONS, HEIGHTS, AND EFFICIENT CONGRUENCING

In recent years there has been a great deal of success in applying methods of analytic number theory to questions of arithmetic geometry. This thematic program focussed on three topics: o-minimality, heights, and "efficient congruencing" and featured two graduate courses, a mini-course, three workshops, and a post-doctoral seminar.

The two graduate courses were taught by Patrick Ingram and myself. My own course was designed mostly to serve as background for unlikely intersections, which is a topic that underpins a large part of the program. One enticing feature about this subject is that it brings together several different fields, so this course was designed to acquaint everyone with the background they were missing. Patrick Ingram's course on Arithmetic Dynamics was extremely interesting as a developing subject that has more and more to say about unlikely intersections. This was evident during our very first workshop in a wonderful talk by Laura Demarco, when she explained how to prove new and old results on simultaneous torsion. I know of at least one graduate student at Toronto who is now working with Patrick as a result of the course.

There was also a nine-hour mini course taught jointly by Trevor Wooley and Yu Ru-Liu. These were very well attended and explained the Hardy-Littlewood method as well as the refinements provided by the efficient congruencing method, and how it can be used to improve bounds on the Waring problems.



Workshop in efficient congruencing and translation-invariant systems

Our Heights workshop took place in February and featured some wonderful talks both from the technical height-machinery crowd (Kühne, Amoroso, and Wüstholz) and some who used heights in a softer manner to obtain wonderful results on equidistribution (Demarco, Daw, Shankar, etc.). One exceptionally wonderful talk that everyone enjoyed was by Boris Zilber who unveiled some of his new conjectures based on model theory, which try to generalize Zilber-Pink to the finite-field setting. This provided lots of new concrete problems to work on and there was much discussion on this for the rest of the conference.

The workshop on Efficient Congruencing had a variety of talks centered around Vinogradov's mean value theorem, exploring both the decoupling approach and the approach with translation-invariant systems, and how they relate.

We were also very lucky to have Umberto Zannier and Robert Vaughan give our Distinguished and Littlewood lecture series respectively. Zannier gave an extremely nice series of talks on the machinery of heights and its evolution over time. These were simultaneously very accessible (he began by carefully defining heights!) yet led to a series of open problems which seemed just out of reach.

The 2017 Littlewood Lecture series was given by Professor Robert Vaughan, FRS on the Hardy-Littlewood method. Vaughan masterfully described the method from every perspective—how it was viewed historically, the various advances which were brought to bear for Vinogradov's theorem and Waring's Problems, among others, and leading up to the most recent work on the subject. His talks were extremely clear while maintaining an impressively high level of technical precision. ❖

— Jacob Tsimerman


Robert Vaughan


Umberto Zannier

SPOTLIGHT

SIMON MYERSON is a post-doc from University College London who participated in the "Unlikely Intersections, Heights, and Efficient Congruencing" Thematic Program. His project at Fields, as well as his other work, is in the field of analytical number theory, which he describes as "giving rough estimates for the number of solutions to some arithmetic problem."

"You might be able to get an extremely unpleasant formula for the exact answer, which isn't going to tell you anything very useful, but you might be able to get a very simple, clear formula for the rough answer," explains Simon. Fermat's last theorem (finally proven by Andrew Wiles in 1995) and the twin prime conjecture (still unproven) are two famous examples of analytic number theory problems.

Simon came to Fields hoping to broaden out from what he worked on in his PhD and found that the atmosphere of the Fields Institute was naturally conducive to collaboration.

"What I'm working on while [at Fields] is actually quite different than what I was working on previously. I'm collaborating with several of the other post-docs on a couple of projects. One of them is actually something that I was curious about for a while, and it turned out that my office mate at Fields had worked in that area."

When he's not working, you might find Simon expanding his felt rock collection.

"It turns out that once you've bought one felt rock you can't stop. You don't see them every day, so now when I see a felt rock I think 'well I'm the person who has felt rocks; I am obligated to buy this felt rock.'"

Simon is now back at UCL working on new applications of the circle method to Diophantine problems. ❖

— Malgosia Ip

In the Field

Math Horizons Day

MANY STUDIES SHOW THAT ONE of the major difficulties encountered by students is seeing the relevance of the course they are taking. This can seriously affect their motivation and their ultimate success. This effect seems to be most pronounced in mathematics.

The 16th edition of the Math Horizons Day at the **University of Ottawa** took place on Friday, April 28. This year, we had record participation with high school students, teachers, and colleagues from 20 English and 12 French schools in and beyond the Ottawa region. The main goal of this event is to provide students with the opportunity to see a side of mathematics and its applications that they don't typically get to see in a classroom setting.

The day started with words of welcome from the mathematics department Chair followed by two presentations: an English presentation about the value and importance of formal mathematical proof with some concrete examples, and a French presentation on the theory and applications of mathematical cryptography. Students had the chance to practice on some interesting cryptography exercises. As many students and teachers commented afterwards, the presentations were an inspiration on the important role mathematics plays in our modern society. The day continued with team competitions, relays, and an individual competition.

Both students and teachers commented on the importance of such enrichment activities to give students the chance to sharpen their mathematical skills in a challenging but fun environment. ❖

— Joseph Khoury

Living on the Precipice

THE RESILIENCE OF COMPLEX SYSTEMS to disturbance is a topic of long-standing and continuing interest in multiple academic communities and has led to both insights into real-world systems and policy improvements. However, significant theoretical, empirical, and policy challenges remain. This conference was convened on May 16 and 17 in Waterloo, Ontario to take steps toward addressing some of these challenges, with a special emphasis on natural, human, and coupled natural-and-human systems. Coupled systems include many important real-world systems such as the global climate system and endangered ecosystems, but due to their higher complexity, they also represent a significant challenge in terms of their mathematical characterization and analysis.

The meeting attracted 87 participants from Ontario and the US, and brought together mathematical modellers (including the plenary speaker Alan Hastings, Distinguished Professor of Environmental Science and Policy at the University of California, Davis) and experts from biology, environmental sciences, economics, and sociology. Events included a plenary talk, 8 invited talks, a poster session, 16 contributed talks in three parallel sessions, two workshops (one led by grad students), a Maple software demonstration, and even a group activity involving composition of haikus along the theme of resilience.

The conference was a resounding success. As one invited speaker commented, "although many of us regularly discuss the benefits of embracing a multidisciplinary perspective, [this] conference took things to a higher level". This conference also laid the foundations for new collaborations, as several participants agreed to continue their discussions and plan future research. In a further example of impact, some graduate students were inspired to incorporate resilience analysis into their mathematical models of ecological dynamics. ❖

— Madhur Anand

"If you can obtain a simple result in a complicated way, you should be able to obtain that simple result in a simple way."

A Tribute to Professor G.M.L. Gladwell

The 9th International Conference on Inverse Problems in Engineering (ICIPE), hosted by the University of Waterloo, was held in honour of Professor Graham Gladwell, FRSC, who sadly passed away on March 11th of this year.

AS A MATHEMATICIAN would say, Professor Graham Gladwell was my academic father. Somehow, this is much more accurate than saying he was simply my PhD supervisor. Upon his passing, I have been engulfed by a flood of memories with strong feelings of respect, affection, and gratitude.

Perhaps of greatest impact was the Gladwellian rule: "If you can obtain a simple result in a complicated way, you should be able to obtain that simple result in a simple way." I can still hear his voice ringing with this message phrased so poetically. Now that I look back on my 26 years as a faculty member at the University of Saskatchewan, I realize how many of my own contributions have sprung from this lesson.

It was from Professor Gladwell that I especially learned how mathematical thinking could permeate every facet of a person's life. During one of many visits to the Gladwells' lovely home in the country, the after-dinner activity included a board game called Chaos. In this game, each player must keep track of an evolving, mind-stretching pattern of checkers. Prof. Gladwell suggested that each of us play the pieces for two players. I felt like my mental capacity was being tested. During the game, Professor Gladwell was calm and collected, smoothly and rapidly making each move. I was sweaty, intense, and apprehensive, pushing my brain to full capacity. We completed our final moves in succession. Professor Gladwell got up, looked refreshed, and said, "a tie, what fun".

I could go on with more anecdotes involving math challenges and lessons, but I would like to focus the remainder of this tribute on what I consider to be one of Professor Gladwell's greatest attributes. He was perhaps the most open-minded academic I have ever encountered. His high standard of excellence for himself and others did not rely on adherence to a particular style or a pre-conceived set of superficial rules; his criteria were pure and fundamental – clear, concise descriptions and flawlessly logical arguments. Beyond these

cognitive pillars, he was open to various approaches and paths. So often I would hear Graham firmly but fairly challenge other academics to be clear and informative. Upon hearing a meaningful response, he was receptive and gracious without fail.

In closing, let me say that I can still hear the melodic humming of Prof. Gladwell down the hallway at the University of Waterloo. It's as if his "work" was an ongoing piece of beautiful classical music which filled his soul with joy and satisfaction. Thankfully, this symphony will continue and flourish – through his many wonderful papers, his graduate and undergraduate students, and everyone who has had the pleasure of his company. ❖

— Allan T. Dolovich

"Suddenly, through these activities, the mathematical processes in the math curriculum came to life right before my eyes."

FIELDS IN THE ELEMENTARY CLASSROOM

I RECENTLY ATTENDED MY FIRST Mathematics Education (MathEd) Forum at the Fields institute. Admittedly, I was rather nervous as I drove into Toronto from Hamilton. I was equally worried about my own level of mathematical proficiency as an elementary classroom teacher, and intimidated by the reputation of the speakers, the other attendees, and the Institute itself. I was educated in a system where we were led to believe that there were 'math people' and 'non-math people,' and I firmly believed that I fell into the latter group.

As a teacher of 13 years, I came to the profession with an English degree and worked for a number of years in the Hamilton-Wentworth District School Board (HWDSB) as a system literacy coach—this was my niche and certainly my comfort zone. However, since my return to the classroom in 2014, I felt a common lethargy with my junior students whenever we turned our attention to mathematics. Textbooks were passé, worksheets were not my style, and I felt the need for something more than a 3-part math lesson. It was clearly time to find inspiration so that I could, in turn, share that passion with my students.

The March MathEd Forum looked at math through art and allowed me to put myself in my student's shoes. I walked into this 'math class' not knowing whether I would understand, or whether my questions would seem unsophisticated or completely rudimentary. What I found was a group of educators willing to support my mathematical journey regardless of my experience or aptitude. Some of the math was a little beyond me, but I couldn't help seeing the beauty and wonder of Dr. Daniel Jarvis using a simple protractor and angles to draw a perfect egg. I couldn't help feeling the excitement as George Hart and Elizabeth Heathfield allowed us to explore the place where mathematics meets art by having us create and build. I couldn't wait to bring this to my classroom!

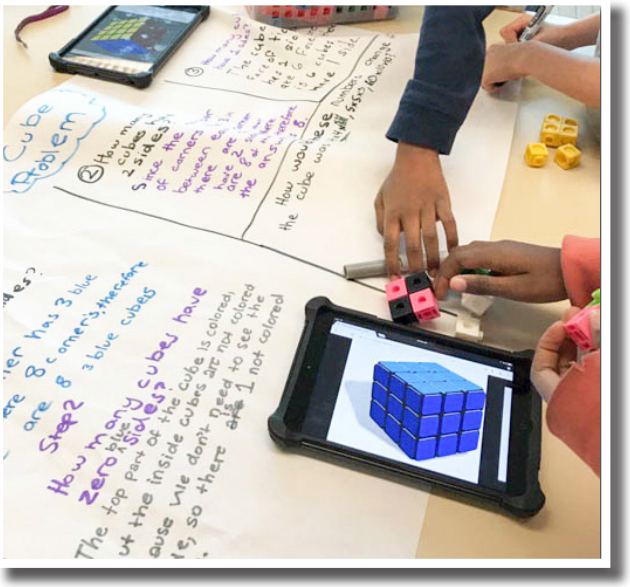
For the first time in my career, I saw my students naturally wanting to discover mathematics. Building hyperboloids with sticks and elastics was followed by 10 year olds hypothesizing why the straight sticks would begin to appear curved. During another activity, I watched in wonder as my junior students searched the internet to understand how the number patterns in the Fibonacci sequence could ever 'know' how to draw a perfect shape. Suddenly, through these activities, the mathematical processes in the math curriculum came to life right before my eyes. Without lengthy instructions or top down expectations, students were problem solving, reflecting, connecting, communicating, and representing their ideas. An excitement, a 'phenomenon of learning', typically reserved by students for things like Pokemon Go and fidget spinners, was happening in a math class.

April's MathEd Forum on Statistics got me thinking about what data management typically looks like in a classroom—simple

surveys—compared to the challenges that statisticians like Justin Detlor grapple with in the real world.

I wondered, "what if my students really had to organize complex information with clarity?" Boaler's 'low floor, high ceiling' tasks such as the Painted Cube challenge and a simple card game Ron Lancaster of OISE shared with me transformed into weeks of mathematical inquiry. Our math classes went from ordinary to extraordinary, as students moved through math challenges collaboratively and were determined to find solutions. For the first time ever, I had junior students begging for more math time because they 'had just one more thing they wanted to try' as they manipulated data and tried to find patterns. My students were able to demonstrate advanced mathematical learning outside their expected range simply by working on rich tasks in an environment that celebrated learning over knowing.

Through the MathEd Forum at Fields I have connected with many wonderful people, but must especially thank my friend, Dragana Martinovic for giving me the courage to try something new in mathematics and to abandon the notion of 'best practice' in exchange for innovation, for learning, and for my students.



I encourage educators from all panels to seek out professional learning opportunities through the Fields Institute, knowing that it is a safe place to grow and explore—no matter where you fall on the math continuum. ❖

— Alison Boehme

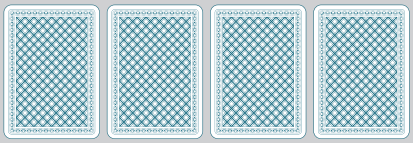
THE PAINTED CUBE

Jo Boaler, Stanford University

Imagine a 5 x 5 x 5 cube made up of smaller 1 x 1 x 1 cubes that has been painted blue on the outside only. Consider: how many of the smaller cubes would have 1 blue side? How many would have 2 blue sides? 3 blue sides? How many would have no blue sides? How would these numbers change if the cube was 6 x 6 x 6 and 7 x 7 x 7? Is there a pattern? If there is, can you predict the number of small painted cubes in a 50 x 50 x 50 or 100 x 100 x 100 cube?

MR. RON'S CARD GAME

Ron Lancaster, OISE



Begin with 4 playing cards, face down. There are only 3 rules and you must follow all the rules on each turn. Rule 1: You must always turn over a face-down card first. Rule 2: You must then turn over the card to the immediate right. Rule 3: If the card to the immediate right is face up, simply turn it down. This negates being able to turn over the card in position 4 because there is no card to the immediate right. What is the maximum number of moves you can do before the game ends (all cards facing up OR all cards facing up except the last card)? How does this number change depending on which card was turned over first? What if the game began with 5 cards? 10 cards? 100 cards? How could the maximum number of moves be determined and recorded?

Patterns in Art and Mathematics

The Visual Arts formed the basis for the 2016-2017 season of the Bridges Lecture Series: each of the three public lectures featured a mathematician and an artist. With an average attendance of 180 and an audience drawn from all walks of life, these lectures 'tricked' people who would typically never attend a math public lecture into learning some math, just as they hoodwinked a number of mathematicians into learning something non-mathematical. The Bridges Lecture Series takes place at St. Jerome's University in the University of Waterloo, and is sponsored by St. Jerome's University, The University of Waterloo Faculties of Arts, Mathematics, and Science, as well as the Fields Institute.

— Benoit Charbonneau, Paul Craig, and Alysia Kolentsis

by Malgosia Ip

"There is a strong connection between epiphanies in mathematics and epiphanies in religious experience."

In 1998, **Professor Matthew Scott** happened to pick up a copy of Scientific American, attracted by a story entitled "Japanese Temple Geometry".

The story described Sangaku, exquisitely illustrated geometric results drawn on wooden tablets and left as offerings in Shinto shrines and Buddhist temples in Japan. The results were typically presented without proof and people of all ages would flock to the temples to work on the problems.

Scott was hooked. He spent the summer working on Sangaku problems and they have been a hobby of his ever since. Almost twenty years later, he shared the story of the Sangaku tradition in his Bridges Lecture at the University of Waterloo.

Though it may seem odd to work on mathematical proofs in religious temples Scott says that there is a strong connection between epiphanies in mathematics and epiphanies in religious experience.

"If you work through a mathematical problem, there is a sort of enlightenment that doesn't occur if the answer is simply presented to you."

He compares it to the koan in the Japanese tradition of Zen Buddhism. A koan is a story, dialogue, question, or statement presented to a student by a Zen Master. It is meant to provoke thought and potentially lead to enlightenment, but you have to work through it yourself – no one can explain it to you. A koan can be as simple as, "what is the sound of one hand clapping?"

The Sangaku served a similar purpose. Each Sangaku tablet begins with a preamble explaining who wrote it and why they left it there. In many cases, the connection between mathematics and religious belief comes through.

Mathematics is the origin of everything in the universe… If visitors would look at my sangaku, then I would be very happy (Ogura Yoshisada, 1817)

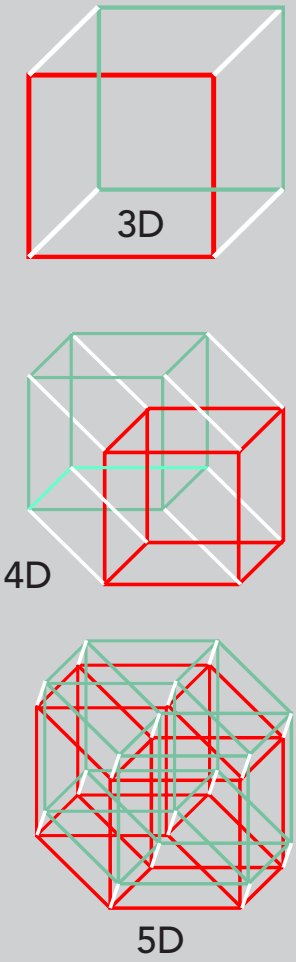
When I had questions, I visited and asked mathematician Ono Eijyu. I appreciate my master's teachings.

For his kindness I will hang a sangaku in this temple (Saito Kuninori, 1828).

The Sangaku were part of a larger phenomenon of recreational mathematics that developed during Japan's seclusion in the Edo period (1635-1838). With the end of the period came the end of the Sangaku tradition, though many of the problems remain unsolved. It is now up to enthusiasts like Scott to solve them. ❖

A PARADE OF PROJECTIONS

Carlo Séquin



> "From geometric exercise we get things that are more and more artistic"

Geometry has been in **Carlo Séquin's** blood since the 11th grade, when one of his assignments was to construct the lines of intersection between two cylinders.

This early assignment – to represent a mathematical concept as a tangible object – was the beginning of Séquin's fascination with, what he calls, artistic geometry.

In his Bridges lecture, Séquin explained how all five regular 3D polyhedra (such as the cube) can be constructed from 2D regular polygons (6 squares make up a cube). From 2D to 3D this is easily visualized, but what about in higher dimensions? Although geometric reasoning can show convincingly that there are exactly six regular polytopes (higher dimension equivalent of a polyhedron) in 4D that can be constructed from 3D polyhedra, you will understandably have a harder time picturing this.

To visualize 4D objects, we need to rely on wireframe projections—mapping every point from the edges of the 4D object onto a 3D space. The results are fantastical shapes that can look wildly different depending on what direction you look at them.

"From geometric exercise we get things that are more and more artistic," says Séquin.

But the connection between geometry and art goes both ways. One of Séquin's longest standing collaborations is with artist Brent Collins. With no mathematical training, Collins intuitively created art that captured the geometric concept of minimal surfaces, prompting Séquin to give him a call. Together, they have created many pieces whose loops and swirls make you feel like you're riding a geometric roller coaster.

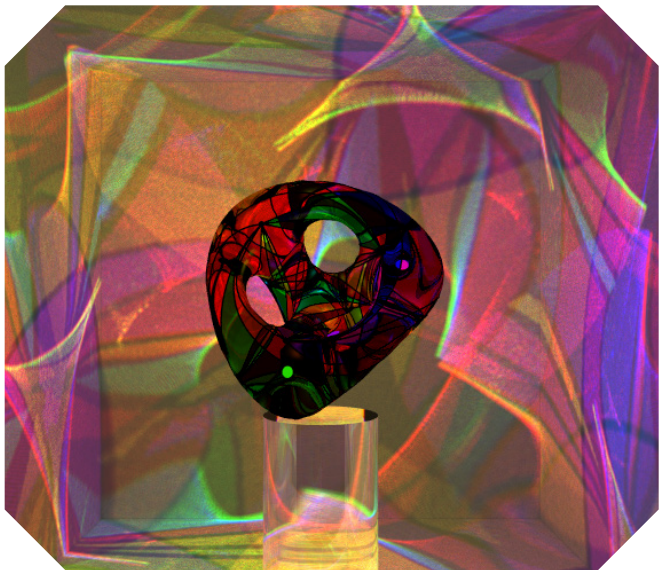
At this point, it's impossible to tell what came first—the geometry or the art? ❖

Hans Schepker's life has taken a lot of twists and turns since his formal training as an electrical engineer. When he moved to the US from Germany he worked as a tailor and remembers once dressing up a whole Scottish family in custom-made tartan clothes. For nine years he made kites, where his training as a tailor allowed him to sew curved surfaces using sail cloth – something not many people could do well at the time. He was also a baker for many years.

"I became quite famous as a kite maker," Schepker mused, "but it didn't make any money."

Regardless of profession, Schepker was always building things in his spare time – out of paper, fabric, beads.

"One day I decided to put a light bulb into a paper cube, but the result was disappointing – it was just a blob of light. "



Model of a genus-6 lamp

So he experimented with cutting shapes out of the paper first, sending tiny specs of light across the room. Still, Schepker was not satisfied.

“I didn’t know what I was looking for, but I knew I’d know it when I saw it.”

The real breakthrough came when, one day, Schepker decided to put a light bulb into a cube made of glass panes. The light streamed through with only the edges of the shape appearing as shadowy projections on the walls. This was what he was looking for.

Now Schepker makes lamps of all different shapes out of clear and coloured glass. His inspiration comes from anything and everything.

“I just discover some shape that interests me somehow,” explains Schepker.

That shape can be an origami sculpture by Tom Hull or the 600-cell that he is now working on. In his Bridges lecture, he talked about creating a genus-6 lamp that embodied the solution to a certain graph-embedding problem, though he still has to figure out how to make the curved glass pieces.

Now Schepker travels to many high-schools and middle schools, using his unique glass creations to teach geometry concepts, because for him, it’s not about the pretty colours, it’s about the shapes. ❖

When you look at the tiling patterns that cover the walls of the Alhambra in Spain, or raise your eyes to the intricate patterns on the ceiling of the Tomb of Hafez in Iran, you feel almost as though you are entering another dimension. The shapes seem to move and sway as your eyes shift in and out of focus.

“It’s a very prominent over the top kind of patterning that you don’t see in any other culture,” says **Soheila Esfahani**, artist and lecturer at the University of Waterloo.

Yet underlying their complexity, these patterns are composed of simple geometric shapes – just a few circles, squares, and strategically drawn lines.

“When geometry becomes visual, it becomes art,” says Esfahani. She is currently teaching a course on geometric patterns in Islamic art, which was also the topic of her Bridges Lecture.

Image after image, Esfahani broke down the complexity of the geometric patterns that adorn many buildings in Iran, showing how they can be drawn in a few simple steps using only a compass and ruler. Some, like arabesques, are patterns derived from foliage, while others are derived from groups of intersecting circles. The results are stunning configurations that capture the eye.

But Esfahani shares the view that the use of patterns rooted in geometry serves a much bigger purpose.

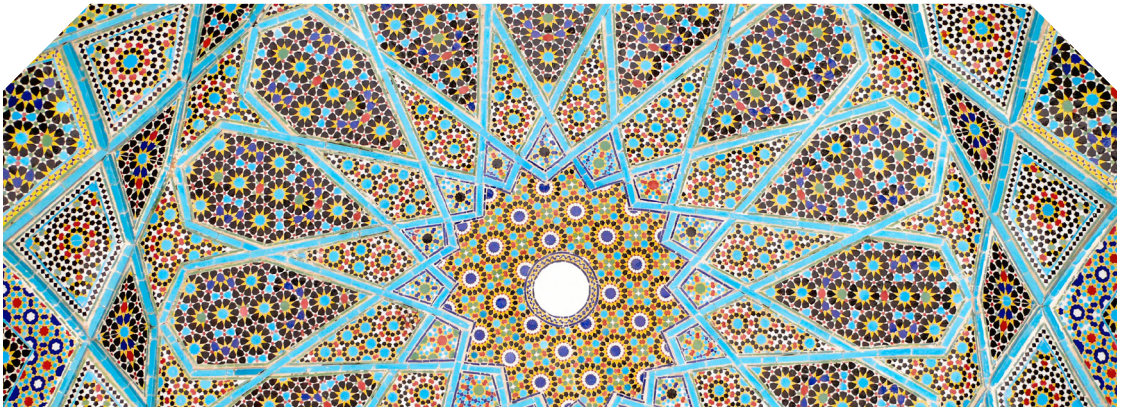
“This type of geometry becomes an intermediary, a passage to get to something else… it becomes a metaphor,” she explains.

Even though the patterns may be culturally specific, the geometry is abstract, allowing connection on another level. Esfahani quotes the well-known art historian and archaeologist, Oleg Grabar:

> “This type of geometry … becomes a metaphor.”

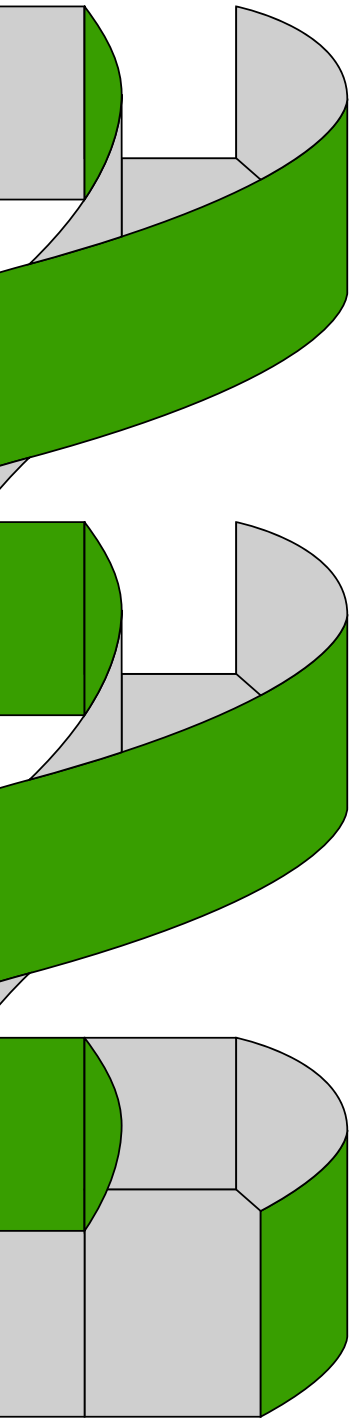
“Humble triangles on a dress or in the weaving of a basket or the very sophisticated brick walls in Iranian towers share an ability to make us wonder what they mean, because, like moths or butterflies, we are attracted to an abstraction which seems to be devoid of cultural specificity. It is only meant to be beautiful.”

Mathematics has often been called the universal language – pi is still the same number whether you’re in Iran or Canada. Geometry is a special case of this idea that captures the visual imagination. ❖



Tomb of Hafez roof

Excerpts



1 The Fields Institute is named after Canadian mathematician John Charles Fields (1863-1932).

2 Fields has a wall of postcards that we've received over the years from our international visitors.

3 The sculpture in front of the Fields building is called "Intuition"and represents Borromean rings.

4 The Fields Fellows program was started in 2002 for Fields 10th Anniversary. There are now 117 Fields Fellows.

5 Hanging from the Fields atrium ceiling is a 120-cell mobile, the 3D shadow of a 4D dodecahedron, created by Marc Pelletier in honour of H.S.M. Coxeter's 95th birthday.

THE
FIELDS INSTITUTE
TURNS **25**

Look for the rest of the "25 facts about Fields" scattered around this section.

The full e-book "The Fields Institute Turns Twenty-Five" is now available online.

From the Book

Where it all began

by W.F. Shadwick

THE FIELDS INSTITUTE WAS MY IDEA.

When this all began, I was an NSERC University Research Fellow, and an Associate Professor in the Pure Mathematics Department at the University of Waterloo. I had recently turned thirty-four.

I was about to spend the next six years leading a much more senior group of people on a journey with no roadmap and no indication that we could ever reach our destination. The outcome was an excellent illustration of George Bernard Shaw's dictum about progress—"the reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore, all progress depends upon the unreasonable man."

6 The Fields Institute officially opened in the summer of 1992.

This is a brief sketch of what I remember about the critical points in the creation of the Fields Institute and the pivotal contributions to it.

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7 The Fields Institute was originally located at the University of Waterloo.

In the winter of the 1985–86 academic year at a meeting of the University of Waterloo Mathematics Faculty Council, Waterloo's plans were announced for participation in a new program of research entitled the "Centres of Excellence," initiated and funded by the Province of Ontario.

No consideration had been given to mathematics as a potential area of research to be supported in this program. I thought this was especially odd given that Waterloo had the singular distinction of having an entire faculty devoted to mathematics and was home to several first rate mathematicians.

...

I quickly found a number of supporters for the idea of pressing Waterloo to back a proposal for a Centre of Excellence in Mathematics. As I recall, the ad hoc committee I recruited to apply this pressure consisted of Adrian Bondy, Grafton Hui, David Jackson, John Lawrence, and John Wainright. Aside from me, they were all senior professors, making this important committee difficult to ignore.

After a good deal of debate in the Mathematics Faculty, a meeting between my committee and Waterloo President Doug Wright was convened by the Dean of Mathematics. Wright agreed that the University would support an application for a Mathematics Centre of Excellence in the expected call for proposals for a second round of funding. ❖

Original Fields Institute group, 1992

What is the Connection between J.C. Fields and the Fields Institute?

by Elaine McKinnon Riehm

J.C. Fields

FOR MANY YEARS, I HAVE thought about the relationship between the Institute and its namesake, John Charles Fields. While doing research for *Turbulent Times in Mathematics: The Life of J.C. Fields and the History of the Fields Medal*, I came to know the man well. The connection between the man Fields and the Institute is that of a shared mathematical vision that spanned the twentieth century. The two are offset in time, however, by six decades: the Institute was established in 1992; Fields died in 1932.

But they are linked in geographical proximity—that of being in the same place at widely different times. During the thirty years when Fields taught mathematics at the University of Toronto, he always lived in rooms on streets that bordered the University: Huron Street, St. George, Sussex Avenue, all now subsumed by the University itself in its western expansion. For many years, Fields was active in the Royal Canadian Institute, then located in an old house at 198 College Street, just east of St. George, where he was responsible for creating a reading room modelled on one he knew as a graduate student in the 1880s at the Johns Hopkins University. Fields sat in the bay window there and watched the College streetcars trundle along, as they do past the Institute today. Fields' life in Toronto was bounded by Bloor St. on the north, College St. on the south, Spadina Ave. on the west, and Queen's Park on the east. His neighbourhood then was that of the Fields Institute now.

8 The idea to name the Institute after Fields came from Elaine McKinnon Riehm.

...

Notwithstanding the time warp between 1932 and 1992, John Charles Fields and the Fields Institute are a perfect fit philosophically. They share a fierce commitment to scientific research. When Fields was organizing the 1924 Toronto Congress, in the absence of scientists from Germany and its World War I allies, he had to drum up attendance. This he did by defining mathematics as broadly as possible and as inclusively as possible—including talks on actuarial science and statistics, forestry, astronomy, mechanics, ballistics, naval architecture, economics, radiotelegraphy, geophysics, aeronautics, mining engineering, and the aurora borealis, to mention only a few. His broad definition of pure and applied mathematics corresponds closely to the vision of the founders of the Fields Institute and of those who have followed the trail of mathematical research wherever it has led over the past quarter century. ❖

The Competition

by Robert Prichard

THE IDEA OF THE FIELDS INSTITUTE pre-dated my becoming President of the University of Toronto. It was strongly supported by the Department of Mathematics and the Faculty of Arts and Science. After being temporarily housed at the University of Waterloo, it was agreed that there would be a province-wide competition to settle the permanent location of the Institute and a competitive process was established. I believe Peter Nicholson chaired it.

9 In 1994, there was a competition among Ontario Universities to host the Fields Institute.

If there had never been a competition for the permanent location, it would have remained at Waterloo and done fine. But by holding a competition, the Board of the Fields Institute forced potential hosts to make their strongest possible bids. It was in this context that we decided to put our bid forward.

My useful contribution was to state an absolute determination that Toronto must win the competition and that we would

do whatever was necessary to do so. Mathematics (best symbolized by the extraordinary brilliance of Jim Arthur) was exceptionally strong, and I could not imagine our letting the Fields go anywhere else. I also saw it as symbol of our broader aspirations to assert the pre-eminence of the University of Toronto as Canada's leading research university.

…

Despite challenging budgetary times, knowing that the Fields had special external funding and that it would attract a constant stream of great scholars at no cost to the University, allocating resources was an easy call. I also saw it as attracting new resources as much as spending them.

…

We knew it was the right thing to do and history has judged us well. And that win inspired other wins as colleagues raised their sights and aimed for the stars. Simcoe Hall was judged as having been value added instead of a dead weight in the process and that helped reposition the administration as well. In the end, it turned out that winning Fields was an important turning point for the University and we have never looked back.

…

I remain enormously proud that the Fields Institute is on the University of Toronto campus and doing so well. ❖

10 The Fields Institute is supported by 9 Principal Sponsoring Universities from across Ontario.

11 The current Fields Institute building at 222 College St. was built specifically for the Institute as part of the University of Toronto's winning bid to host.

Early Days and Near Mishaps

by Bradd Hart

…

AFTER THE INSTITUTE MOVED to Toronto, one of Fields' strongest supporters and users was George Elliott. The joke was that when John Chadam showed up the first day the Institute opened, he found George conducting a seminar. George would often take matters into his own hands when he didn't think things were being done correctly. Feeling that it was a great oversight that the lecture room did not have a wooden pointer, he acquired a very long stick which stood for many years in the lecture room. On another occasion, the cleanliness of the Institute's backyard became an issue. At that time there was a small enclosed area immediately behind the Institute for its use. The garbage bins for the bookstore were unfortunately located immediately on the other side of the wall, and packing peanuts from the bins would blow onto the grass behind the Institute. George could not convince the University of Toronto cleaning staff to do anything about this and so one day he brought a vacuum cleaner from home, plugged it in on the back patio and proceeded to vacuum the back lawn.

The model theory program in 1996–97 was a smashing success that people in our field continue to remember to this day. Here is one representative remark that highlighted the vision of the Institute both literally and figuratively. A colleague from Paris, shortly after arriving said "this is fantastic—anything I want to know and anyone I want to talk with—I just walk out of my office and take a look around!"

I am sure that many people have said something about Andrew Wiles' lecture; let me add a couple of personal remarks. I attended with a group of people including a friend from the economics department, Karen. She was quite taken by the event and said it felt like a rock concert. I was just praying that this wouldn't set mathematics and the Fields Institute back twenty years! When Wiles began speaking, in Latin, for a good 45 seconds, I was sure all hope was lost. He then gave a comedic pause, and said "For those who don't speak Latin …" and he read Fermat's margin note. The rest was brilliant and brought the house down. Afterwards, at the reception at the Fields, most mathematicians were either too shy or too intimidated to talk with Wiles. I looked over and who was talking to Wiles? My friend Karen! She asked "How often do you get to talk with a rock star?"... ❖

12 The Fields back entrance is accessible via a bridge across a moat.

13 The Fields Institute houses Donald Coxeter's piano.

14 The Fields building was originally meant to have a domed library at its entrance with an oculus looking into the heavens, but this was scrapped due to budget constraints.

Thematic Institutes: The Particle Accelerators of Mathematics

by Tom Salisbury

KEN DAVIDSON AND BRADD HART recruited me to be Deputy Director of the Fields Institute in 2003. I served for a year under Ken and two years under Barbara Keyfitz, stepping down in 2006 prior to starting as Canadian Mathematical Society (CMS) President. I had spent time at Fields before, while on sabbatical leave in 1997–98 and as one of the organizers of the Probability thematic program in 1998–99. Since my time as Deputy Director, I have been involved in one of the Fields start-ups, the Quantitative Wealth Management Analytics Group (QWeMA), and I am currently back in a different role, as Associate Director for Industry Liaison.

15 To ensure unbiased representation, the Fields Institute Director changes every 3-5 years.

Three very successful thematic year-long programs ran while I was deputy director: on partial differential equations; string theory (jointly with the Perimeter Institute); and renormalization/holomorphic dynamics. Planning also took place for the two following years' programs. These thematic programs are the Institute's flagship activity, shining a bright light on a topic ripe for special attention, and providing an opportunity for a critical mass of researchers to move their field forward in a way that would not otherwise happen. Thematic institutes are the particle accelerators of mathematics, except that what we bring together and collide are mathematicians. They work because, unlike laboratory scientists, mathematicians are portable—they can work anywhere.

16 Fields call for program proposals is open to anyone anywhere in the world.

These programs are a transformative experience for the group of post-docs who attend them. I know during my own thematic program in probability, the network our post-docs established during their time at Fields had a major impact on their post-Fields careers. It is inspiring to see young researchers and post-docs eagerly working together at a blackboard long after the Institute has closed for the day! Bringing the world's leading researchers to Fields, where they interact with the Canadian research community, raises all our games. I know my own department has been able to achieve more, and to recruit outstanding people, because of the presence of the Fields Institute.

…

The following Fields story was told to me by Wendelin Werner. He and Greg Lawler were in an upstairs office at Fields, as participants at a 1999 conference (that year's Seminar on Stochastic Processes), when they received an e-mail from Oded Schramm sharing a construction of a new conformally invariant random process, now called SLE. Those who know this subject will recognize that this means there is an important Fields Institute chapter in the work that eventually led to Wendelin's 2006 Fields medal.

...

In addition to its flagship thematic and focus programs, the array of conferences and workshops it organizes as general scientific activity, and its support for mathematical education, the Fields Institute has a long-running program in commercial and industrial mathematics (CIM). I've worked on that program for the past year, as Associate Director for Industry Liaison, having taken this over from Huaxiong Huang when he became Deputy Director of the Institute.

The basic goal of this program is to stimulate useful conversations and interactions between academic researchers and practitioners from the private sector. Fields has successfully done this in the finance industry for years, in part because the many mathematicians working in that sector make those conversations quite natural. The CIM program's goal is to continue doing that, and to replicate this success in some of the other fields where mathematics can be applied.

…

We also try to develop relationships between firms and individual researchers. Sometimes these arise from the problem solving workshops mentioned above, where a workshop problem leads naturally to an ongoing research project or internship. Sometimes this develops internally, from one of the startup firms Fields incubates. In other cases, we have a conversation with an outside firm and then try to identify a researcher who might be able to help. With the other Institutes, we are attempting to do this on a national level through the website solutionscanada.com. We also work with Mitacs to expedite mathematically oriented internships.

It turns out that many firms can make use of mathematics, and many mathematicians are interested in doing some work with industry, or in exposing their students to internships. Fields is helping make these connections. ❖

17 The Fields Institute has a start-up program that has turned out successful names like Sigma Analysis & Management and R^2 Financial Technologies.

What a mathematics Institute looks like

by Alison Conway

LONG BEFORE I WENT TO WORK at the Fields Institute I had heard about a think tank in Toronto. My curiosity got the better of me and I slipped into Fields one day to see what a think tank might look like. In my mind I assumed I would see a glass-walled fish tank of some sort with people walking in circles, scratching their heads and thinking deeply. What I found of course was a beautiful, light-filled building, with natural wood finishes, a clerestory flooding light into the interior, and a wonderful transparency to the whole design. Many years later I understood that the purpose of the building had been understated as a think tank and ultimately Fields was designed for the two things that it has become known for — collaboration and communication.

The architects of the Institute, Kuwabara, Payne, McKenna and Blumberg (KPMB), were inspired by the power of mathematics and its creativity in their design. Within the rigidity of architecture they incorporated a juxtaposition of rhythm, using serendipitous forms with consistent proportions and order. From the cantilevered entry portico and the piano nobile of rusticated limestone, the Institute has a subdued almost austere appearance at street level. It is only when you have climbed up to the Institute's main floor that the structure slowly starts to reveal itself.

18 Fields was built for collaboration, with lots of spaces for spontaneous gatherings and 60+ blackboards.

...

The broad staircase at Fields is the essence of the building. There is something about it that encourages the opportunity to follow its full course from top to bottom and to take a moment to appreciate the view throughout the building. Conversations start on the stairs and carry on into research spaces. The staircase functions as a terrific lookout to scan the building for a lost colleague or to hear snippets of mathematical dialogue that might pique the interest of and draw the listener into the conversation. The staircase holds no hierarchy but allows researchers and students to flow through the building having conversations, making appointments, or sharing recent collaboration in the daily flow up and down.

19 The design of the Fields pallazo and its windows follows the golden ratio.

...

The Institute has more than fulfilled its purpose in terms of mathematical activity and research — yet to me this is not the complete measure of the building. The measure of the success of the Fields Institute as a building design lies also in its quiet moments. During the 15 years I had the pleasure of working at Fields, there was not a week that passed when I didn't see researchers showing a friend or family member around the building, describing where they worked and spent their days. As they toured the building the pride in their voices when speaking about Fields brought home to me how much the building had succeeded in its purpose. The Fields Institute is a world of its own, a welcoming place, a building shaped by mathematicians and in turn shaping them. ❖

The Fields Medal Symposium

by Ed Bierstone

THE FIELDS MEDAL SYMPOSIUM had its origin in an unsuccessful bid by the Fields Institute as one of three finalists (together with Instituto Nacional de Matemática Pura e Aplicada, Rio de Janeiro, and the Weierstrass Institute, Berlin) in a competition to house the permanent administrative offices of the International Mathematical Union. I presented the Fields bid to the General Assembly of the IMU, meeting in Bangalore in August 2010, just before the International Congress of Mathematicians in Hyderabad. A decision in favour of the Weierstrass Institute was made by a majority vote. The IMU Executive was very appreciative of all three bids. It also provided an opportunity to get the IMU to support the idea of the Fields Medal Symposium, which I felt would be scientifically of great interest to the Fields Institute and the mathematical world. IMU President Ingrid Daubechies and Secretary Martin Grötschel were both enthusiastic about the idea. The IMU endorsed the initiative as a way to raise public awareness of the Fields Medal and to increase its monetary value.

20 The Fields Institute does not award the Fields Medal (that's up to the International Mathematical Union) but it does host the winners each year during the Fields Medal Symposium.

The Fields Medal Symposium each year celebrates the discoveries of one of the recent Fields medallists. The Symposium includes an honorarium of $25,000 for the honoured medallist, still very modest by the standards of other top international awards.

To get the Fields Medal Symposium off the ground, I felt it was necessary to raise private sponsorship support for at least the first eight years in order to enable the Symposium to get established and attract more stable long-term support. We decided to recognize several levels of support. I was thrilled by the enthusiasm for the idea of the Symposium, and we succeeded in raising sponsorship support for the first ten years, including a Gold Level Sponsorship by the Great West Life, London Life, and Canada Life group, and a Silver Level Sponsorship by renowned text-book author James Stewart. Jim was a personal friend, as well as a friend and builder of the Fields Institute from its earliest days. The entire Fields community was deeply saddened by his premature death in December 2014; Jim left a very generous bequest to the Fields Institute which is an inspiration to those who share in his vision of the Institute's future.

The Fields Medal Symposium was conceived as a four-to-five-day annual event with several ambitious goals: to bring together researchers and help take the area of the honoured Fields medallist to the next level, to raise public awareness of mathematics and the Fields Medal, and to inspire the next generation. The scientific goals parallel those of John Charles Fields, who created the Medal not as a distinguished career award, but rather as a recognition of great breakthroughs, and to provide the encouragement and freedom needed to take on even greater challenges. The Symposium is meant to include public lectures and activities for high-school and undergraduate students involving the medallist. The aim is to inspire scientific activity in Canada by raising the awareness of Canada as the home of the Fields Medal.

The inaugural Fields Medal Symposium was held with great success in October 2012, as one of the highlights of the Institute's twentieth anniversary year, celebrated in 2012–13. Ngô Bau Châu was invited as the honoured Medallist for the inaugural Symposium, both because of the incredible impact of his achievements and also because of their Canadian connection. …

21 The first prototype bronze casting of the Fields Medal is housed in a safe at the Fields Institute.

The inaugural Fields Medal Symposium set the tone for the four that have already followed, honouring the remaining three 2010 Fields Medallists— Elon Lindenstrauss, Cédric Villani, and Stanislav Smirnov— and the first of the 2014 Medallists, Manjul Bhargava. Jim Stewart graciously hosted a banquet at his home, Integral House, each year, which became a highlight of the Symposium until his death.

…

I am pleased to say that planning for the sixth Fields Medal Symposium, on the work of Martin Hairer and its current and potential impact, is well underway. ❖

22 The Fields Institute was tasked with revamping the grade 12 math curriculum in partnership with the Ontario Ministry of Education in 2006.

23 The Fields Undergraduate Summer Research Program has been running for 8 years. This year, we have 33 students participating.

Math as a magical subject

by John Mighton

WHEN I WAS A CHILD I read a story about two children who (somehow) used a Möbius strip to travel in time. Because I had spent a good deal of my childhood reading stories of this sort, I remember thinking that it might actually be possible to do that kind of thing with a Möbius strip. I thought of math as a magical subject that could give anyone who was lucky enough to understand its subtleties the power to manipulate space and time and to penetrate the deepest mysteries of the universe. At school, however, I often found those subtleties hard to understand, and, after I almost failed first year calculus at university, I decided I would have to give up on my dream of becoming a mathematician. I did not develop the confidence I needed to return to math at the University of Toronto until I was thirty-three.

24 Andrew Wiles gave a lecture for one of the Fields Institute programs in the spring of 1995, shortly after his proof of Fermat's last theorem.

In 1995, when I was in the fifth year of my program, the Fields Institute opened on the campus of the university, and I started attending lectures there regularly. It is hard to describe how lucky I felt to have the opportunity to hear some of the greatest minds in mathematics share their thoughts on the very mysteries that I had dreamt of learning about as a child.

...

I knew that all of these new ideas—that were being discussed with very little fanfare in the lecture hall of the Fields—would not only shape the course of mathematics but would also eventually find applications in nearly every sphere of science and technology. And I knew that most of these applications would be almost unimaginably different from the applications for which the ideas were first conceived.

...

Over the past twenty years I have had the opportunity to teach math to thousands of children. I have seen many children cheer for math or beg to stay in from recess to do math. I believe that every child is born with the same sense of wonder and curiosity about math that I felt when I was a child. But the majority of people gradually lose their interest in math and even develop a deep aversion to the subject because they struggled too much at school.

25 The Fields Institute supports many events bridging mathematics and the arts such as the ArtSci Salon seminar series and the Bridges Lecture series.

While I was doing my post-doctoral work at the Fields, I got to know Bradd Hart, who was the Deputy Director of the Institute and who also had a passionate interest in education. I told Bradd about a charity I had recently founded to help students learn math. At the time, JUMP Math was a small tutoring club that I was running in several schools (and my apartment) with a handful of volunteers. Bradd saw the potential of the program and offered to incubate JUMP by giving us free office space and technical support. Since then, JUMP has trained hundreds of parents and teachers at the Fields and has held many talks and conferences on the site. The program now reaches over 150,000 students in Canada and is expanding in the United States, Europe, and South America.

It is hard to imagine what my life would have been like if I had not had the support of the Fields Institute in my research and my charitable work. ❖

List of contributors

David Andrews
James Arthur
Edward Bierstone
John Chadam
Alison Conway
Derek G. Corneil
Walter Craig
Donald Dawson
Ron Dembo
George Elliott
Sheila Embleton
George Gadanidis
John R. Gardner
Steve Halperin
Ian Hambleton
Bradd Hart
Barbara Lee Keyfitz
Peter Lancaster
William Langford
John Mighton
Moshe A. Milevsky
Eric Muller
Thomas Payne
J. Robert Prichard
Carl Riehm
Elaine McKinnon Riehm
Tom Salisbury
William F. Shadwick
Sivabal Sivaloganathan
Victor Snaith
Mary E. Thompson
Matt Valeriote

Insights Into Human Survival

Barbara Keyfitz, was just seven years old the day her father, Nathan Keyfitz, now a renowned demographer, got his PhD. Yet even at that age, Keyfitz was quite sure his daughter was a mathematical genius.

“She knew from the start that mathematics was the most difficult subject in the curriculum and so it was the one she wanted. She never deviated from that path,” Keyfitz said of Barbara in his memoirs.

In 1970, Barbara obtained her own PhD in mathematics from New York University and in 2004, she became the first female Director of the Fields Institute.

“When his little girl became the Director of an international mathematics institute, [my father] couldn’t conceal his pleasure and pride,” says Barbara.

So Nathan Keyfitz and his wife Beatrice decided to start an endowment to fund a public lecture series on the intersection between mathematics and the social sciences, a natural reflection of both of the worlds their family lived in. The Fields Institute didn’t really have any public lectures at the time, and the idea of bringing mathematics to non-mathematicians and broadening the scope of the mathematical sciences was appealing.

Ten years later, the Keyfitz lecture continues to bring together mathematics and the social sciences, with prestigious speakers from all over the world.

This year, **Dr. Noreen Goldman** from Princeton University spoke about her “Insights Into Human Survival”. The lecture was attended by a sell-out crowd of 130 people that included mathematicians, students, professionals, and interested citizens.

Goldman, who was Nathan Keyfitz’s graduate student at Harvard, spoke about interesting “Keyfitz-inspired” problems in demographics that she had encountered and worked on over the years. From demographic dating of a remote atoll in the South Pacific (though it is actually 3° north of the equator, as was pointed out by Goldman’s future husband), to the abnormally low life expectancy for unmarried men in 1940s Japan (18 years lower than married men), to whether a photograph of your face is a good predictor of life expectancy (it is).

“She put a lot of herself into the presentation,” said Barbara. “She presented studies and problems in the order that she had worked on them, which was quite clever.”

Goldman’s stories highlight how statistical tools and simple mathematical models can be used to understand complex populations and address important societal problems. They also generated many questions and led to several lively discussions between mathematicians and non-mathematicians at the reception following — undoubtedly one of Nathan Keyfitz’s goals in establishing the series. ❖

— Malgosia Ip

Ian Hambleton, Noreen Goldman, Barbara Keyfitz

Fields Annual General Meeting

The Fields Annual General Meeting is a chance for all members, stakeholders, and University representatives to give their feedback on the past year and suggest improvements for the year ahead. This year, the meeting took place on a beautiful, sunny Thursday, June 29. Highlights of this year's event included a preview of the next thematic program on Geometric Analysis from organizer Spiro Karigiannis, a special screening of the documentary "Integral Man" about Canadian mathematician and acclaimed textbook author James Stewart, a Q&A with the film's director and one of the architects that built Stewart's famous house, and a lovely reception at the Faculty Club.

> "[Fields] is the hub of a thriving, ever-evolving academic community, and a wonderful partner."

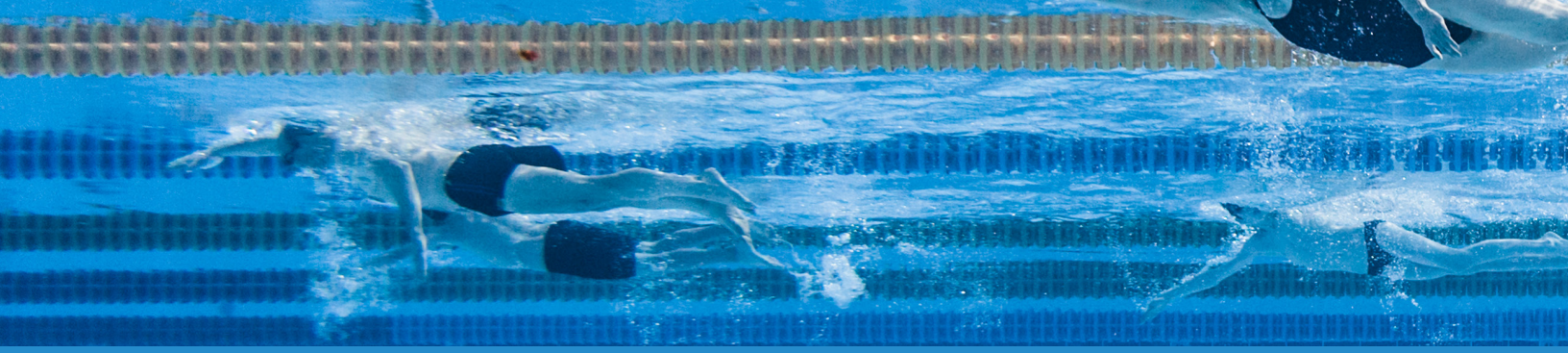
The reception began with opening remarks from the President of the University of Toronto, **Meric Gertler**, who described the Institute's "important role as a part of U of T's extended community." Gertler noted the "breadth and extent of [Fields] collaboration and outreach" which is responsible for "generating world-class research, connecting students and scholars from around the world, collaborating with industry and entrepreneurs, and more."

The reception also honoured the newly elected 2017 Fields Fellows and featured a talk from new Board member **Cindy Forbes** of Manulife Financial. Forbes spoke about the role mathematics plays in her position as Chief Analytics Officer at Manulife, from qualification for life insurance, to client retention, to fraud detection. She likes to think of her work as "people plus machine", allowing both people and machines to focus on what they're good at. ❖

Meric Gertler

Lisa Baiton, Cindy Forbes, Bill Janeway, Ian Hambleton

Donna Kotsopoulos, Gila Hanna



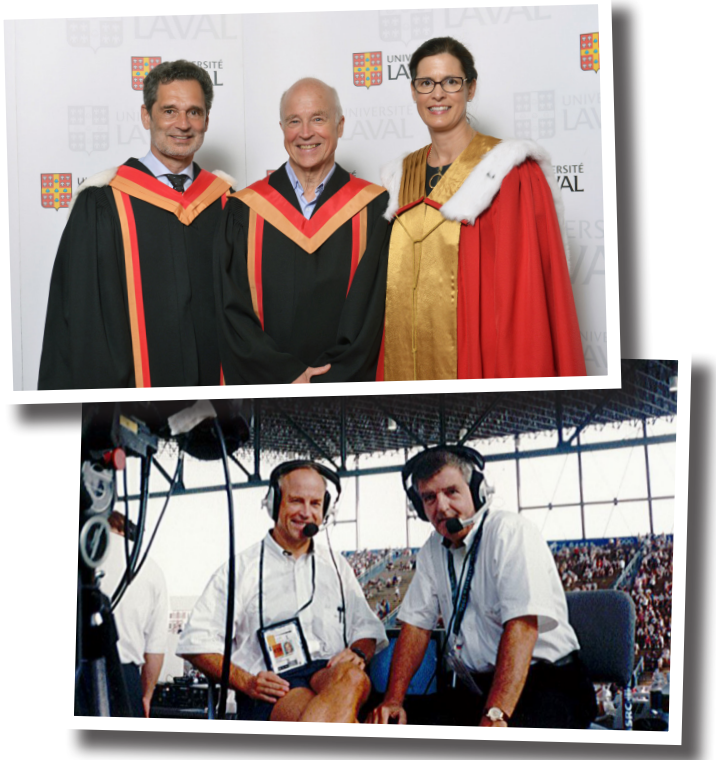
The Human Part of the

with Jean-Marie De Koninck

Professor Jean-Marie De Koninck was nine years old when he decided to become a mathematician. He still remembers his fifth grade math teacher excitedly writing equations on the board. Her passion was infectious, and Professor De Koninck has spent much of his career transmitting that same passion to the next generation. De Koninck received the 2016 Margaret Sinclair Memorial Award Recognizing Innovation and Excellence in Mathematics Education for his accomplishments.

De Koninck's award lecture at the Fields Institute began with the question: "Are we good at math?" He was referring not to any individuals, but to the human race as a whole.

André Darveau, Jean-Marie De Koninck, Sophie Damours



Jean-Marie De Koninck and Pierre Dufault at the 1996 Olympic Games in Atlanta

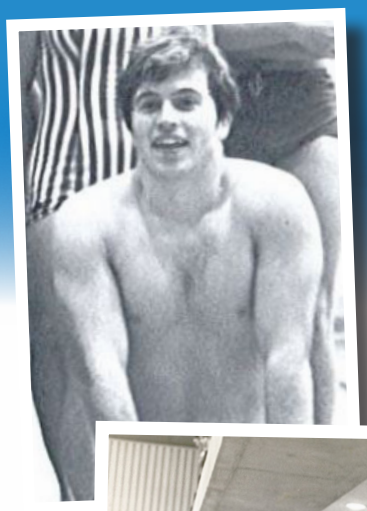
The answer, he went on to say, is yes. From the day they are born, babies have an intuitive number sense, but as we age, many of us lose confidence in our mathematical ability and consequently, lose interest in mathematics. De Koninck believes this is at least partially because mathematics education lacks humanity—we hear about theories and learn rigorous proofs, but we never see the people and the hard work that underlies them. His lecture, entitled "The Human Part of the Equation", focused on some of these mathematicians and their stories.

"The role of the teacher has changed," explains De Koninck in an interview with me shortly before his lecture. "The teacher used to be the one with the knowledge and he would pass that knowledge on to the students, but with the advent of the internet, knowledge is everywhere, so the role of the teacher is more as a guide and motivator, a coach."

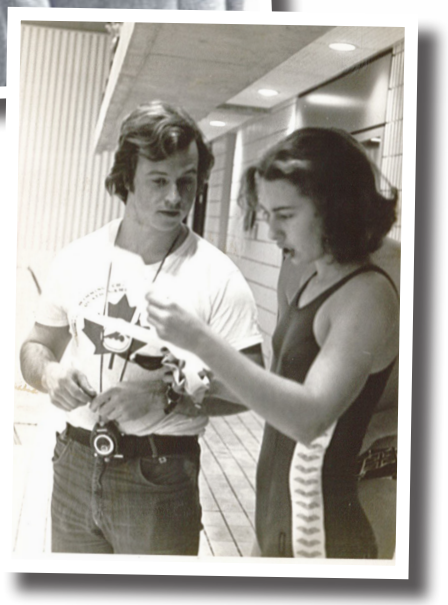
The coaching analogy comes easily to De Koninck who has been coaching swim teams for almost as long as he has been teaching math. In 1984, De Koninck was growing tired of seeing his best swimmers leave for US schools that offered hefty scholarships. He and his team started fundraising using all the usual methods—selling chocolate bars, washing cars—but it was a lot of effort for a relatively small sum of money. One day, he was in his car when he heard a shocking statistic: 50% of fatal motor vehicle accidents were due to drinking and driving.

"I couldn't believe the number was that high," he says. "People were leaving the bars at 3 am and they didn't want to leave their cars behind. So I thought 'I have 55 swimmers, I'll offer to drive people home in their own cars over Christmas time.'" He called it "Operation Red Nose."

Equation



De Koninck at 19 years old



De Koninck coaching swimming

The idea was an instant hit, attracting major sponsors and raising $25,000 in its first year. Now there are operations in over 100 Canadian cities raising over $1.3 million every year for youth programs and sports teams.

De Koninck's forays into math outreach started with interviews on mathematics related subjects for several television and radio networks.

Math outreach is different from math education, De Koninck says.

"In math education, you have the people in the room already; for math outreach, they're not there yet. You have to go get them. There's a lot of people that never hear about mathematics because they never get the right messenger."

For many, the right messenger was De Koninck himself. In 1999, he was giving a talk about prime numbers at Cegep (a publicly funded pre-university college in the province of Quebec's education system), when he was noticed by a television crew who were looking for someone to host a new popular mathematics show called "C'est mathématique!" De Koninck initially refused, but was urged by his colleagues to change his mind.

The show ran for two seasons on the Z Network and was later purchased by the TFO Network (Télévision française de l'Ontario/Ontario French Television) where they continue to be aired each Fall. College professors would call De Koninck asking for copies of the tapes.

"This was really the starting point. I noticed that I could do outreach and it made an impact."

In 2005, De Koninck started the Science and Mathematics in Action (SMAC) project, which he has directed ever since. Its mission is to arouse and reinforce the interest of young people for mathematics and demystify mathematics for the population at large. SMAC activities include Show Math, an educational show about mathematics aimed at the general public, and MathAmaze/Math en jeu, a free online mathematical game developed in collaboration with Mitacs. In the game, you move through a maze by answering math questions that are tailored in difficulty according to your level.

"The kids are in front of their computers all the time now, so let's go where they are," he explains.

Reaching the younger generations is a priority for De Koninck and his passion for math is evident in every answer he gives.

"We need [their] brightness and energy to solve tomorrow's problems and when you're very passionate you do influence behaviour." ❖

— Malgosia Ip

Spotlight

SIGMA ANALYSIS AND MANAGEMENT

David Rudd and Luis Seco

THE SIGMA ANALYSIS & MANAGEMENT offices located on the 11th floor of the new MaRS tower are beautiful. I wait for **Luis Seco**, one of Sigma's founders, in a light-filled, glass-walled room, and think how pleasant it would be to work in this large open space with expansive views of Queen's Park. But like most companies, Sigma began modestly, boasting only three employees when they opened their doors at the Fields Institute in 1999. This year, we celebrate the 10th anniversary of Sigma's "graduation" from Fields' start-up program.

It was Luis Seco who, in 1999, suggested that Fields incubate his fledgling company. Don Dawson, the current Director of the Fields Institute, and Deputy Director Bradd Hart were looking for ways to fulfill Fields technology transfer mandate, and Seco thought that this would fit the bill. At the next Board of Directors meeting, two decisions were made — Fields would begin an incubation program and Sigma Analysis would be its first company.

"It was the perfect way to start a company that had no clear market definition, that was still in the world of ideas," said Seco.

Along with his cofounder, David Rudd, and one employee, they set up shop in the building at 222 College Street, where they began using portfolio optimization theory and other mathematical tools to change the investment world.

In those early years, Fields provided the credibility that Sigma needed to gain clients, but also helped gauge which clients were worthwhile.

"Fields was a very good reflection of our company DNA — we were mathematicians. Clients saw that, and they either liked it or they didn't."

Within three years, Sigma became commercially interesting and expanded rapidly. They organized events at the Institute, including a wildly popular lecture from Economics Nobel Prize winner **Myron Scholes** that forced the Institute to close its doors to avoid breaking fire regulations.

"People were hanging from the ceiling," laughs Seco.

By 2007, the company had grown so successful that Fields could no longer hold them, but Seco continues to value their mathematical origins.

"Mathematics is part of our culture. It allows us to do things that other people find difficult, to create technology and infrastructure that are challenging for other companies. Our employees are people who are not scared of equations, who are not scared of mathematical structures."

Despite his busy life balancing roles as the CEO of Sigma Analysis, Professor at the University of Toronto, Director of the U of T Mathematical Finance Program, Director of the U of T RiskLab, and of course, husband and father, Seco still finds time to participate in Fields events every few months.

"Fields gave us something that money cannot buy." ❖

— Malgosia Ip

@FieldsInstitute

Our favourite tweets from the last four months

When we posted an April Fool's joke, saying mathematicians admitted pi was exactly 3.15

> Physicists be like "I knew that all along"
>
> - Claudio Contardo, @claud10contardo

When we announced our biggest Fields Undergraduate Summer Research Program (FUSRP) ever

> i did the fusrp back in 2011. it was a great experience - glad to see it still happening!
>
> - Cam DP, @Cmrn_DP

From participants in our Spring School on Statistical Inference for Survey Data with Missing Observations

> Learning lots at the @fieldsinstitute spring school on missing data! @compass_UW
>
> - Mahmood Gohari, @mahmudgohar

Our Machine Learning Seminar with the Vector Institute is super popular.

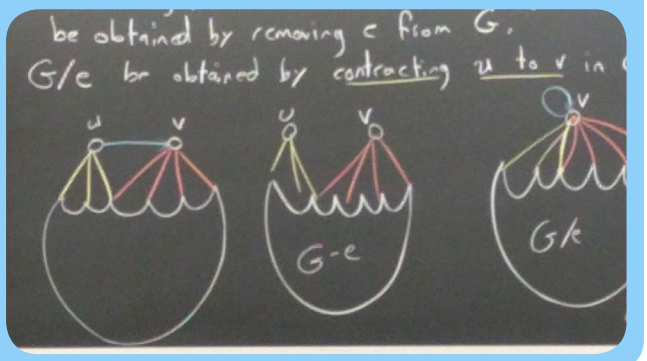
> i'm @fieldsinstitute for topic models talk by prof. david blei - excited :)
>
> - Dr. Zoe Kats, @zoe_kats

From one of the participants in the Winter 2017 Workshop on Algebraic Varieties, Hodge Theory and Motives

> not sure what my fave thing abt @ fieldsinstitute is, the spiral staircase or the cowbell that ends breaks
>
> - Adriana Salerno, @mathyadriana

Some interesting diagrams at our Summer School on Random Graphs and Probabilistic Methods

> Have a sudden craving for eggs. Don't know why.
>
> - Johanna Stromberg, @aajohannas



When we tweeted a random "Algebra Fact" of the day

> @fieldsinstitute "I have a wonderful proof of this fact but the tweet is too small to contain it." @fermat2017 :D
>
> - Jacqui Ramagge, @jacquivelli

When our Commercial and Industrial Mathematics Program hosted an AR/VR networking event

> Had a great time at @fieldsinstitute AR/VR event!
>
> - WebMoti, @web_moti

When we added a 9th Principal Sponsoring University

> Amazing news! @Ryerson Becomes fields' principal sponsoring university
>
> - Anthony Bonato, @Anthony_Bonato

Back pages

Call for proposals, nominations, and applications

THEMATIC AND FOCUS PROGRAMS

The Fields Institute solicits proposals for a variety of programs in areas of current research interest in the mathematical sciences: (1) Major thematic programs, four-six months in length. (2) Thematic or focus programs, from one to two months in length to run concurrently with our major thematic programs; in particular, two-month summer programs of an interdisciplinary nature. Proposals or letters of intent should be submitted by March 15 or September 15, with a lead time of at least two years recommended for six-month programs.

GENERAL SCIENTIFIC ACTIVITIES

Proposals for short scientific events in the mathematical sciences should be submitted by October 15, February 15, or June 15 of each year, with a lead time of at least one year recommended. Activities supported include workshops, conferences, seminars, and summer schools.

OUTREACH PROPOSALS

The Fields Institute provides support for projects whose goal is to promote mathematical culture at all levels and bring mathematics to a wider audience. Faculty at Fields sponsoring universities or affiliates are invited to submit a proposal to the Fields Outreach Competition. There are two submission deadlines each year, October 15 and February 15. Proposals should include a detailed description of the proposed activity and the target audience. A budget indicating other sources of support is also required.

FIELDS INSTITUTE FELLOWS

To nominate someone as a Fields Fellow, please send a CV plus a letter briefly outlining why your candidate is a worthy nominee, to proposals@fields.utoronto.ca, or to:

The Director
Fields Institute
222 College Street, Second Floor
Toronto, Ontario M5T 3J1, Canada

Winners of the CRM-Fields-PIMS prize are automatically recommended for fellowship. No member of the current Fields Institute Board of Directors nor any continuing member of the Fields Institute Scientific Advisory Panel will be eligible. Nominations are encouraged from all qualified individuals, including women, members of visible minorities, and persons with disabilities.

THE DEAN'S DISTINGUISHED VISITING PROFESSORSHIP

The Dean's Distinguished Visiting Professorship is a joint program of the Fields Institute with the Faculty of Arts and Science, and the Department of Mathematics of the University of Toronto. Each year, the program brings a leading international researcher in the mathematical sciences to give a full-term course connected to a Fields Institute program, for graduate and advanced undergraduate students of the University of Toronto and other students participating in the program.

The Professorship currently provides a stipend of $50,000, and is selected by a committee representing the Fields Institute and the Department of Mathematics. Nominations can be made either to the Director of the Institute or to the Chair of the Department of Mathematics.

THE MARGARET SINCLAIR MEMORIAL

The Margaret Sinclair Memorial Award recognizes an educator in Canada who has demonstrated innovation and excellence in promoting mathematics education at the elementary, secondary, college or university level. This annual award is administered by the Fields Institute and comprises a $5,000 prize and inscription of the winner's name on a plaque at the Fields Institute recognizing the recipients.

Candidates for the award may nominate themselves or be nominated by others.

A complete nomination packages consists of:

1. A nomination letter of no more than 1000 words demonstrating alignment with The Margaret Sinclair Memorial Award
2. A recent curriculum vitae
3. Three (3) letters from arm's length referees

Nominations for the 2018 Margaret Sinclair Memorial Award must be received electronically by the Fields Institute by December 1, 2017. Send to deputydirector@fields.utoronto.ca

Please note that nominations for the Margaret Sinclair Award will be kept under consideration for two additional years following the initial submission.

POSTDOCTORAL FELLOWSHIPS

The Fields Institute's Postdoctoral Fellowships provide for a period of research activity at the Institute and participation in our programs. We are currently soliciting applications for Fields Postdoctoral Fellowships and Jerrold E. Marsden Postdoctoral Fellowships. Qualified candidates who will have a recent PhD (normally awarded not more than five years before tenure of the Fellowship) are encouraged to apply.

FIELDS RESEARCH FELLOWSHIP

This fellowship provides an opportunity for a period of full-time "Research in Residence" at the Fields Institute. Faculty members at our Principal Sponsoring Universities are invited to apply (e.g. for a period during a research leave from their own university), or to nominate a mathematical scientist for the purpose of collaborative research.

Fellowship holders will be provided with office space, access to all Fields facilities and activities, and an allowance for living expenses up to $3,500 for each month of full-time residence. The minimum length of residence is 1 month, and the maximum length normally 3 months. Note that faculty living in the GTA are not eligible to hold the fellowship, but may nominate external candidates for the award.

Selection of successful candidates will be made by the Directors of the Institute, in consultation with the Scientific Advisory Panel.

All application materials should be sent by e-mail to director@fields.utoronto.ca at least 3 months prior to the proposed start date. The annual application deadlines are September 15, January 15 and May 15.

FIELDS-PERIMETER AFRICA POSTDOCTORAL FELLOWSHIP

The Fields Institute for Research in Mathematical Sciences and Perimeter Institute for Theoretical Physics are inviting applications from African Nationals for a one-year Joint Postdoctoral Fellowship.

The deadline for applications to the 2018 Fields-Perimeter Africa Postdoctoral Fellowship will be November 15, 2017.

Applications are accepted through Mathjobs: www.mathjobs.org/jobs/jobs/5691

FIELDS INCUBATOR PROPOSALS

In 1999, Fields began a program to foster start-up companies that commercialize mathematical ideas and that can benefit from the expertise at the Fields Institute. Companies are approved by the Fields Board on recommendation by the Industrial Advisory Board. The goal of the program is to enable members of the Fields community to start business ventures by giving them access to the physical, intellectual, and logistical resources of the Institute. Examples of successful Fields start-ups are Sigma Analysis and Management and R^2 Financial Technologies.

More information about this program can be obtained by contacting the Director at director@fields.utoronto.ca.

WANT TO SEE YOUR NAME IN PRINT?

Do you have a great math story to tell? Are you excited about your math research? FieldsNotes accepts contributions on a volunteer basis. Send your pitches to communications@fields.utoronto.ca.

BECOME A SUPPORTER OF THE FIELDS INSTITUTE

Mathematics provides a deep and powerful way of thinking about the world, yet it is not a static, finished subject. There are still many questions and great intellectual challenges remaining, and you can be part of the discovery.

With your support, the Fields Institute can create a more supportive, inclusive, diverse, and stimulating environment for research in the mathematical sciences. When you support Fields, you become part of the equation.

Donations are tax-deductible. For more information, please visit http://www.fields.utoronto.ca/about/fundraising or contact development@fields.utoronto.ca.

2017 FIELDS MEDAL SYMPOSIUM

FEATURING
MARTIN HAIRER

TORONTO

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