IN THIS ISSUE
DANS CE NUMÉRO

CMS
Canadian Mathematical Society
Société mathématique du Canada

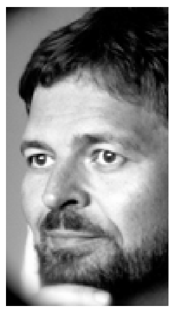
CMS NOTES de la SMC

September/ septembre 2015

Vice-President's Notes / Notes du Vice-président

Florin Diacu, *University of Victoria, Vice-President Pacific / Université de Victoria, Vice-Président Pacifique*

Can we predict financial trends?



Friends and acquaintances have often asked me whether the stock market can be predicted. In many people's view, trained mathematicians should be able to figure out how the financial world functions and, perhaps, make good profits out of it. My usual answer, that the stock market is chaotic, therefore difficult to forecast, and we care more about our abstract problems than about money, was obviously disappointing. So a few years ago, when I became interested in mathematical models that help us predict extreme events, I also started investigating stock market crashes and learned more about the research area that deals with them.

Are there ways to understand future trends of the stock exchange in spite of the unpredictable daily fluctuations of share prices? Many experts have asked this question, but only few have so far made some light into this matter. Since the variations of the market depend on people's choices, it is natural to try to quantify the psychological aspects of how decisions are made. Game problems are as old as history and can be found in ancient texts, like the Talmud, but the foundations of game theory were laid less than a century ago. In 1928, John von Neumann published an article entitled "Zur Theorie der Gesellschaftsspiele" (On the Theory of Social Games), followed by a book with Oskar Morgenstern, *Theory of Games and Economic Behavior*. Soon, other mathematicians brought new contributions,

Continued on page 4

Pouvons-nous prédire les tendances financières ?

Des amis et connaissances m'ont souvent demandé si les marchés boursiers peuvent être prédits. Pour beaucoup de personnes, des mathématiciens compétents devraient être capables de comprendre comment fonctionne le monde boursier et y faire de bons profits. Ma réponse habituelle - que les marchés financiers sont chaotiques, donc difficiles à prédire et que nous sommes plus intéressés par des problèmes abstraits plutôt que l'argent - était manifestement décevante. C'est pourquoi, quelques années plus tôt, lorsque je commençais à m'intéresser aux modèles mathématiques nous aidant à prévoir les événements extrêmes, j'en profita aussi pour étudier les krachs boursiers et en apprendre plus sur les aires de recherches traitant de cette question.

Pouvons-nous comprendre les tendances futures des marchés malgré les fluctuations quotidiennes imprévisibles des cours des actions ? Beaucoup d'experts se sont penchés sur la question mais peu d'entre eux ont trouvé des éclaircissement à ce sujet jusqu'à maintenant. Étant donné que les variations du marché dépendent de choix humains, il est naturel d'essayer de quantifier le poids que tient l'aspect psychologique dans les prises de décisions. Les problèmes basés sur les jeux sont aussi vieux que le monde et peuvent se retrouver dans d'anciens écrits, tel que le Talmud, bien que les fondations de la Théorie des Jeux aient seulement été bâties depuis moins d'un siècle. En 1928, John von Neumann publia un article appelé « Zur Theorie der Gesellschaftsspiele » (De la

Suite à la page 10

CMS Notes
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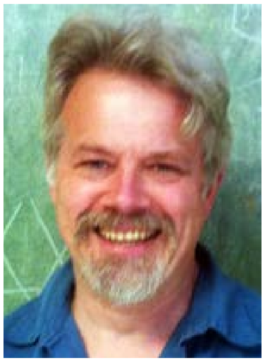
In Adversity

Robert Dawson, *Saint Mary's University, Halifax*



This year the Abel Prize was awarded to John F. Nash Jr of Princeton University and Louis Nirenberg of the Courant Institute of Mathematical Sciences, New York University, for "striking and seminal contributions to the theory of nonlinear PDF and its applications to geometric analysis." This prize, according to the press release, "recognizes contributions of extraordinary depth and influence to mathematical sciences." Tragically, Nash and his wife Alicia were killed in a traffic accident, when the taxi they were taking to their home from the airport lost control.

Nash did not have an easy life. He was known for his brilliant work in pure and applied mathematics. His brief doctoral thesis, a mere 28 pages long, introduced the concept of Nash equilibrium in non-cooperative game theory and earned him a Nobel prize in economics – completely different work than that which won him the Abel prize! However, he was equally well known as "The Phantom of Fine Hall," a silent figure who drifted through the corridors of Princeton, during his lengthy battle with paranoid schizophrenia. A battle that he eventually won and returned successfully to research and teaching. (This was described accurately in Sylvia Nasar's book *A Beautiful Mind*, and in a rather more fanciful and sanitized form in the film of the same name.)

Some mathematicians are fortunate enough to live and work with comparatively few obstacles. Others, like Nash, face – and sometimes overcome – barriers that many might think insuperable. Isaac Newton seems to have suffered from a range of physical and mental problems; his alchemical studies were in his day hardly a sign of more than eccentricity, but may have contributed to major problems via heavy-metal poisoning. Pascal similarly suffered from poor health for most of his life, and died young.

The great Euler was blind in one eye from comparatively early years. Around the age of sixty, still productive, he lost sight in the other eye to a cataract. However, due to a phenomenal memory – it is said that he could recite the entire Aenid without a text – he was able to continue his research. Using secretaries to transcribe his words, he remained productive until his death 17 years later. More recently, Bernard Morin, who lost his sight as a young child, has done amazing work in geometry: he worked with Shapiro and Smale to show that a sphere could be everted in R^3, and he found a parametrization of Boy's surface.

Clearly, great mathematical work can be done under the most challenging circumstances. In Nash's case, it is true that in the depths of his illness he was completely unable to work; but his return to active research will stand as an inspiration.

Dans l'adversité

Robert Dawson, *Université Sainte-Marie de Halifax*

Cette année, le prix Abel a été décerné à John F. Nash Jr de l'Université Princeton et Louis Nirenberg du Courant Institute of Mathematical Sciences de l'Université de New York, pour des « contributions fondamentales et exceptionnelles à la théorie des équations aux dérivées partielles et ses applications à l'analyse géométrique ». Ce prix, selon le communiqué de presse, « reconnaît des contributions de grande portée et d'influence aux sciences mathématiques ». Tragiquement, Nash et sa femme, Alicia, sont décédés dans un accident de la route, quand un taxi, qui les ramenait chez eux de l'aéroport, a perdu le contrôle.

Nash n'a pas eu une vie facile. Il était reconnu pour son travail brillant en mathématiques pures et appliquées. Sa brève thèse de doctorat, de seulement 28 pages, introduisit le concept de l'équilibre de Nash dans la théorie des jeux non-coopératifs, qui lui valut un prix Nobel d'économie ; un travail complètement différent que celui qui lui fit obtenir le prix Abel ! Néanmoins, il était aussi reconnu comme étant le « Fantôme de Fine Hall », une silhouette silencieuse qui errait dans les corridors de Princeton, durant ses longues luttes contre la schizophrénie paranoïaque. Il gagna finalement cette bataille pour revenir avec succès à la recherche et l'enseignement (cette bataille fut décrite avec précision dans le livre de Sylvia Nasar: *Un Cerveau d'Exception* et d'une manière plus romancée et aseptisée dans le film *Un Homme d'Exception*).time machine

Certains mathématiciens sont suffisamment chanceux pour vivre et travailler avec comparativement peu d'obstacles. D'autres, tels que Nash, font face – et parfois dépassent – des barrières que certains peuvent imaginer comme étant insurmontables. Isaac Newton semblait avoir souffert d'un large spectre de problèmes mentaux et physiques ; ses études alchimiques n'étaient perçues dans son temps que comme une certaine excentricité, bien qu'elle aient pu contribuer à ses problèmes majeurs, notamment à cause d'empoisonnements aux métaux lourds. Pascal souffra aussi pour la majeure partie de sa vie d'une santé très affaiblie et mourut jeune.

Le grand Euler perdit l'usage d'un oeil à un âge comparativement bien jeune. Vers l'âge de soixante ans, encore alors productif, il perdit la vue de l'autre oeil à cause d'une cataracte. Néanmoins, grâce à une mémoire phénoménale, – on dit qu'il pouvait réciter l'Énéide par cœur – il fut capable de poursuivre ses recherches. Faisant usage de secrétaires afin de retranscrire ses mots, il continua de travailler pendant plus de 17 ans. Plus récemment, Bernard Morin, qui perdit la vue étant jeune enfant, effectua un travail remarquable en géométrie : il travailla avec Shapiro et Smale afin de démontrer qu'une sphère pouvait être retournée dans R^3 et permit la première paramétrisation de la Surface de Boy.

Il est clair que de grands travaux mathématiques peuvent être effectués malgré des circonstances parmi les plus exigeantes. Dans le cas de Nash, il est vrai que lorsque sa maladie fut à son summum, il était dans l'incapacité totale de travailler, néanmoins, son retour actif à ses recherches resteront une inspiration.

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Letters to the Editors

The Editors of the NOTES welcome letters in English or French on any subject of mathematical interest but reserve the right to condense them. Those accepted for publication will appear in the language of submission. Readers may reach us at the Executive Office or at **notes-letters@cms.math.ca**

Lettres aux Rédacteurs

Les rédacteurs des NOTES acceptent les lettres en français ou en anglais portant sur n'importe quel sujet d'intérêt mathématique, mais ils se réservent le droit de les comprimer. Les lettres acceptées paraîtront dans la langue soumise. Les lecteurs peuvent nous joindre au bureau administratif de la SMC ou à l'adresse suivante : **notes-lettres@smc.math.ca**.

NOTES DE LA SMC

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Note aux auteurs : indiquer la section choisie pour votre article et le faire parvenir au Notes de la SMC à l'adresse postale ou de courriel ci-dessous.

Les Notes de la SMC, les rédacteurs et la SMC ne peuvent être tenus responsables des opinions exprimées par les auteurs.

CMS NOTES

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some of which showed that people make decisions according to certain rules. The Nash equilibrium (named after John Nash), which occurs in a game when players find no incentives to change their strategy after learning the opponents' choices, is well known today even outside mathematics. But from here to predicting the stock market was still a long way to go.

A myth has circulated for a long time in the scientific community about the prediction skills of Claude Shannon, the founder of information theory, who gained high returns at the stock exchange in the 1970s, comparable to –if not better than –those of top investment firms. In truth, Shannon's strategy was far from spectacular. He had no magic formula to get rich. Like all investors, he was more interested in his own portfolio than in the global mechanisms of the market. However, he understood a crucial fact, which belongs today to the basics of investment strategies: ignore the noise of daily fluctuations in stock prices and focus on the long-term potential of a company. This idea spread, and economists embraced it in the following years. It was a small step in the right direction.

One of those who succeeded to find some natural indicators for future market trends was Robert Shiller of Yale University. In the year 2000, just before the Dow Jones peaked, he published a book entitled *Irrational Exuberance*, where he predicted that the market was likely to collapse soon. The crash came within days.

The main idea behind his prediction was to consider the price-earnings ratio of shares at the New York Stock Exchange, adjusted to inflation, between 1881 and 2000. The spikes he found, such as those of 1901 and 1929, corresponded to crashes followed by economic downturn. The year 2000 showed an abrupt increase of this indicator at a height never reached before. He concluded that this was a bubble, which could burst anytime soon. Unfortunately, he was right. The Dow Jones Industrial Average plunged and needed more than a decade to reach the level of March 2000. For this and many other contributions towards the understanding of the stock market, Shiller was awarded the Nobel Memorial Prize in Economic Sciences in 2013.

Didier Sornette, a former UCLA professor who now holds the Chair of Entrepreneurial Risks at ETH in Zurich, adopted an approach based on the theory of complex systems. In his book, *Why Stock Markets Crash*, he explains his methodology, which earned him a few remarkable successes. One of them, for instance, was related to an *antibubble*, a term he defined to mean a low in the market when stocks are undervalued, so that prices can only go up. The analysis he performed together with one of his postdoctoral fellows, Anders Johansen, revealed antibubble patterns in Japan. In January 1999, they published a paper in which they predicted a 50 percent increase of the Nikkei index by December. This forecast was very much against the conclusions of financial analysts, who thought that the Japanese economy would continue to stay depressed and the stock market would remain steady. By the end of 1999, the Nikkei index rose 49 per cent.

Another prediction Sornette made was related to the Standard and Poor's 500 Index. In September 2002, he wrote that this indicator would keep going up for the next few months, but would then descend by about 20 per cent during the first semester of 2004. In fact, the index reached a high of 924 in September, went down to 768 in October, and, after a slight increase in the following months, it hit another low of 788 in March 2003. During the following 12 months, the index rose slightly on average, to level at about 1,100 in March 2004. Although this prediction was not accurate, Sornette had captured the general trend of the market. Still, this example shows how difficult it is to understand the subtleties of the financial world, even when using sophisticated mathematical tools.

So the answer to the question in the title is: we have made good progress in unraveling market dynamics, but we are still far from understanding all the details.

Nevertheless, like in any field where mathematics applies, our methods and approaches have a good chance to bring new insights in the future.

Note : The author adapted this article from Chapter 7, "Economic Breakdown", of his book *Megadisasters: The Science of Predicting the Next Catastrophe*, Princeton University Press and Oxford University Press, 2010, which received the "Best Academic Book Award" in 2011.

Calendar Notes brings current and upcoming domestic and select international mathematical sciences and education events to the attention of the CMS readership. Comments, suggestions, and submissions are welcome.

Johan Rudnick, *Canadian Mathematical Society, (director@cms.math.ca)*

Le calendrier des événements announce aux lecteurs de la SMC les activités en cours et à venir, sur la scène pancanadienne et internationale, dans les domaines des mathématiques et de l'enseignement des mathématiques. Vos commentaires, suggestions et propositions sont le bienvenue.

Johan Rudnick, *Société mathématique du Canada (directeur@smc.math.ca)*

SEPTEMBER 2015 SEPTEMBRE

Aug31-4 CRM **Conference on Topology, Geometry and Dynamics in Honour of François Lalonde**, Montreal, Que.

10 CRM **Lecture by Kai Behrend, 2015 CRM-Fields-PIMS Prize Recipient**, CRM, Montreal, Que.

14-16 CRM **Workshop: AdS/CFT and quantum gravity**, Montreal, Que.

14-21 FIELDS **Workshop on Symbolic Combinatorics and Computational Differential Algebra**, The Fields Institute, Toronto, Ont.

24-26 PIMS **Conference on the Mathematics of Sea Ice**, Simon Fraser University, Harbour Centre Campus, Vancouver, B.C.

28-30 FIELDS **International Conference on Analysis, Applications and Computations**, The Fields Institute, Toronto, Ont.

OCTOBER 2015 OCTOBRE

2-4 FIELDS **5th International Conference on Mathematical Modeling and Analysis of Populations in Biological Systems (ICMA-V)** University of Western Ontario, London, Ont.

5-6 FIELDS **Industrial-Academic Workshop on Optimization in Finance and Risk Management**, The Fields Institute, Toronto, Ont.

10-11 CRM 2015 **Montreal-Toronto Workshop in Number Theory**, CRM, Montreal, Que.

12-14 **SIAM Conference on Geometric and Physical Modeling (GDSPM15)** Salt Lake City, Utah

16-17 CRM **59e Congrès de l'AMQ**, Montreal, Que.

19-22 **FIELDS Medal Symposium**, The Fields Institute, Toronto, Ont.

19-23 CRM **Workshop: Applications of AdS/CFT to QCD and condensed matter physics**, CRM, Montreal, Que.

19-23 CRM **GRASTA 2015 - 7th Workshop on GRAph Searching, Theory and Applications & 5th workshop on Moving and Computing (MAC)**, CRM, Montreal, Que.

21 **Panorama of Mathematics: A Conference of the Hausdorff Center**, Bonn, Germany

23 **PIMS/UBC Distinguished Colloquium: Yakov Sinai**, University of British Columbia, Vancouver, B.C.

25-26 CRM-CANSSI **Workshop on Statistical inference for complex surveys with missing observations**, CRM, Montreal, Que.

26-31 FIELDS **Workshop on Linear Computer Algebra and Symbolic-Numeric Computation**, The Fields Institute, Toronto, Ont.

NOVEMBER 2015 NOVEMBRE

1-6 BIRS **Women in Geometry** Banff, Alta.

22-27 **BIRS First Nations Math Education** Banff, Alta.

DECEMBER 2015 DÉCEMBRE

4-7 **CMS Winter Meeting**, McGill University, Montreal, Que.

7-10 SIAM **Conference on Analysis of Partial Differential Equations**, Scottsville, Arizona

7-11 **39th Australasian Conference on Combinatorial Math & Combinatorial Computing**, Brisbane, Australia

7-16 FIELDS **Workshop on Algebra, Geometry and Proofs in Symbolic Computation**, The Fields Institute, Toronto, Ont.

14-18 **Geometric & Categorical Representation Theory**, Mooloolaba, Queensland, Australia

JANUARY 2016 JANVIER

6-9 **AMS/MAA Joint Mathematics Meeting**, Washington State Convention Centre, Seattle, WA

9-13 CRM **Workshop: Moduli spaces, integrable systems, and topological recursions**, Montreal, Que.

10-15 BIRS **Creative Writing in Mathematics and Mathematical Sciences**, Banff, Alta.

10-16 BIRS **19th Conference on Quantum Information Processing**, Banff, Alta.

31-Feb 5 CANSSI **Mathematical and Statistical Challenges in Neuroimaging Data Analysis**, BIRS, Banff, Alta.

Book Review Notes brings interesting mathematical sciences and education publications drawn from across the entire spectrum of mathematics to the attention of the CMS readership. Comments, suggestions, and submissions are welcome.

Karl Dilcher, *Dalhousie University (notes-reviews@cms.math.ca)*

Les critiques litéraires présent aux lecteurs de la SMC des ouvrages intéressants sur les mathématiques et l'enseignement des mathématiques dans un large éventail de domaines et sous-domaines. Vos commentaires, suggestions et propositions sont le bienvenue.

Karl Dilcher, *Dalhousie University (notes-critiques@smc.math.ca)*

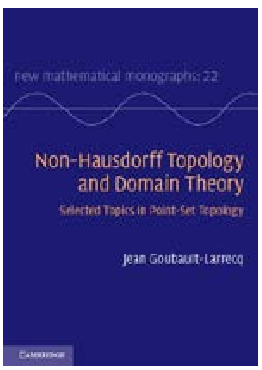
Non-Hausdorff Topology and Domain Theory: Selected Topics in Point-Set Topology

by Jean Goubault-Larrecq

Cambridge University Press, 2013

ISBN: 978-1-107-03413-6

*Reviewed by **Gino Tironi**, University of Trieste*



Jean Goubault-Larrecq has written a book on the interplay between general set-theoretic topology and domain theory. Chapters from 2 to 4 are dedicated mainly to topology and contain essentially all the set theory and the topology that a mathematician should know. Starting with Chapter 5, introduction to domain theory becomes the more important subject, but topology is not forgotten. Indeed the author suggests that domain theory could be thought of as *topology done right*.

Chapter 1 presents the plan of the book.

Chapter 2 is dedicated to set theory, which is axiomatized according to the von Neumann-Gödel-Bernays system.

Chapter 3 on metric spaces, and

Chapter 4, in its first part, provide a thorough review of material that should be familiar from a graduate course in Topology.

Up to this moment all spaces are Hausdorff. However, as the author writes, nonHausdorff spaces are important already in algebraic geometry and crucial in fields like domain theory.

Then the deep connection between topology and order is studied, by introducing the notion of *specialization quasi-ordering*. The author now introduces the Alexandroff, Scott and upper topologies. A *dcpo* is any partially ordered set X that is directed-complete. A first introduction to Category Theory is given with the notions of *category, functor, limit and colimit.*

Chapter 5, dedicated to approximation and function spaces, starts with the definition of the way-below or approximation relation. Unfortunately, the definition contains a misprint. Given a poset $(X, \leq)$ and two elements of it, x is way-below $y(x \ll y)$), if for every directed family of elements z_i that have a least upper bound z above y, there is an $i \in I$ such that $x \leq z_i$ (not $y \leq z_i$).

Let $[X \to Y]$ denote the set of continuous maps $f : X \to Y$; giving this an appropriate topology yields the concept of a function space. A number of important topologies for *function spaces* are introduced and studied, notably exponential topologies, core-open topologies, the pointwise-convergence topology, the compact-open topology, and others. A second account of the Category Theory is given, and the notions of exponential objects, adjoints and of Cartesian-closed category (CCC) are presented.

Chapter 6 is dedicated to metrics, quasi-metrics and hemi-metrics. Various results are presented, including the important result that every separable quasi-metric space embeds topologically into the *directed Hilbert cube*. The Stone-Čech compactification is also briefly discussed.

Chapter 7 is about completeness. Various kinds of completeness are described in the realm of hemi-metric spaces: Smith, Yoneda, Choquet, and their properties and relationships between them are discussed in detail. The chapter closes with a characterization of *Polish space* and a look at the continuous and ω-continuous models.

Chapter 8 concerns *sober spaces*. A topological space X is *sober* if it is T_0 and every irreducible closed subset of X is the closure of a unique point. It is proved that for every complete lattice $L, pt(L)$ is sober. Hausdorff spaces, in particular metric spaces, continuous dcpos with the Scott topology and Smyth-complete quasi-metric spaces are sober. For every space X the *sobrification* of $X, S(X)$, is the set of all irreducible closed subsets of X, with the *Vietoris topology*. A topological space is coherent if given two compact saturated subsets Q_1 and Q_2, their intersection is compact.

Chapter 9 is on *stably compact* and *compact pospaces*: a topological space is stably compact if it is sober, locally compact, compact and coherent. Again, many results are given.

The book is self-contained. You can find in it all the proofs of the stated theorems and a great number of exercises and examples, sometimes with important hints. There are some misprints, that usually are easily detected, but, in my opinion, this is an excellent book for consultation that every researcher in topology should have in his bookcase.

Education Notes brings mathematical and educational ideas forth to the CMS readership in a manner that promotes discussion of relevant topics including research, activities, and noteworthy news items. Comments, suggestions, and submissions are welcome.

Jennifer Hyndman, *University of Northern British Columbia (hyndman@unbc.ca)*
John McLoughlin, *University of New Brunswick (johngm@unb.ca)*

Les articles sur l'éducation présente des sujets mathématiques et des articles sur l'éducation aux lecteurs de la SMC dans un format qui favorise les discussions sur différents thèmes, dont la recherche, les activités et des nouvelles d'intérêt. Vos commentaires, suggestions et propositions sont le bienvenue.

Jennifer Hyndman, *University of Northern British Columbia (hyndman@unbc.ca)*
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Mathematical outreach offers examples of bridging mathematics and education in various contexts. This issue of Education Notes brings experiences of students to the forefront of this discussion. The contributors (Jean Bowen, Svenja Huntemann, Marie B.Langlois, Ben Cameron and Lucas Mol) are graduate students in mathematics.

Looking ahead the co-editors would like to publish more stories of (graduate) students engaged in teaching, outreach, research, or other initiatives pertinent to the readership of this feature. Please encourage students to share ideas here and/or contact us to develop seeds for stories worth sharing with the CMS community. Your stories of collaborating on such efforts with students would also be appreciated, especially if it is practical to share the authorship.

Math Play Outreach Sessions

Jean Bowen, *University of Northern British Columbia, bowenj@unbc.ca*

So far in 2015, as a Master's in Mathematics student at the UNBC, I have been fortunate to participate in three forms of outreach events and am currently planning for another in 2016. The outreach this year varied in audience and location but had two main similarities; all the sessions involved *Math Play*, and all sessions were facilitated by volunteers. *Math Play* is math based games and activities that ensure success, avoid criticism and emphasize maximum engagement. To meet these objectives I compiled a collection of both boxed games and paper and pencil or plastic chip games. I chose a combination of these types of games to allow parents and children to purchase the games and play them at home, and to allow teachers to easily bring the games into the classroom.

The list of games and activities is long, and many would be hard to find based on name alone. The list includes but is not limited to: *Hidato, Tri-Hex, Neighbours, Guess the Number, Rectangles, Towers* (a floor version over 5 feet by 5 feet), *Suspend, Q-Bitz, Qwirkle, Tri-hexaflexagons, Tantrix, Unit Origami, Set* (https://cms.math.ca/notes/v45/n2/Notesv45n2.pdf) and *Blink*. Not all games/activities were used in all the outreach sessions. Several of the paper games were selected from an extensive collection of math games found in a Dropbox started by Susan Milner, an Associate Professor at the University of the Fraser Valley. Some of these are discussed in (http://cms.math.ca/notes/v45/n5/Notesv45n5.pdf). Susan has since created a website containing many of the games (http://susansmathgames.ca/). Several of the games and activities that I selected are part of the afterschool daycare program that I have run for the past 8 years. The math focus in my program gave me a jumping off point for the outreach I started in 2015.

Discovery Centre was the first location, beyond my care facility, at which *Math Play* was introduced. This was a UNBC hosted event for people of all ages. It took place during the 2015 Canada Winter Games running for two weeks from 10 am to 6 pm. During this time over 2600 people walked through the doors to take part in excitingly educational activities and presentations of which *Math Play* was a part. The other UNBC volunteers and I had a great two weeks of sharing our areas of passion. Hands on exhibit tables introduced topics such as Math, Chemistry, Health Sciences, Life Sciences, Physics, First Nations Foundations of UNBC, Northern BC Weather, Computer Science, and Robotics, as well as exhibitors from outside UNBC (http://www.unbc.ca/events/34473/unbc-discovery-centre). Math took up two tables and a large section of the floor. One of the math tables was dedicated to *Unit Origami*. The other math table had a variety of games. The floor in front of the tables was home to *Towers*, large foam blocks, *Duplo* and *Mega Blocks*. Each day we saw some new and some familiar faces, young and not so young, come through the doors to experience subjects in a new way.

The second set of outreach events was part of my graduate research. Starting in March 2015 and stretching over a five week period, I supervised

14 UNBC MATH 190 students (Math for Elementary Education) in 6 classrooms doing *Math Play* for one hour a week. The classes included grade 2 and 3 students. Two to four MATH 190 students facilitated 3 games/activities each session allowing for approximately 20 minutes per activity. The classroom teacher was there for classroom management but did not run the sessions. Most of the sessions started with the entire class working on a paper and pencil activity. The facilitators took turns leading the first activity each week. The class was then split into two groups. Each facilitator was responsible for introducing a second activity to half the class and after about 20 minutes the groups of students switched activities. The students worked on their own, in pairs or in small groups depending on the activity. Each session presented a new collection of games/activities. We were always greeted with smiles and enthusiasm.

Beginning in mid-May 2015 I started facilitating *Math Play* sessions in 6 new classrooms. These *Math Play* sessions were similar to those facilitated by the MATH 190 students except I was the facilitator with the support of the classroom teacher. The sessions involved grade 2 to 4 students. There were five sessions, each 45 minutes to an hour long. I did not need to keep all of the sessions as consistent across classes this time, so the number of games we played varied. Often the children were so engaged with the first two activities that we did not even get to the third.

The third opportunity I had to do outreach this year was drop-in *Math Play* sessions. There were two of these. First I brought *Math Play* to a grade 8 classroom. During the one-hour session we played four games, floor size *Towers*, *Q-Bitz*, *Blink* and *Tantrix*. These games were selected because I thought they would be of particular interest to a more mature audience. The second drop in session was with a group of children from age 3 and up who are homeschooled. We had a two-hour session involving several games.

Next year Dr. Jennifer Hyndman, Chair of Mathematics at UNBC, Vivian Fayowski, Academic Success Centre Coordinator at UNBC and I hope to expand the outreach opportunities with a grant for experiential learning from UNBC. The grant will be used to facilitate bringing as many volunteers as we can into classrooms for *Math Play* sessions. The volunteers will be from the 2016 MATH 190 class. The limitations for the number of classes we visit will be based on the number of students who enroll in the Math 190 class.

When planning for next year's *Math Play* sessions I will definitely include three games that stood out this year: *Blink, Q-Bitz* and *Suspend.* I have seen these games played by younger children alongside more mature players. All three of these games develop with the player. This makes them excellent for groups with differing abilities.

For me being able to share math in an unintimidating way with a wide variety of people has been fulfilling and rewarding. Watching the level of interest and the smiles, listening to the laughter and the questions and feeling the enthusiasm in the room cannot be described adequately.

What is *NS Math Circles*?

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Nova Scotia Math Circles is an outreach program running out of Dalhousie University and funded by Eastlink. Our outreach is twofold: monthly events and classroom presentations.

The monthly events (September - June) are interactive presentations given by faculty and graduate students. The topics are directed at the upper high school level. These events attract 30 to 50 enthusiastic junior and senior high (and the occasional elementary school) students, teachers, and parents for a 2 hour period at the math department. Presence from the graduate student community involved with *Math Circles* is usually evident. The evening is broken up into a short warm-up activity or introduction to the topic, a pizza supper, and subsequently about another hour of activities. The presenter chooses the topic of personal interest usually based on a nice problem encountered previously or a historical element of mathematics. Some of the topics from this past year are Pythagorean Triples, Math & Art, Fibonacci numbers & mathemagic, historical use of logarithms, combinatorial game theory, probability puzzles, and sum-free partitions. Results are rarely just presented to the audience, but rather everyone gets to try their hand at several small examples, and maybe even try and generalize.

Problem solving and small group activities are commonly integrated into the evening. As an example, when I talked about combinatorial games and their outcome classes (whether player A or player B wins, or whoever goes first or second), I had everyone play the game *Domineering*. In particular, I would put up two positions (whose individual outcome classes we determined earlier), and have them figure out the outcome class for the sum of the two. Finally, everyone had the chance to think about whether or not this result holds in general (and find a reason), e.g. whether or not a player A win plus a first player win is always a player A win. Other examples of hands-on activities include finding Pythagorean triples, drawing art based on modular arithmetic, and using logarithmic tables to find approximate solutions to multiplication problems.

Our classroom visits take us all across the province into grade 4-12 classrooms. This past year (the 2014-2015 school year), we have worked with over 3500 students on general skills such as problem solving, as well as curriculum material. Topics for classroom visits are chosen by the teachers. We have a list of prepared talks available on our website together with appropriate grade levels. We will also make suggestions if a teacher is looking for particular focus topics. Occasionally, we will even create a new talk if a specific topic is not yet covered. Most of our school presentations are also very hands-on (i.e. a lot of experimenting and trying examples for the students), but are length-wise adjusted to fit the period, so usually around an hour. For these presentations we are also working with the entire class, rather than just providing enrichment for students interested in math. It is very encouraging to hear from teachers that students normally struggling in class were very engaged during our visit.

Our presenters for the school visits are mostly trained on the job. Rather than going out with just a second person (as they will later on), when they first start they will head out with two experienced presenters. These veterans will lead the bulk of the activities, and slowly let the trainee take over until they are confident working with students. If a presenter is supposed to give a presentation they have not done before, but have had training, we will go through the content of the talk in advance, including some tips on how to lead certain activities. Additionally, all of our presentations are completely annotated with solutions and notes, giving a back up in the rare case that a presenter forgets a detail.

What might be most surprising about *Math Circles* is that it is almost entirely student run. The program director (and assistant director as of next year) are PhD students at Dal, and the presentation team consists of approximately 10-15 graduate and undergraduate students at various levels of their studies. Oversight and support is provided by a faculty advisor (Richard Nowakowski), with additional help offered by office staff.

Our current funding from Eastlink ($500,000 over 5 years) covers salaries for the program directors, teaching assistants, and presenters; all travel costs (rental cars, accommodation, meals); pizza for the monthly events; and materials. We are very grateful for this support since without it the program would not be able to run. If you would like to learn more about *Math Circles*, visit our website at www.nsmathcircles.ca

What are some advantages to working with *NS Math Circles* for graduate students?

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As graduate students at Dalhousie, working with *Nova Scotia Math Circles* gives us the opportunity to work with grade school level students and present fun math, either at their school or at the math department. There are many ways that graduate students can benefit from giving math outreach presentations. Several techniques and approaches used in the outreach setting often transfer very well to the undergraduate setting. As most graduate students will end up teaching at the university level while obtaining degrees and many of us aspire to become educators after graduating, giving presentations at the grade school level is an excellent way to get teaching experience. The grade school classroom is a far less intimidating environment than a university lecture hall, where many will teach their first class.

Giving *Math Circles* presentations requires adapting to the age and background of the students. Being able to think on your feet when you are asked a question or need to explain a background concept is necessary in order to deliver a good presentation. This is a skill that takes time and practice to develop, and is useful at all levels. Since *Math Circles* presentations often involve a lot of student-teacher interaction, these settings offer opportunities to learn how to adapt one's teaching style to different individuals. Learning how to explain a concept in many ways is valuable in teaching.

Graduate students learn the value of working in groups through mathematical outreach activities. Firstly, *Math Circles* is an opportunity to work with other graduate students and see how they interact with students. As graduate students we can learn a lot from one another. In addition, we encourage the students attending our presentations to work in groups, and this works well for several reasons. The students can be given more difficult problems as they can reach conclusions together that they may not have been able to achieve on their own. When the students work through difficult problems, they reach a deeper understanding of the material. We can easily transfer this practice to small undergraduate classes by allowing the students to work in small groups on assignments or in-class activities.

We try to make *Math Circles* presentations engaging and fun, and we can do this for our undergraduate classes as well. A typical undergraduate math class often starts with a mathematical theory or technique being explained by the teacher, followed by several example problems that are solved using the mathematical tools presented earlier in the lecture. We never start *Math Circles* presentations by explaining a mathematical theory and applying it to various problems. Instead, we start by posing a problem and we allow students to think deeply about how to solve it. They are often able to develop a mathematical technique for solving the problem themselves, and through this effort they now understand the mathematical idea in greater depth. This technique of teaching mathematics through problem solving can be used as a motivator in higher-level math courses.

For graduate students, math outreach is a great opportunity to develop our teaching and presentation skills in a more relaxed environment than the front of a university classroom. Giving the presentations with other graduate students also takes some of the pressure off of being the sole person of attention. Through the outreach we learn to think on our feet, explain concepts concisely and clearly, and make math fun. Along with developing our teaching skills, it is also very rewarding to see young minds genuinely interested and excited by new mathematical ideas. We immediately notice the benefits of the teaching practice, but ultimately we hope that the presentations inspire some of the kids to continue their studies in mathematics after high school. Perhaps some will even return to their old schools and do some math outreach of their own.

Postscript: I, John McLoughlin, have been fortunate to be involved with *Math Circles* for several years. On numerous occasions I have given evening presentations and done classroom visits. Svenja coordinated a teaching workshop offered by me this spring for graduate students at Dalhousie. Marie, Ben, and Lucas were among the participants, and it is a credit to them and *Math Circles* the commitment made to professional development with respect to teaching and presentations. In addition, I spent time with Svenja, Ben and Marie this winter discussing ideas for activities in elementary (middle) school classrooms, as *Math Circles* continues to extend beyond its original secondary school focus. *Math Circles* at Dalhousie was introduced to this readership in 2010 by Angela Siegel, the director at the time. See https://cms.math.ca/notes/v42/n6/Notesv42n6.pdf. Danielle Cox succeeded Angela in the role up to 2014, when Svenja Huntemann assumed the directorship. Involvement with *Math Circles* has been central to my engagement as an Adjunct Faculty at Dalhousie.

Théorie des Jeux Sociaux), suivi d'un livre avec Oskar Morgenstern : « *Theory of Games and Economic Behavior* » (Théorie des Jeux et des Comportements Économiques). D'autres mathématiciens apportèrent rapidement d'autres contributions, dont certaines démontrent que les personnes prennent des décisions en suivant certaines règles. L'équilibre de Nash (nommé d'après John Nash) - surgissant dans un jeu lorsque des joueurs ne trouvent pas d'avantage à changer leur stratégie même après avoir appris les choix de leurs adversaires - est désormais bien connu même en dehors des mathématiques. Même en partant de cette base, la prédiction des marchés financiers avait encore un long chemin à parcourir.

Un mythe a circulé pendant longtemps dans la communauté scientifique à propos des aptitudes de prédiction de Claude Shannon, le fondateur de la Théorie de l'information qui a eu d'excellents gains en bourse dans les années 1970, comparables à – s'ils ne sont pas meilleurs que – ceux des meilleurs firmes d'investissements. En vérité, la stratégie de Shannon était loin d'être spectaculaire. Il n'avait aucune formule magique pour devenir riche. Comme tous les investisseurs, il était plus intéressé par son propre portefeuille que par les mécanismes globaux du marché. Il avait cependant compris un fait crucial, faisant désormais parti des bases des stratégies d'investissement : il faut ignorer le bruit des fluctuations journalières des cours des actions et se concentrer sur le potentiel à long terme d'une entreprise. Cette idée s'est propagée et les économistes l'ont adoptée dans les années qui suivirent. Ce fut le premier pas dans la bonne direction.

L'un de ceux qui fut le premier à réussir à trouver des indicateurs naturels pour des tendances de marché futures était Robert Shiller de l'Unversité Yale. En 2000, avant que le Dow Jones atteigne son sommet, il publia un livre intitulé *Exubérance Irrationnelle* (*Irrational Exuberance*) prédisant que le marché avait de fortes chances de s'effondrer prochainement. Le krach surgit quelques jours plus tard.

L'idée principale derrière sa prédiction reposait sur le fait de prendre en compte le ratio entre les cours et les bénéfices (Price-Earnings ratio) sur le marché du New York Stock Exchange, ajusté à l'inflation, entre 1881 et 2000. Les pics qu'il trouva, comme ceux de 1901 et 1929, correspondaient à des krachs suivis d'un déclin économique. L'année 2000 vit une forte hausse de cette indicateur à une hauteur jamais atteinte par le passé. Il en conclut que les marchés étaient en plein dans une bulle financière qui pouvait éclater à n'importe quel moment. Malheureusement, il eut raison. Le Dow Jones Industrial Average plongea et il lui fallut plus d'une décennie afin d'atteindre à nouveau son niveau de mars 2000. Pour l'ensemble de ses contributions facilitant la compréhension des marchés, dont celle-ci, Shiller reçut le Prix Nobel d'Économie en 2013.

Didier Sornette, ancien professeur de l'Université de Californie à Los Angeles, désormais professeur de risque entrepreneurial à l'Institut fédéral suisse de Zurich (ETH), adopta une approche basée sur la théorie des systèmes complexes. Dans son livre, *Why Stock Markets Crash* (*Pourquoi les marchés boursiers s'effondrent*), il explique sa méthodologie, qui lui valut certains réussites remarquables. Un de ses succès fut celui de *l'antibulle* (*antibubble*), un terme qu'il précisa comme étant un bas de marché, où les actions sont sous-évaluées et les prix ne peuvent aller qu'à la hausse. L'analyse qu'il effectua, conjointement avec un de ses collègue de post-doctorat, Anders Johansen, révéla un schéma d'antibulle au Japon. En janvier 1999, ils publièrent un article dans lequel ils prédirent une hausse de 50 pourcent de l'indice Nikkei pour décembre de la même année. Leur prévision était à l'inverse des conclusions des analystes financiers qui pensaient que l'économie japonaise resterait en dépression et son marché boursier stable. À la fin 1999, l'indice Nikkei avait augmenté de 49 pourcent.

Une autre prévision faite par Sornette était reliée à l'indice 500 du Standard and Poor. En septembre 2002, il écrivit que cet indicateur continuerait à augmenter pour les mois suivants mais descendrait d'environ 20 pourcent lors du premier semestre 2004. En réalité, l'indice atteint un sommet de 924 en septembre, baissa à 768 en octobre et, après une légère hausse dans les mois suivants, il atteint un nouveau bas à 788 en mars 2003. Durant les 12 mois suivants, l'indice augmenta légèrement en moyenne à un niveau d'environ 1100 en mars 2004. Bien que cette prévision s'avéra fausse, Sornette avait capturé la tendance générale du marché, cet exemple démontre la difficulté de compréhension du monde financier, même en utilisant des outils mathématiques sophistiqués.

La réponse à la question sous-jacente est dans le titre : nous avons fait de bons progrès dans l'éclairage des dynamiques de marché mais nous sommes encore loin d'en saisir tous les détails.

Toutefois, comme tout domaine où les mathématiques peuvent s'appliquer, nos méthodes et approches ont de bonnes chances d'apporter de nouveaux éclairages dans le futur.

Note : L'auteur a adapté cet article du Chapitre 7, « Economic Breakdown », de son livre : *Megadisasters: The Science of Predicting the Next Catastrophe*, publié à Princeton University Press et à l'Oxford University Press en 2010, qui a reçu le "Best Academic Book Award"("Prix du Meilleur Livre Académique") en 2011.

Marketing on Populations Modelled as Random Graphs

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In classical models of epidemiology (such as the SIR model, see below) or in marketing models (like the Bass model) the population under consideration is assumed to be homogeneous, i.e., any two individuals are directly connected and may transmit the disease (or the product information) at a universal rate. This homogeneity leads to very simple ODE models. For example, if the total population size is N and S, I, R are the fractions of susceptibles, infected and recovered individuals, then the S-I-R model is

$$\dot{S} = -qIS, \quad \dot{I} = qIS - \gamma I, \quad S + I + R = 1 \tag{1}$$

and the Bass Model (where S are here the potential buyers and I the owners of a product) [1]

$$\dot{I} = qIS + \alpha S, \quad S + I = 1. \tag{2}$$

These two models are very similar. In (2) there is no recovery and hence no recovered class. Market penetration is accelerated by external advertising, giving rise to the term αS. Bass models can be (and have been) generalized to a market with many competing products, and to markets where products become obsolete or break down, and the owners rejoin the S-class.

The underlying assumption of a homogeneous population is clearly simplistic and unrealistic, and recent efforts aim at modelling the populations as random graphs of configuration type. Such a graph is given by a number N of vertices (nodes, thought of as the individuals; N is in general not known but should be thought of as huge), and by an edge distribution $\{P_k\}$, $k = 0, 1, 2, \ldots$ where P_k is the probability that a randomly chosen node has k connections to others. This distribution defines the random graph and is really all one knows about it. This knowledge can be encoded in terms of the generating function, defined by $\Psi(x) = \sum_{k=0}^{\infty} P_k x^k$, and quantities like the average number of edges, variance and other statistical quantities can be computed in terms of Ψ, for example, $\langle k \rangle = \Psi'(1)$.

Here are a few trivial examples: If $\Psi(x) = x^{N-1}$, meaning $P_{N-1} = 1$, all other $P_i = 0$, we recover the homogeneous case. If $P_0 = 1$, we are talking about a population of hermits (nobody has any connections), not really a random graph at all, and, say, if $P_1 = 1$, the population is split into connected pairs (only possible for even N; the only randomness in this case is that the pairs can be chosen randomly).

Of much more interest are Poisson networks ($P_k = \frac{\lambda^k}{k!} e^{-\lambda}$) where the expectation and variance of connections are both $\lambda > 0$. They arise in the limit $N \to \infty$ if each pair of nodes has identical probability $p = \lambda/N$ of being connected. Other relevant examples are so-called scale-free networks with $P_k = Ck^{-r}$ where C is a normalizing constant. These latter networks are popular in epidemiological and social applications and arise when nodes are added to a growing network and new edges attach to an existing node with a probability proportional to its degree: more popular nodes attract more connections. Depending on the parameter r and the size of N, the expected number of edges and their variance can be huge. For example, with $r = 2$ and $N = \infty$ the expected value $\langle k \rangle$ is infinite!

Miller and Volz [2] generalized the SIR model to random graph models, and their fundamental idea was to study the dynamics of the edges rather than the dynamics of the nodes. To this end, let $\theta(t)$ be the probability that a random edge has not transmitted "an infection" by time t and let $\phi(t)$ be the probability that a randomly chosen edge is of class θ and has an infected source. Moreover, assume that transmission per edge happens at rate β, and recovery of a node happens at rate γ. Then θ and ϕ satisfy

$$\frac{d\theta}{dt} = -\beta\phi. \tag{3}$$

An edge of type ϕ can change status only because of a transmission along it, or because of recovery of the infected source. An edge can enter class ϕ only if its source (which has degree k with probability $kP_k / \sum_{i=0}^{\infty} iP_i$) becomes infected. This once-susceptible source, given that it has degree k, can be infected only if at least one of its other $k-1$ edges is of class ϕ. Thus,

$$\begin{aligned} \frac{d\phi}{dt} &= -(\beta+\gamma)\phi + \beta \sum_{k=0}^{\infty} (k-1)\phi\theta^{k-2} \frac{kP_k}{\sum_{i=0}^{\infty} iP_i} \\ &= -(\beta+\gamma)\phi + \beta\phi \frac{\Psi''(\theta)}{\Psi'(1)}. \end{aligned} \tag{4}$$

Observe that the gain term in [4] can also be written as $-h'(t)$, where

$$h(t) = \sum_{j=1}^{\infty} \theta^{j-1} \frac{jP_j}{\sum iP_i} = \frac{\Psi'(\theta)}{\Psi'(1)} \tag{5}$$

is the probability that a θ-edge has a susceptible source.

A target node remains susceptible while none of its edges (contacts) has transmitted. If the node has degree k, then, assuming independence, the probability that it is susceptible is θ^k. In general, a random node is susceptible with probability

$$S(t) = \sum_{k=0}^{\infty} P_k \theta^k = \Psi(\theta),$$

and from this

$$\frac{dI}{dt} = -\frac{dS}{dt} - \gamma I = -\Psi'(\theta)\frac{d\theta}{dt} - \gamma I.$$

The two differential equations for θ and ϕ form the Miller-Volz model and the fractions S and I can be recovered from θ and ϕ as seen above (see [3]). The model is consistent with the classical SIR model: In a totally connected graph ($P_{N-1} = 1$), if $N \to \infty$ and $\beta \to 0$ such that $N\beta \to q$, one recovers ([1]). Numerical experiments comparing solutions of these simple ODEs with microscopic numerical simulations show excellent agreement.

In [3] we generalized this approach to marketing models with two competing products, showed consistency with the classical cases, provided some analysis and conducted a series of satisfying numerical experiments. For brevity, we do not include all the equations for the two-product case here, but we show the one-product model. We add an outside (marketing) node A to the network and assume that A is connected to all the nodes in the random network, now denoted as W. Let $\theta_A(t)$ be the fraction of all edges with source A which have not transmitted by time t. A node in the word-of-mouth network W remains susceptible if and only if information has been transmitted neither by word of mouth nor by A-edges. This leads to

$$S(t) = \Psi(\theta_W)\theta_A. \tag{6}$$

The edges in the class θ_A only leave the class because of transmission. Thus,

$$\frac{d\theta_A}{dt} = -\alpha\theta_A. \tag{7}$$

Further, the probability that the source node of a θ_W edge is susceptible should be modelled as

$$h(t) = \frac{\Psi'(\theta_W)}{\Psi'(1)}\theta_A.$$

The reduction of this probability by the infection of a susceptible source causes a θ_W edge to enter ϕ_W. Thus,

$$\frac{d\phi_W}{dt} = -\beta\phi_W - h'(t) = -\beta\phi_W + \beta\phi_W\frac{\Psi''(\theta_W)}{\Psi'(1)}\theta_A + \alpha\theta_A\frac{\Psi'(\theta_W)}{\Psi'(1)}. \tag{8}$$

To obtain initial conditions, we assume that, initially, every node is susceptible, and no edge has transmitted. In summary, the network marketing model is:

$$S(t) = \Psi(\theta_W)\theta_A, \tag{9a}$$

$$\frac{d\theta_A}{dt} = -\alpha\theta_A, \tag{9b}$$

$$\frac{d\theta_W}{dt} = -\beta\phi_W, \tag{9c}$$

$$\frac{d\phi_W}{dt} = -\beta\phi_W + \beta\phi_W\frac{\Psi''(\theta_W)}{\Psi'(1)}\theta_A + \alpha\theta_A\frac{\Psi'(\theta_W)}{\Psi'(1)}, \tag{9d}$$

with initial conditions $S(0) = 1$, $\theta_W(0) = 1$, $\phi_W(0) = 0$, $\theta_A(0) = 1$.

For more detailed interpretations of the various terms in these equations see [3]. This article also presents the more complicated case of two competing products, including some analytical predictions of market shares.

Finally, we mention that the Miller-Volz idea works well for SIR and SI cases because an edge can transmit only once, and so one can start from an independence assumption which gives rise to $S = \Psi(\theta)$ (for the Miller-Volz model). This identity will no longer hold for SIS models; in the marketing context, this means that a customer will abandon a product (because of a breakdown or product fatigue) and rejoin the S-class. Clearly, the history of original market penetration will then have generated correlations between the states of nodes and edges, and the approach described here is no longer applicable. However, the ideas of edge and node dynamics remain applicable, and a new model for SIS dynamics on random graphs is our current object of research.

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Integrability, Anti-Integrability and Volume-Preserving Maps

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Unlike dissipative or contracting systems, the typical dynamics of volume-preserving (VP) systems exhibits an intriguing, infinitely complex mixture of regular and chaotic components. One of the most extensively studied examples is the area-preserving, Hénon family

$$f(x,y) = (y + x^2 - a, -x). \tag{1}$$

Hénon thought of the model as encapsulating the type of motion one might expect to see of a star in a galaxy, if one could watch it for millions of years. Since x^2 is perhaps the simplest nonlinear function, (1) represents the most elementary step beyond affine transformations. This map is bijective; indeed, its inverse is also quadratic: $f_a^{-1}(x,y) = (-y, x + a - y^2)$. Intriguingly, any quadratic diffeomorphism of $\mathbb{R}^2$ has the form (1) (with the addition of a constant Jacobian factor b). More generally, polynomial automorphisms of the plane were classified by Jung and can be written as compositions of generalized Hénon maps [1].

Trajectories of (1) are sequences $(x_{t+1}, y_{t+1}) = f(x_t, y_t)$, $t \in \mathbb{Z}$. Since $y_t = -x_{t-1}$, this map can also be viewed as a second-order difference equation

$$x_{t+1} + x_{t-1} = x_t^2 - a. \tag{2}$$

The Hénon map has a pair of (real) fixed points that are born when $a = -1$ at $x = -y = 1$ in a saddle-center bifurcation. Near this point, the dynamics becomes nearly "integrable." To see this, set $x = 1 + \epsilon\xi$, and $a = -1 + \epsilon^2\alpha$, to obtain

$$\xi_{t+1} - 2\xi_t + \xi_{t-1} = \epsilon(\xi_t^2 - \alpha).$$

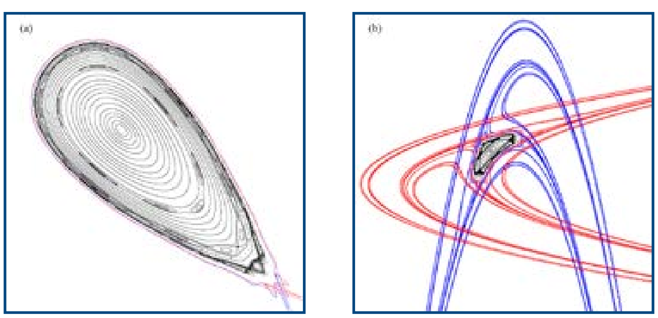

Figure 1: Phase portraits of the Hénon map for $a = -0.8$ (left) where it is nearly integrable, and $a = 2.5$ (right) where there is almost a Smale horseshoe. The red and blue curves are the unstable and stable manifolds of the hyperbolic fixed point.

This is a second difference approximation to the ODE $\ddot{q} = -V'(q)$, an oscillator with potential $V(\xi) = -\frac{1}{3}q^3 + \alpha q$. Since the energy $E = \frac{1}{2}\dot{q}^2 + V(q)$ is conserved, the orbits of this ODE are very simple indeed. Trajectories in the potential well around the stable equilibrium at $q = -\sqrt{\alpha}$ are bounded, periodic orbits. There is a separatrix at $E = V(\alpha)$, and orbits outside this loop are unbounded.

The actual dynamics, seen in (1(a)), has similar aspects. Indeed, Moser (the "M" of KAM theory) tells us that orbits near the elliptic fixed point are bounded (for any $a \in (-1,3)$ except 0 and 1). Specifically, there is a Cantor set of invariant circles on which the dynamics is quasiperiodic.

By contrast, there is also a Cantor set of orbits near the separatrix of the saddle fixed point that is chaotic. Indeed for large a, the bounded dynamics is hyperbolic and topologically conjugate to a Bernoulli shift—it is as random as a coin toss. One way to see this is to use Aubry's notion of "anti-integrability" (AI). Thinking of a as large, rescale (2), setting $z = \epsilon x$ where $a = \epsilon^{-2}$, to obtain

$$\epsilon(z_{t+1} + z_{t-1}) = z_t^2 - 1. \tag{3}$$

The limit $\epsilon = 0$ is singular in the sense that (3) degenerates to the algebraic equation $z_t^2 = 1$: "orbits" become arbitrary sequences $\{s_t\} \in \{-1,1\}^\infty$. Hence the coin toss. Aubry showed that such sequences continue to true orbits for positive ϵ. One way to see this (and a good way to compute the orbits) is to solve (3) for z_t to obtain a map S on $\ell^\infty(\mathbb{R})$ defined by $S_t(z) = s_t\sqrt{1 + \epsilon(z_{t+1} + z_{t-1})}$, whose fixed points are orbits. The map S is a contraction when ϵ is small. Thus there is a one-to-one correspondence between orbits of the Hénon map and sequences for small ϵ. Numerical investigations indicate this persists up to a homoclinic tangency near $\epsilon = 0.41887923$ [2].

A roadblock to generalizing (1) to higher dimensions is that it's not known if a constant Jacobian, polynomial map has a polynomial inverse (this is the content of Keller's "Jacobian conjecture"). The inverse of a quadratic map *is* polynomial, though it need not be quadratic. The general form of a quadratic 3D VP diffeomorphism with *quadratic* inverse is

$$g(x,y,z) = (z + G(x,y), x, y), \tag{4}$$

for any degree-two polynomial G [3]. This map can again be written as a difference equation, upon elimination of y and z:

$$x_{t+1} - x_{t-2} = G(x_t, x_{t-1}). \tag{5}$$

Just like (1), g has at most two fixed points. Near the saddle-center-Hopf bifurcation that creates these points, they are saddles, one with a 2D unstable and the other with a 2D stable manifold. These manifolds nearly join to form a two-sphere (a separatrix) whose interior contains a Cantor set of two-tori. As far as I know, there is no theorem, like Moser's, that guarantees this structure (though Xia proved a KAM theorem for VP maps).

In contrast to the two-dimensional case, the existence of an invariant, $\Phi : M \to \mathbb{R}$ such that $\Phi \circ g = \Phi$, no longer implies that a VP map is integrable. There are examples of (4) with a polynomial integral when G is a rational function [4], generalizing Suris's 2D case. Though orbits are restricted to level sets, $M_\mu = \{(x,y,z) : \Phi(x,y,z) = \mu\}$, the dynamics on each level set is chaotic. The missing ingredient for integrability is a symmetry.

For a symplectic map, each invariant Φ generates a Hamiltonian vector field, V, that is a symmetry of the map, $f^*V = V$. Symmetry is crucial for Liouville-Arnold integrability and the construction of action-angle variables. Interestingly, invariants do not automatically give symmetries for volume-preserving maps. If a 3D VP map does have an invariant, then it can be reduced to a symplectic map on each M_μ. Existence of an additional symmetry or invariant then implies integrability [5]. Geometrically, these two cases are distinguished: in one there are two "actions," and in the other there are two "angles."

What about an AI limit for (4)? As we did for (3), (5) can be scaled to obtain

$$\epsilon(\xi_{t+1} - \tau\xi_t + \sigma\xi_{t-1} - \xi_{t-2}) = Q(\xi_t, \xi_{t-1}) - 1,$$

where Q is a quadratic form. However, the AI limit now becomes the relation $Q(\xi_t, \xi_{t-1}) = 1$—much more complicated than the full shift of (3). Some aspects of this problem have been studied, [6], but the general continuation problem is very much open.

Acknowledgment. The author was supported in part by NSF grant DMS-1211350.

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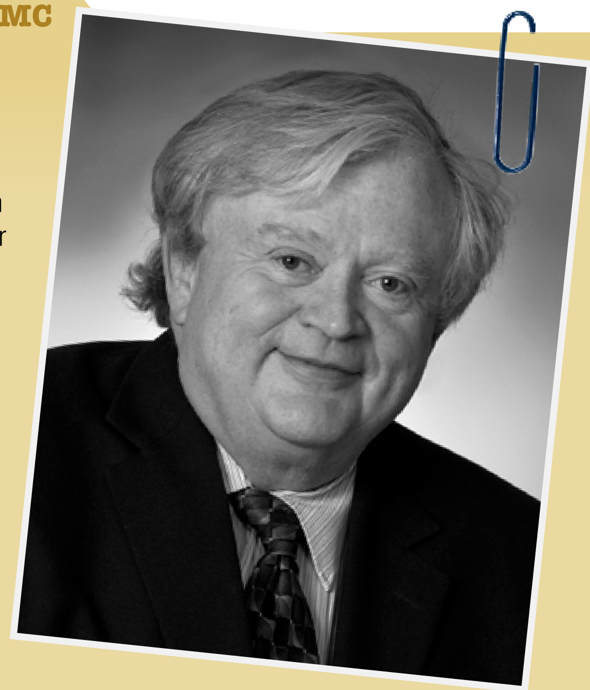
CMS Member Profile / Profil membre de la SMC

Robert Woodrow



HOME: Calgary, Alberta (University of Calgary, Department of Mathematics and Statistics)

CMS MEMBER SINCE: 1981

RESEARCH: Model Theory of Relational Structures, Homogeneous Structures, Structural Ramsey Theory and applications.

SELECTED ACHIEVEMENTS: Graham Wright Distinguished Service Award, Order of the University of Calgary.

HOBBIES: Food and wine, travel.

LASTEST BOOK READ: Mon village a l'heure allemande.

LATEST PUBLICATION: Ramsey precompact expansions of homogeneous directed graphs, Jasinski J., Laflamme 2C., Nguyen Van The L., Woodrow R.E., Electronic Journal of Combinatorics, Volume 21, Issue 4.42, 31 pages 2014.

WHAT I WOULD CHANGE (ABOUT THE CMS):
The CMS needs to be seen as an effective advocate for all mathematics in Canada from school age through research.

CMS ROLES: Former: member of the Board, Chair and member of the Education Committee, member of the Advancement Committee, member Math in Moscow selection committee

CURRENT: Member of the Student Committee, Chair of the COMC Committee.

WHY I BELONG TO THE CMS:
Mathematics is important to understanding the world in which we live, and that relationship leads to some important contributions to society. The CMS has a central role in speaking for mathematics at every level, and for putting in place programs and opportunities for Canadian mathematicians. It needs broad support from those interested in Mathematics in Canada.

CSHPM Notes brings scholarly work on the history and philosophy of mathematics to the broader mathematics community. Authors are members of the Canadian Society for History and Philosophy of Mathematics (CSHPM). Comments and suggestions are welcome; they may be directed to either of the column's co-editors,

Amy Ackerberg-Hastings, *University of Maryland University College (aackerbe@verizon.net)*

Hardy Grant, *York University [retired] (hardygrant@yahoo.com)*

Les articles de la SCHPM présente des travaux de recherche en histoire et en philosophie des mathématiques à la communauté mathématique élargie. Les auteurs sont membres de la Société canadienne d'histoire et de philosophie des mathématiques (SCHPM). Vos commentaires et suggestions sont le bienvenue; ils peuvent être adressées à l'une des co-rédacteurs,

Amy Ackerberg-Hastings, *University of Maryland University College (aackerbe@verizon.net)*

Hardy Grant, *York University [retraité] (hardygrant@yahoo.com)*

Remarks on the History of CSHPM/SCHPM, History of Mathematics (HOM), and Philosophy of Mathematics (POM)

Robert Thomas, *University of Manitoba*

As this space has been used by members of CSHPM/SCHPM to attract the eyes of CMS members for a while now, it has occurred to me, as a long-time member of both organizations, to write a few historical words about the related topics announced in the title. This was not in any way co-ordinated with the words on HOM in the last issue but is a happy accident. The CSHPM (since I'm writing this in English) [1] was founded out of concern with HOM all across Canada but was focused on establishing its historical journal *Historia Mathematica* (HM) forty years ago. The first meeting was at the University of Toronto, where Kenneth May, the founder of HM, worked, and where the Learneds were meeting in 1974. The relation between the CSHPM and HM has never been financial but one of institutional support embedded in the Society's constitution. When, nearly twenty years later, I refounded *Philosophia Mathematica* (PM), I was able to receive similar support from the Society, support that was badly needed because PM had developed a poor reputation since its founding in Chicago in 1964. The convenient coincidence of the Latin names was not an accident, the name 'HM' having been chosen in imitation of 'PM' in order to avoid the Canadian double-name custom, as in CSHPM/SCHPM. In association with the Society, PM [2] and HM [3] have thrived, as has it. It is a truly global organization, which occasionally holds meetings outside Canada. Its annual meeting in 2015 is in Washington, D.C., with the MAA's special interest groups on HOM [4] and POM [5] and the British Society for History of Mathematics [6].

What of the subjects? There are substantial differences between POM and HOM beyond their just being different windows on mathematics. For one thing, they have very different ages. At the time when the ancient Greek civilization was inventing what we now regard as our sort of mathematics, what we now regard as philosophy was also being invented. It is fair to say that the sort of document-based scholarship that we now regard as history was not yet even being considered. (That is sometimes attributed to Gibbon's eighteenth-century work on the decline and fall of the Roman Empire.) Historical writing, to the extent that it existed at all, was varied and not scholarly. As a result of this difference in their ancient history and the contribution of mathematicians like Descartes and Leibniz to general philosophy, POM turns up in the best general philosophy journals, such as *Mind and the Journal of Philosophy*, and always has. Mathematics is a central topic of philosophy in a way that is not true of history. One would not expect to find a paper on the history of some mathematical topic in the *Journal of the Canadian Historical Association/Revue de la Société historique du Canada*. The growing interest of historians in social history has not dug down far enough into what people do to come up with anything to do with mathematics. Hence the need forty years ago for a journal to encourage HOM publication. There are now other such journals but none with as wide a readership as HM.

Something interesting has happened in HOM in recent decades, as Len Berggren wrote of HOM (ancient) in this space in June in some detail. As the initial membership of CSHPM indicates, historians of mathematics tended to be academic mathematicians with an interest in history. Few were professionally trained or self-taught historians of mathematics. Len Berggren and Kenneth May were two of the exceptions, and they trained students of their own to be historians—starting out from a mathematical background, of course. This process, taking place elsewhere as well as in Canada, has had the effect that, while I have watched the process, professional historians have displaced amateurs. This has had the further effect of improving HOM from a historical-scholarly point of view. But, generally speaking, interest has shifted to what was going on at some past time in its own terms rather than how something in the past is related to some piece of present-day mathematics. One way of putting this difference is Ivor Grattan-Guinness's distinction [7] between 'mathematical history' or 'what happened in the past', and what most mathematicians are more interested in, 'mathematical heritage' or 'how did we get here?'. This change has provoked a response from the mathematical side. Two 'perspectives' articles in the *Journal of Humanistic Mathematics* at the end of 2014 [8] are a complaint and response. These articles suggested to me that a mathematical audience might be interested. Both 'what happened in the past' and 'mathematical heritage' are thoroughly historical, although mathematical heritage covers a longer time period, and both can be made interesting.

As I said above, POM is older and so is as mature a discipline as any besides mathematics. So the distinction between what mathematicians might be interested in and what professional philosophers talk about when they are doing POM is well established. Reuben Hersh complained of it as long ago as 1979 in his paper 'Some proposals for reviving the philosophy of mathematics', published in the journal *Advances in Mathematics* with the connivance of the philosophically inclined editor, Gian-Carlo Rota. The way that I usually characterize this division when I have to is that philosophers typically consider what they'd like to talk about rather than what is real or more typical mathematics. They tend to focus on arithmetic, logic, and set theory, which we do not. They usually ignore current mathematics, which is part of what David Corfield aimed at in his book, *Towards a Philosophy of Real Mathematics*, published by Cambridge University Press in 2003. Another difference, which may be more fundamental, is that mathematics is used as a test bed for arguments about quite general philosophical matters (Do abstract objects exist?) rather than being the actual subject that an investigator is trying to understand: about mathematics but only incidentally. Another response is organizational. There has been since 2009 an Association for Philosophy of Mathematical Practice based in Europe [9]. It charges no dues and arranges meetings at a less than annual frequency; the third will be in Paris this year.

Bringing together the two movements hinted at in the previous two paragraphs, I have this observation. There is a danger to both historians and philosophers of mathematics in the foci that I have mentioned. The primary audience for HOM is mathematicians, and mathematicians form at least the secondary audience for POM. In neither case is it wise to ignore an important segment of those one might expect to be interested in what one does. Historians of mathematics are a much smaller base of potential readers than the general run of mathematicians. One does not need to lower one's scholarly standards to aim at a wide readership. On the mathematical side, one needs to pay attention to find either work on mathematical heritage or reflection on current mathematics.

References

[1] www.cshpm.org or www.schpm.org.

[2] philmat.oxfordjournals.org.

[3] www.journals.elsevier.com/historia-mathematica.

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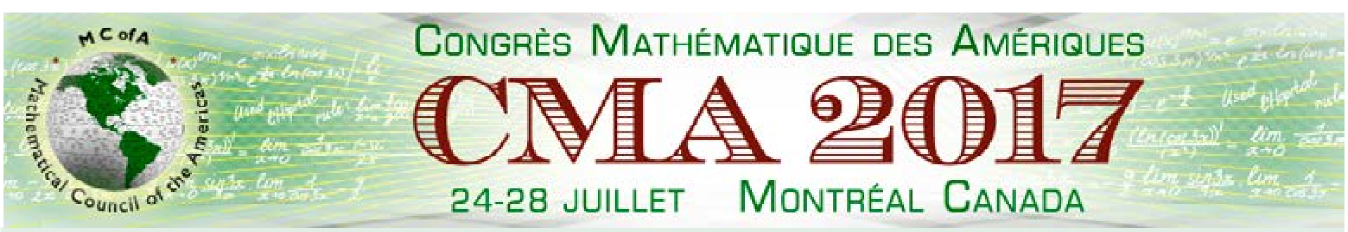
Robert Thomas, a former president of CSHPM, worked at the University of Manitoba in Computer Science, Applied Mathematics (of which he was the last head), and Mathematics, where he studied bus routes, elastic waves in two-dimensional solids, and weaving. He edits Philosophia Mathematica.



Le décompte est lancé pour le CMA2017

Avec encore deux ans avant l'événement, la SMC vient de lancer le site web du Congrès mathématiques des Amériques (CMA) - **mca2017.org/fr**. Le congrès se tiendra au Centre Mont-Royal et à l'Université McGill, à Montréal, du 24 au 28 juillet 2017. L'événement devrait attirer des mathématiciens et mathématiciennes ainsi que des étudiantes et étudiants de partout à travers l'Amérique du Nord, l'Amérique centrale, l'Amérique du Sud et les Caraïbes.

Le CMA2017 met en lumière les accomplissements mathématiques des Amériques et encourage la collaboration entre les différentes communautés mathématiques du continent. Le congrès est une initiative collective du **Mathematical Council of the Americas**. Le CMA2017 est financé par un comité canadien incluant le Pacific Institute for the Mathematical Sciences (PIMS), l'institut Fields (FIELDS), le Centre de recherches mathématiques (CRM), l'Atlantic Association for Research in the Mathematical Sciences (AARMS) et la SMC, qui organise aussi l'événement.

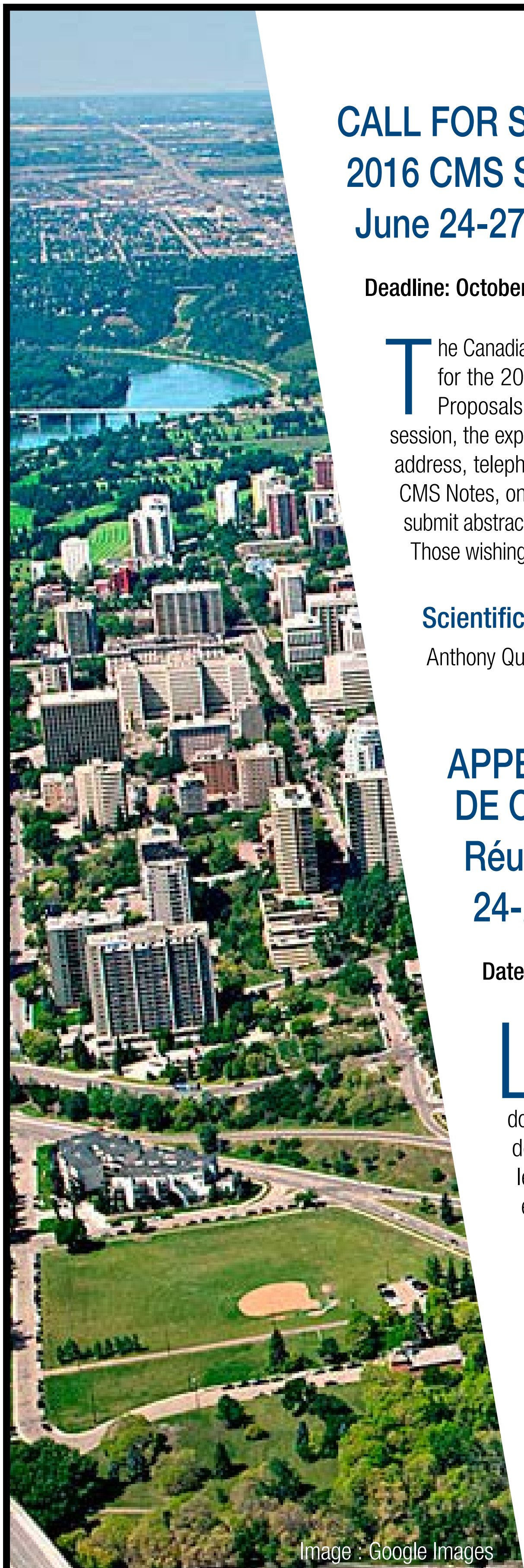


Image : Google Images

CALL FOR SESSIONS
2016 CMS Summer Meeting
June 24-27, 2016, Edmonton, Alberta

Deadline: October 15, 2015

The Canadian Mathematical Society (CMS) welcomes and invites session proposals for the 2016 CMS Summer Meeting in Edmonton from June 24 to 27, 2016. Proposals should include a brief description of the focus and purpose of the session, the expected number of speakers, as well as the organizer's name, complete address, telephone number, e-mail address, etc. Sessions will be advertised in the CMS Notes, on the web site and in the AMS Notices. Speakers will be requested to submit abstracts, which will be published on the web site and in the meeting program. Those wishing to organize a session should send a proposal to the Scientific Director.

Scientific Director :

Anthony Quas : **aquas@uvic.ca**

APPEL DE PROPOSITIONS DE CONFÉRENCES
Réunion d'été de la SMC 2016
24-27 juin 2016, Edmonton, Alberta

Date limite : 15 octobre 2015

La Société mathématique du Canada (SMC) invite les gens à proposer des conférences pour la Réunion d'été de la SMC 2016 qui se tiendra à Edmonton du 24 au 27 juin 2016. Ces propositions doivent présenter une brève description de l'orientation et des objectifs de la conférence, le nombre de conférenciers prévu, de même que le nom, l'adresse complète, le numéro de téléphone et l'adresse électronique de l'organisateur. Tous les conférences seront annoncés dans les Notes de la SMC, sur le site Web et dans les AMS Notices. Les conférenciers devront présenter un résumé, qui sera publié sur le site Web et dans le programme de la réunion. Toute personne qui souhaiterait organiser un conférence est priée de faire parvenir une proposition au directeur scientifique.

Directeur scientifique :

Anthony Quas : **aquas@uvic.ca**

CMS Winter Meeting
Réunion d'hiver de la SMC

MONTRÉAL 2015

Public Lectures | Conférence publiques

John Baez (U. C. Riverside, California)
Isabelle Gallagher (Université Paris-Diderot)

Plenary Lectures | Conférences plénières

Gilles Brassard (Montréal)
Anna Gilbert (Michigan)
Martin Hairer (Warwick, U.K.)
Caroline Series (Warwick, U.K.)

CSHPM Plenary Lecture | Conférence plénière de la SCHPM

Jamie Tappenden (Michigan)

Prizes | Prix

Adrien Pouliot Award | Prix Adrien-Pouliot

recipient to be announced | lauréat à confirmer

Doctoral Prize | Prix de doctorat

Yuval Filmus (Toronto), Hector H. Pasten Vasquez (Queen's)

G. de B. Robinson Award | Prix G. de B. Robinson

Philippe Gille (Université Claude Bernard, France)

Graham Wright Award for Distinguished Service | Prix Graham Wright pour service méritoire

recipient to be announced | lauréat à confirmer

Jeffery-Williams Prize | Prix Jeffery-Williams

Alejandro Adem (UBC)

Scientific Director | Directeur scientifique

Louigi Addario-Berry : louigi.addario@mcgill.ca

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Related Events | Événements liés

The **CMS Town Hall** meeting will occur on Saturday, December 5, from 12:30 - 14:00. All CMS members and meeting participants are invited to join the CMS Executive and to engage on upcoming plans and to discuss any interests or concerns that members of our community may have.

La **Séance de discussion de la SMC** aura lieu le samedi 5 décembre de 12 h 30 à 14h. Tous les membres de la SMC et participants à la réunion sont invités à se joindre à l'exécutif de la SMC à s'engager sur les plans à venir et de discuter des préoccupations ou des intérêts que les membres de notre communauté peuvent avoir.

The Canadian Mathematical Society invites you to their **awards banquet** on Sunday, December 6, to highlight exceptional performance in the area of mathematical research and education. Prizes will be awarded during the event.

La Société mathématique du Canada vous invite à son **banquet de prix** le dimanche 6 décembre pour souligner des contributions exceptionnelles en recherche mathématique et en enseignement des mathématiques. Des prix seront remis durant la soirée.

Regular Sessions | Sessions générales

Algebraic Combinatorics | Combinatoire algébrique
Christophe Hohlweg (UQAM), Hugh Thomas (UNB), Franco Saliola (UQAM)

Algebraic Number Theory | Théorie algébrique des nombres
Antonio Lei (Laval)

Analysis on Singular Manifolds | Analyse sur des variétés singulières
Alexey Kokotov (Concordia), Frédéric Rochon (UQAM)

Analytic Number Theory | Théorie analytique des nombres
Daniel Fiorilli (Ottawa), Nathan Jones (UIC), Dimitris Koukoulopoulous (Montréal), Matilde Lalin (Montréal)

Bridging the Gap between Mathematical Approaches and Biological Problems | Combler le fossé entre les approches mathématiques et problèmes biologiques
Fred Guichard (McGill), Erik Cook (McGill), Lea Popovic (Concordia)

Cohomological Methods in Quadratic Forms and Algebraic Groups | Méthodes cohomologiques pour les formes quadratiques et les groupes algébriques
Stefan Gille (Alberta), Nikita Karpenko (Alberta)

Combinatorics on Words | Combinatoire des mots
Alexandre Blondin Massé (UQAM), Srecko Brlek (UQAM), Christophe Reutenauer (UQAM)

Complex Analysis and Operator Theory | Analyse complexe et théorie des opérateurs
Javad Mashreghi (Laval), Thomas Ransford (Laval)

Computational and Topological Methods in Dynamical Systems | Calcul et méthodes topologiques en systèmes dynamiques
Tomasz Kaczynski (Sherbrooke), Jean-Philippe Lessard (Laval)

Descriptive Set Theory | Théorie descriptive des ensembles
Marcin Sabok (McGill)

Differential Geometry | Géométrie différentielle
Ailana Fraser (UBC), Regina Rotman (Toronto)

Diophantine Equations and Harmonic Analysis | Équations diophantiennes et analyse harmonique
Scott Parsell (West Chester University of Pennsylvania), Craig Spencer (Kansas State)

Discrete and Continuous Optimization | Optimisation discrète et continue
Dan Bienstock (Columbia), Andrea Lodi (École Polytechnique de Montréal)

Fibrations, Mirror Symmetry and Calabi-Yau Geometry | Fibrations, symétrie miroir et géométrie de Calabi-Yau
Charles Doran (Alberta), Andreas Malmendier (Colby College), Alan Thompson (Waterloo)

Geometric Spectral Theory | Théorie géométrie spectrale
Alexandre Girouard (Laval)

Graph Theory | Théorie des graphes
Hamed Hatami (McGill), Sergey Norin (McGill)

History and Philosophy of Mathematics | Histoire et philosophie des mathématiques
Tom Archibald (SFU)

Logic, Category Theory and Computation | Logique, théorie des catégories et calcul
Prakash Panangaden (McGill)

Low Dimensional Topology and Geometric Group Theory | Topologie en basse dimension et théorie géométrique des groupes
Mark Powell (UQAM), Piotr Przytycki (McGill), Adam Clay (Manitoba)

Mathematical Finance | Finance mathématique
Cody Hyndman (Concordia), Alexandre Roch (UQAM), Alexandru Badescu (Calgary)

Mathematics Education | Enseignement des mathématiques
Org: to be announced | Org : à venir

Continued on next page | Suite à la page suivante

Continued from previous page | Suite de la précédent page

Mathematics: Source of New Solutions to Old Problems in Pharmaceutical Research and Therapy | Mathématiques: source de nouvelles solutions à de vieux problèmes en recherche pharmaceutique et en pharmacothérapie
Fahima Nekka (Montréal), Jun Li (Montréal)

Measure-Valued Diffusions | Diffusions à valeurs mesurées
Xiaowen Zhou (Concordia)

Nonlinear Evolutionary Equations | Équations d'évolution non linéaires
Dong Li (UBC), Xinwei Yu (Alberta)

Operator Algebras | Algèbres d'opérateurs
Mikael Pichot (McGill)

Probability and Statistical Mechanics | Probabilités et statistique mécanique
Alex Fribergh (Montréal), Louis-Pierre Arguin (Montréal)

Representation Theory | Théorie des représentations
Clifton Cunningham (Calgary), David Roe (UBC)

Stochastic Partial Differential Equations | Équations aux dérivées partielles stochastiques
Lea Popovic (Concordia), Don Dawson (Carleton)

Symplectic Geometry, Moment Maps and Morse Theory | Géométrie symplectique, applications moment et théorie de Morse
Lisa Jeffrey (Toronto)

AARMS-CMS Student Poster Session | Présentations par affiches des étudiants - AARMS-SMC
Org: to be announced | Org : à venir

Contributed Papers | Communications libres
Org: to be announced | Org : à venir

Math Team Canada places 9th at the International Mathematical Olympiad

Math Team Canada placed ninth out of 104 countries at the 56th International Mathematical Olympiad (IMO) in Chiang Mai, Thailand.

The team achieved impressive individual results, with **Zhuo Qun (Alex) Song** (Phillips Exeter Academy, Exeter, N.H.) and **Kevin Sun** (Phillips Exeter Academy, Exeter, N.H.) both earning gold medals and **Yan (Bill) Huang** (West Windsor-Plainsboro High School South, West Windsor, N.J.), **Michael Pang** (Fort Richmond Collegiate, Winnipeg, Man.), **Alexander Whatley** (North Houston Academy of Science and Mathematics, Houston, Texas) and **Jinhao (Hunter) Xu** (University Hill Secondary School, Vancouver, B.C.) earning bronze medals.

Alex Song had a record-breaking sixth and final year at the IMO. He was the only student to achieve a perfect score on the challenging two-day, four hour and 30 minute exam. Alex now holds the world record for IMO medals and currently is ranked by the IMO as the top mathematics student in the world.

L'équipe mathématique du Canada décroche la 9e place à l'Olympiade internationale de mathématiques

L'équipe mathématiques du Canada s'est placée neuvième sur les 104 pays représentés lors de la 56e Olympiade internationale de mathématiques (OIM) à Chiang Mai, en Thaïlande.

Les membres de l'équipe ont obtenu d'impressionnants résultats, avec **Zhuo Qun (Alex) Song** (Phillips Exeter Academy, Exeter, N.H.) et **Kevin Sun** (Phillips Exeter Academy, Exter, N.H) chacun gagnant une médaille d'or et **Yan (Bill) Huang** (West Windsor-Plainsboro High School South, West Windsor, N.J.), **Michael Pang** (Fort Richmond Collegiate, Winnipeg, Man.), **Alexander Whatley** (North Houston Academy of Science and Mathematics, Houston, Texas) et **Jinhao (Hunter) Xu** (University Hill Secondary School, Vancouver, B.C.) chacun gagnant une médaille de bronze.

Alex Song a battu un record en étant un participant à l'OIM pour une sixième (et son dernier) année. Il était le seul étudiant à obtenir un score parfait lors de l'examen qui a duré deux jours, quatre heures et trente minutes, au total. Alex détient aussi le record du monde en termes de médailles reçues à l'OIM et est actuellement classé par l'OIM comme étant l'étudiant en mathématique numéro un au monde.

Election Results

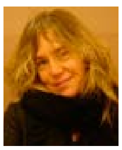
As a result of the 2015 election that was held on June 6, 2015 at the CMS Annual General Meeting, the following twelve officers and directors have been elected to the CMS Board of Directors and Executive:

Résultats des élections

À la suite de l'élection 2015, qui a eu lieu le 6 juin 2015 à l'Assemblée générale annuelle de la SMC, les suivants douze dirigeants et administrateurs ont été élus au Conseil d'administration et Éxécutif de la SMC :

President-Elect/President/Past-President;
Président élu/Président/Président précédant;
Michael Bennett (UBC)

Vice-President – Atlantic;
Vice-Président – Atlantique;
David Pike (Memorial)



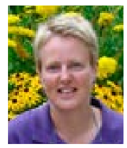
Vice-President – Quebec;
Vice-Présidente – Québec;
Chantal David (Concordia)

Vice-President – Ontario;
Vice-Président – Ontario;
Rahim Moosa (Waterloo)

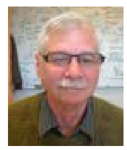
Vice-President – West; and
Vice-Président – Ouest; et
Raj Srinivasan (Saskatchewan)

Vice-President – Pacific
Vice-Président – Pacifique
Florin Diacu (Victoria)

Director – Quebec;
Directrice – Québec;
Lea Popovic (Concordia)

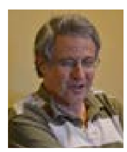


Director – West;
Directrice – Ouest;
Gerda de Vries (Alberta)

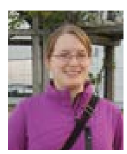


Director – West;
Directeur – Ouest;
Michael Doob (Manitoba)

Director – Pacific;
Directeur – Pacifique;
Nils Bruin (SFU)



Director – Pacific; and
Directeur – Pacifique; et
Brian Marcus (UBC)



Director – Student
Directrice – Étudiante
Svenja Huntemann (Dalhousie)

Countdown begins for MCA2017

With two years to go, the CMS has launched the Mathematical Congress of the Americas (MCA) 2017 web site - mca2017.org. The congress will be held at the Centre Mont-Royal and McGill University in Montreal from July 24 to 28, 2017. The congress is expected to attract mathematicians and students from throughout North America, Central America, South America and the Caribbean.

MCA2017 highlights mathematical achievements of the Americas and fosters collaboration between the continents' mathematical communities. The congress is a collective initiative of the **Mathematical Council of the Americas**. MCA2017 is being supported by a Canada organizing committee that includes the Pacific Institute for the Mathematical Sciences (PIMS), the Fields Institute (FIELDS), Le centre de recherches mathématiques (CRM), the Atlantic Association for Research in the Mathematical Sciences (AARMS) and the CMS, which is staging the event.

PIMS Postdoctoral Fellowship Competition

The Pacific Institute for the Mathematical Sciences (PIMS) invites nominations of outstanding young researchers in the mathematical sciences for Postdoctoral Fellowships for the year 2016-2017. Candidates must be nominated by a scientist or department affiliated with PIMS. The fellowships are intended to supplement support provided by the sponsor, and are tenable at any of the PIMS Canadian member universities: the University of Alberta, the University of British Columbia, the University of Calgary, the University of Lethbridge, the University of Manitoba, the University of Regina, the University of Saskatchewan, Simon Fraser University and the University of Victoria.

Program Features

Nominees must have a Ph.D. or equivalent (or expect to receive a Ph.D. by December 31, 2016) and must be within three years of their Ph.D. at the time of the nomination (i.e., they must have received their Ph.D. on or after January 1, 2013). The fellowship may be taken up at any time between September 1, 2016 and January 1, 2017. The fellowship is for one year and is renewable, contingent on satisfactory progress, for at most one additional year. The amount of the award for 2016-17 will be $20,000 and the sponsor is required to provide additional funds to finance a minimum total stipend of $40,000. PIMS Postdoctoral Fellows are expected to participate in all PIMS activities related to the fellow's area of expertise and will be encouraged to spend time at more than one site. To ensure that PIMS Postdoctoral Fellows are able to participate fully in Institute activities, they may not teach more than two single-term courses per year.

Application Process

- The PIMS PDF nomination/application process takes place entirely online, utilizing the MathJobs service provided by the American Mathematical Society. Having selected their nominees, sponsors direct them to apply online at mathjobs.org/jobs/PIMS. (Detailed instructions regarding all aspects of the MathJobs application procedure may be found in the online MathJobs user guides.) Please note that ***application is by nomination only***; unsolicited applications will not be considered. Please note that all nominees, ***including those associated with PIMS Collaborative Research Groups*** must apply through MathJobs.
- Nominees should upload a list of publications, a curriculum vitae and a statement of research interests. Special justification statements should be included if the applicant plans to either (i) continue to work with his/her PhD advisor, or (ii) remain at their current institution.
- Nominees should arrange for at least two reference letters to be uploaded to MathJobs. At least one letter should be preferably from an outside referee who is at arm's length from the candidate and/or his/her PhD advisor.
- Sponsors must upload both their own reference letter and a ***separate*** statement of financial support that identifies in as much detail as possible the source of matching funds and the level of teaching required from the candidate. Vague or incomplete statements may influence the panel's decision. Sponsors will receive instructions as to how to proceed via an email from MathJobs.

Selection Criteria

- Rankings of candidates are made by the PIMS PDF Review Panel based on the following criteria:
- The scientific qualifications of the candidate;
- The fit between the research interests of the candidate and those of the sponsor;
- Adequacy of matching funds.

Deadlines

- Complete applications must be uploaded to MathJobs by ***December 1, 2015***. For further information, visit: **http://www.pims.math.ca/scientific/postdoctoral** or contact: **assistant.director@pims.math.ca**.

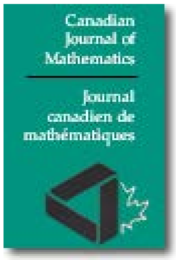
Alberta Canadian Undergraduate Mathematics Conference a Success

The 2015 Canadian Undergraduate Mathematics Conference took place at the University of Alberta from June 17 to 21. With attendees representing universities from coast to coast, the conference truly captured the spirit of the Canadian undergraduate mathematics community. The 2015 CUMC featured 71 student talks and six keynotes, with topics ranging from the mathematics behind string theory and wolf packs to graph theory games and statistics. Attendees also took part in a Gender Diversity in Mathematics evening, roundtable discussions and a closing banquet at the historic Fort Edmonton Park to close the conference.

Alberta Congrès Canadien des Étudiants en Mathématiques un Success

L'édition 2015 du Congrès Canadien des Étudiants en Mathématiques a eu lieu à l'Université de l'Alberta du 17 au 21 juin dernier. Avec des participants venus d'un bout à l'autre du pays, le congrès a bien su capturer l'esprit de la communauté d'étudiants sous-gradués canadiens. Le CCÉM 2015 a donné l'occasion à soixante-et-onze étudiants de donner des exposés auxquels se sont ajoutés six conférenciers pléniers. Les sujets, très diversifiés, sont allés des mathématiques de la théorie des cordes ou des meutes de loups jusqu'aux jeux en théorie des graphes, en passant par la statistique. Les participants ont aussi pris part à une soirée de la diversité des genres en mathématiques, à des discussions en tables rondes et à un banquet de clôture au lieu historique de Fort Edmonton Park.

CJM/CMB Associate Editors



The Publications Committee of the CMS solicits nominations for five Associate Editors for the Canadian Journal of Mathematics (CJM) and the Canadian Mathematical Bulletin (CMB). **The appointment will be for five years beginning January 1, 2016.** The continuing members (with their end of term) are below.

For over fifty years, the **Canadian Journal of Mathematics** (CJM) and the **Canadian Mathematical Bulletin** (CMB) have been the flagship research journals of the Society, devoted to publishing original research works of high standard. The CJM publishes longer papers with six issues per year and the CMB publishes shorter papers with four issues per year. CJM and CMB are supported by respective Editors-in-Chief and share a common Editorial Board.

Expressions of interest should include your curriculum vitae, your cover letter and sent electronically to: **cjmcmb-ednom-2015@cms.math.ca before November 15th 2015**.

Current Members of CJM/CMB Editorial Board

Henry Kim (Toronto)	12/2016	Editor-in-Chief CJM
Robert McCann (Toronto)	12/2016	Editor-in-Chief CJM
Jie Xiao (Memorial)	12/2019	Editor-in-Chief CMB
Xiaoqiang Zhao (Memorial)	12/2019	Editor-in-Chief CMB
Louigi Addario-Berry (McGill)	12/2018	Associate Editor
Florin Diacu (Victoria)	12/2016	Associate Editor
Ilijas Farah (York)	12/2015	Associate Editor
Skip Garibaldi (UCLA)	12/2016	Associate Editor
Dragos Ghioca (UBC Vancouver)	12/2018	Associate Editor
Eyal Goren (McGill)	12/2018	Associate Editor
Robert Leon Jerrard (Toronto)	12/2016	Associate Editor
Izabella Laba (UBC Vancouver)	12/2015	Associate Editor
Anthony To-Ming Lau (Alberta)	12/2016	Associate Editor
Alexander Litvak (Alberta)	12/2016	Associate Editor
Alexander Nabutovsky (Toronto)	12/2015	Associate Editor
Assaf Naor (Courant Institute)	12/2018	Associate Editor
Erhard Neher (Ottawa)	12/2016	Associate Editor
Frank Sottile (Texas A&M)	12/2015	Associate Editor
McKenzie Wang (McMaster)	12/2016	Associate Editor
Juncheng Wei (UBC Vancouver)	12/2018	Associate Editor
Daniel Wise (McGill)	12/2018	Associate Editor
Efim Zelmanov (UCSD)	12/2016	Associate Editor

Rédacteur(trice) associé(e) pour le JCM et le BCM

Le Comité des publications de la SMC sollicite des mises en candidatures pour cinq postes de rédacteurs associés pour le Journal canadien de mathématiques (JCM) et pour le Bulletin Canadien de mathématiques (BCM). **Le mandat sera de cinq ans qui commencera le 1er janvier 2016**. Les membres qui continuent (avec la fin de leur terme) sont ci-dessous.

Revues phares de la Société depuis plus de 50 ans, le **Journal canadien de mathématiques** (JCM) et le **Bulletin canadien de mathématiques** (BCM) présentent des travaux de recherche originaux de haute qualité. Le JCM publie des articles longs dans ses six numéros annuels, et le BCM publie des articles plus courts quatre fois l'an. Le JCM et le BCM ont chacun leur rédacteur en chef et partagent un même conseil de rédaction.

Les propositions de candidature doivent inclure votre curriculum vitae, votre lettre de présentation et doivent être envoyé par courriel électronique à : **jcmbcm-rednom-2015@smc.math.ca au plus tard le 15 novembre 2015**.

Membres Actuels du Conseil de rédaction scientifique pour le JCM et le BCM :

Henry Kim (Toronto)	12/2016	Rédacteur en chef JCM
Robert McCann (Toronto)	12/2016	Rédacteur en chef JCM
Jie Xiao (Memorial)	12/2019	Rédacteur en chef BCM
Xiaoqiang Zhao (Memorial)	12/2019	Rédacteur en chef BCM
Louigi Addario-Berry (McGill)	12/2018	Rédacteur associé
Florin Diacu (Victoria)	12/2016	Rédacteur associé
Ilijas Farah (York)	12/2015	Rédacteur associé
Skip Garibaldi (UCLA)	12/2016	Rédacteur associé
Dragos Ghioca (UBC Vancouver)	12/2018	Rédacteur associé
Eyal Goren (McGill)	12/2018	Rédacteur associé
Robert Leon Jerrard (Toronto)	12/2016	Rédacteur associé
Izabella Laba (UBC Vancouver)	12/2015	Rédactrice associée
Anthony To-Ming Lau (Alberta)	12/2016	Rédacteur associé
Alexander Litvak (Alberta)	12/2016	Rédacteur associé
Alexander Nabutovsky (Toronto)	12/2015	Rédacteur associé
Assaf Naor (Courant Institute)	12/2018	Rédacteur associé
Erhard Neher (Ottawa)	12/2016	Rédacteur associé
Frank Sottile (Texas A&M)	12/2015	Rédacteur associé
McKenzie Wang (McMaster)	12/2016	Rédacteur associé
Juncheng Wei (UBC Vancouver)	12/2018	Rédacteur associé
Daniel Wise (McGill)	12/2018	Rédacteur associé
Efim Zelmanov (UCSD)	12/2016	Rédacteur associé

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