CSHPM Notes / Notes de la SCHPM
**How Objects Reveal Mathematical Culture..... 18**

## IN THIS ISSUE / DANS CE NUMÉRO




CMS NOTES de la SMC

September / septembre 2016

Canadian Mathematical Society
Société mathématique du Canada


*President's Notes / Notes du président*


**Michael Bennett** *(UBC)*
*CMS President / Président de la SMC*


May I begin my first President's Report by expressing my gratitude for the opportunity to serve the CMS. I'd like to convey my special thanks to Lia Bronsard for the outstanding job she did as President (and continues to do as Past President) and to our Vice Presidents, Chantal David, Florin Diacu, Rahim Moosa, David Pike and Raj Srinivasan, our Treasurer, David Oakden and our Corporate Secretary, Graham Wright. The CMS runs effectively through the hard work of our dedicated staff in the Ottawa office and through the efforts of many volunteers across the country.

There is a proverb, often described as an ancient Chinese curse, but almost certainly of recent, Western origin: "May you live in interesting times." Whatever the provenance of this saying, such times are certainly upon our Society. I believe that we are currently facing serious challenges and being presented with remarkable opportunities. I am seeking the input of the membership of the CMS to guide us in shaping the future of the Society. The question I'd really like to ask you, as CMS members, is the following rather existential one: "What is the CMS, or perhaps, what should the CMS be?" More practically, "What, as a Society, should we be focusing our efforts on?"

Currently, the activities of the CMS might be roughly described as threefold. Firstly, we run two meetings each year, one in the summer and one in the winter. These provide an opportunity for mathematicians from across Canada and the world to meet and

*Continued on page 6*

Permettez-moi de commencer mon premier rapport à titre de président en exprimant ma gratitude pour l'occasion qui m'est donnée de servir la SMC. Je tiens à exprimer des remerciements particuliers à Lia Bronsard pour le travail remarquable qu'elle a accompli en tant que présidente (et qu'elle continue à faire à titre de présidente sortante), à nos vice-présidents, Chantal David, Florin Diacu, Rahim Moosa, David Pike et Raj Srinivasan, à notre trésorier, David Oakden et au secrétaire de la Société, Graham Wright. La SMC fonctionne efficacement grâce au travail acharné de notre personnel dévoué situé dans le bureau d'Ottawa, et grâce aux efforts de nombreux bénévoles partout au pays.

Il existe un proverbe, souvent qualifié de vieille malédiction chinoise, mais qui est presque certainement d'origine occidentale récente : « Puissiez-vous vivre à une époque intéressante. » Quelle que soit la provenance de ce proverbe, notre Société est certainement en train de vivre des moments intéressants. Je pense que nous sommes actuellement confrontés à de sérieux défis et que des possibilités remarquables s'offrent à nous. Mon objectif est de consulter les membres afin de nous aider à forger l'avenir de la Société. La question que j'aimerais réellement vous poser, à vous les membres de la SMC, c'est la question existentielle suivante : « Qu'est-ce que la SMC? Ou peut-être, que devrait-elle être? » Plus concrètement, « Sur quoi la Société devrait-elle concentrer ses efforts? »

Pour l'instant, on pourrait dire que les activités de la SMC sont en gros de trois ordres. Tout d'abord, nous tenons deux réunions chaque année, l'une en été et l'autre en hiver. Elles représentent une occasion pour les mathématiciens de partout au Canada et au monde de se rencontrer et d'échanger des idées. Elles ont aussi pour but de constituer

*Suite à la page 7*

CMS Notes
Volume 48 No. 4, September 2016

# Mathematically Impossible

**Robert Dawson**, *Department of Mathematics and Computer Science, Saint Mary's University*

**Srinivasa Swaminathan**, *Department of Mathematics and Statistics, Dalhousie University*

We're having a quiet summer in Canada, so let's look south of the border, to where the presidential primaries are keeping the journalists busy. A few months ago, the outcomes were still unclear. As that situation changed, commentators began to use the words "mathematically impossible" to describe victory by one or another candidate who was dropping back in the pack. It's interesting to consider what was meant by this. It was usually not what a mathematician would mean!

In mathematics, of course, to say that a proposition is impossible is no more and no less than to say that it is false under whatever set of axioms we have agreed to use. In this context, we don't need the longer word, and so we don't use it. The concept of "impossibility" comes into its own when we get into predicates - statements with truth values that depend on one or more parameters. To say that a predicate is impossible is to say that it is false for all legitimate values of its parameters. So it's possible to roll a hundred ordinary six-sided dice and obtain a total score of 600: impossible to roll 601. Now, the axioms governing American party conventions are fairly complicated, but it appears that not a single one of these claims of "mathematical impossibility" was correct. It was - and is, at the date of writing - still possible for delegates to ignore the wishes of those who chose them and pick Jeb Bush or Bernie Sanders. Indeed, with a couple quick changes of party allegiance, the sometime party of Abraham Lincoln could presumably choose Sanders, and the Democrats, Bush. Is it probable? Of course not: but it's possible in the nitpicky sense that mathematicians use.

So why did so many journalists find this phrase so attractive? At the time, not all primary voting had taken place, and so the final results weren't available. But by putting together available facts - votes to date, superdelegate voting patterns, and perhaps certain state outcomes considered as axiomatic - it was possible to compute the possible range within which those final results might plausibly lie. The calculations are simple, trivial even - but they take a set of facts and draw from them a conclusion which is not immediately obvious. That's the "mathematics" in the "mathematical impossibility."

Of course, it doesn't need to be said - a simple "impossible" (or, for fans of *The Princess Bride*, "inconceivable") would do. If any explanation is needed, it was sung perfectly well in the musical *The Pajama Game*: "With a pencil and a pad, I figured it out." There is no need to drag mathematics into it. But mathematics not only tells us the unexpected, it does so with an authority that hunches, intuition, and gut feelings don't share. So even though the recent use of "mathematically impossible" may have been somewhat misleading, it does suggest a level of respect for mathematics that we should appreciate.

# Mathématiquement impossible

L'été s'annonce tranquille au Canada, alors regardons au sud de la frontière, là où les primaires présidentielles tiennent les journalistes occupés. Il y a quelques mois, les résultats n'étaient toujours pas clairs. Lorsque la situation a changé, les commentateurs ont commencé à utiliser les mots « mathématiquement impossible » pour décrire la victoire de l'un ou l'autre des candidats qui traînait en queue de peloton. Il est intéressant de se pencher sur ce que l'on entendait par cela. Ce n'était habituellement pas la signification qu'un mathématicien accorderait à cette expression!

En mathématiques, bien entendu, affirmer que la proposition est impossible revient ni plus ni moins à dire qu'elle est fausse quel que soit l'ensemble des axiomes que nous avons convenu d'utiliser. Dans ce contexte, nous n'avons pas besoin du mot plus long, et nous ne l'utilisons donc pas. Le concept « d'impossibilité » prend tout son sens lorsqu'on aborde les prédicats – des énoncés ayant valeur de vérité qui dépendent d'un ou de plusieurs paramètres. Dire qu'un prédicat est impossible revient à affirmer qu'il est faux quelles que soient les valeurs légitimes de ses paramètres. Il est donc possible de lancer une centaine de dés ordinaires à six côtés et d'obtenir un score total de 600, mais impossible d'obtenir 601.

Maintenant, les axiomes régissant les conventions des partis américains sont assez compliqués, mais il semble qu'aucune de ces affirmations « d'impossibilité mathématique » n'était correcte. Les délégués avaient la possibilité – et l'avaient toujours au moment de rédiger ces lignes – d'ignorer les souhaits de ceux qui les ont choisis et d'opter pour Jeb Bush ou Bernie Sanders. En effet, on pourrait supposer qu'avec quelques changements rapides d'allégeance, le parti qui a été celui d'Abraham Lincoln choisira Sanders, et les Démocrates, Bush. Est-ce probable? Bien sûr que non, mais c'est possible dans le sens précis que les mathématiciens donnent à ce mot.

Alors pourquoi tant de journalistes trouvent-ils cette phrase si attrayante? À l'époque, les votes des primaires n'avaient pas encore tous eu lieu, et donc les résultats finaux n'étaient pas connus. Mais en rassemblant les données accessibles – les votes à ce jour, les habitudes électorales des super délégués, et peut-être les résultats de certains États considérés comme axiomatiques – on pouvait calculer la fourchette possible à l'intérieur de laquelle ces résultats finaux pourraient vraisemblablement se situer. Les calculs sont simples, insignifiants même – mais ils consistent à prendre un ensemble de faits et à en tirer une conclusion qui n'est pas évidente à première vue. C'est ce que signifie le mot « mathématiques » dans l'expression « impossibilité mathématique ».

Bien sûr, il n'est pas nécessaire de le dire – un simple « impossible » (ou pour les admirateurs de The Princess Bride, « inconcevable ») suffirait. Si une explication s'avérait nécessaire, elle a été chantée parfaitement dans la comédie musicale The Pajama Game : « Avec un crayon et une tablette, j'ai trouvé la solution. » Inutile d'impliquer les mathématiques là-dedans. Cependant, non seulement les mathématiques nous disent l'inattendu, mais elles le font avec une autorité qui fait défaut aux pressentiments, à l'intuition et à l'instinct. Ainsi, même si l'utilisation récente de l'expression « mathématiquement impossible » peut avoir été quelque peu trompeuse, elle suggère un niveau de respect envers les mathématiques auquel nous devrions être sensibles.

## 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**.



**Canadian Mathematical Society - Société mathématique du Canada**
209-1725 St. Laurent Blvd., Ottawa, ON, Canada K1G 3V4 tel 613-733-2662

**notes-articles@cms.math.ca | smc.math.ca | cms.math.ca**
ISSN :1193-9273 (imprimé/print) | 1496-4295 (électronique/electronic)

# Mathematics of Planet Earth

Mathematics of Planet Earth (MPE) invites the scientific community to enter the Second International Competition to design museum exhibits on Mathematics of Planet Earth. This new competition is supported by the International Mathematical Union, UNESCO, the International Commission of Mathematical Instruction and IMAGINARY.

The competition will enrich the MPE Open Source Exhibition (https://imaginary.org/exhibition/mathematics-of-planet-earth), which provides material that can be used by museums and schools around the world. Exhibits can take the form of an interactive program, a hands-on physical exhibit, a short film, or an image gallery; and must address some planetary theme where mathematics plays a role. A special call is made for topics related to the African continent.

An international jury will award four prizes to the best modules:

- 1st, 2nd and 3rd prize: 5 000 USD, 2 000 USD, and 1 000 USD respectively.
- A special prize of 2 000 USD for the best exhibit addressing an African topic.

Participation is open until **June 30, 2017**. More information at

www.mathofplanetearth.org/competition.

International Mathematical Union IMU

UNESCO United Nations Educational, Scientific and Cultural Organization — Natural Sciences Sector

ICMI International Commission on Mathematical Instruction

IMAGINARY open mathematics

*The Calendar 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.*

**Denise Charron**, *Canadian Mathematical Society, (managing-editor@cms.math.ca)*

*Le calendrier annonce 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.*

**Denise Charron**, *Société mathématique du Canada (redacteur-gerant@smc.math.ca)*

## SEPTEMBER 2016 SEPTEMBRE

| | |
|---|---|
| **28-Sep 1** | CRM/FIELDS Frontiers in Mathematical Physics: In honour of Barry Simon's 70th Birthday, CRM, Montreal, Que. |
| **1-7** | CRM Aisenstadt Chair - Speakers: Yuval Peres (Microsoft Research) and Scott Sheffield (MIT), CRM, Montreal, Que. |
| **2-6** | CRM Workshop: Random Growth Problems and Random Matrices, CRM, Montreal, Que. |
| **11-16** | BIRS Workshop: Bridges Between Noncommutative Algebra and Algebraic Geometry, BIRS, Banff, Alta. |
| **23** | CRM Lecture by Anne Broadbent, 2016 André-Aisenstadt Prize Recipient, CRM, Montreal, Que. |
| **25-30** | BIRS Workshop: Modular Forms in String Theory, BIRS, Banff, Alta. |
| **29** | PIMS Lecture: Hugh C. Morris Lecture: Francis Su, University of Victoria, Victoria, BC |
| **29** | PIMS-UManitoba Distinguished Lecture: Jun-Cheng Wei, University of Manitoba, Winnipeg, Man. |

## OCTOBER 2016 OCTOBRE

| | |
|---|---|
| **2-7** | BIRS Workshop: Painleve Equations and Discrete Dynamics, BIRS, Banff, Alta. |
| **3-7** | Workshop on Convexity in Algebraic Geometry, Fields Institute, Toronto, Ont. |
| **3-7** | CRM Workshop: Probabilistic Methods in Dynamical Systems and Applications, CRM, Montreal, Que. |
| **8-9** | 2016 Québec-Maine Number Theory Conference, Université Laval, Qué. |
| **11-14** | CRM 14th RECOMB Comparative Genomics Satellite Workshop, ITHQ (Institut de tourisme et d'hôtellerie du Québec), Montreal, Que. |
| **14-15** | 60e Congrès de l'Association de Mathématique du Québec (AMQ), Cégep Garneau, Québec, Qué. |
| **16** | AARMS Workshop: Partial Differential Equations and Numerical Analysis at Atlantic Universities Conference, Cape Breton University, Sydney, N.S. |
| **16-24** | BIRS Workshop: New Trends in Graph Coloring, BIRS, Banff, Alta. |
| **23-28** | BIRS Workshop: Workshop in Analytic and Probabilistic Combinatorics, BIRS, Banff, Alta. |
| **28** | PIMS-CRM-FIELDS Lecture: Daniel Wise, University of British Columbia, Vancouver, BC |
| **30-Nov 4** | BIRS Workshop: Theoretical and Computational Aspects of Nonlinear Surface Waves, BIRS, Banff, Alta. |

## NOVEMBER 2016 NOVEMBRE

| | |
|---|---|
| **1-4** | 2016 Fields Medal Symposium, Fields Institute, Toronto, Ont. |
| **6-11** | BIRS Workshop: Random Geometric Graphs and Their Applications to Complex Networks, BIRS, Banff, Alta. |
| **13-18** | BIRS Workshop: Permutation Groups, BIRS, Banff, Alta. |
| **14-18** | CRM Workshop: Probabilistic Methods in Topology, CRM, Montreal, Que. |
| **14-18** | Workshop on Hall Algebras, Enumerative Invariants and Gauge Theories, Fields Institute, Toronto, Ont. |
| **27-Dec 2** | AARMS Workshop: Fifth Parallel-in-time Integration Workshop, BIRS, Banff, Alta. |

## DECEMBER 2016 DÉCEMBRE

| | |
|---|---|
| **2-5** | 2016 CMS Winter Meeting / Réunion d'hiver de la SMC 2016, Sheraton on the Falls, Niagara Falls, Ont. |
| **5-9** | Workshop on Combinatorial Moduli Spaces and Intersection Theory, Fields Institute, Toronto, Ont. |
| **11-14** | 12th International Conference on Web and Internet Economics (WINE), InterContinental Hotel, Montreal, Que. |
| **14-15** | CRM Workshop: 13th Workshop on Algorithms and Models for the Web-graph, CRM, Montreal, Que. |

*Continued from cover*

share ideas. They also have the auxiliary purpose of providing a forum for recognizing excellence in the Canadian mathematical community, in terms of research, educational leadership and service. Secondly, we publish two research journals, the Canadian Journal of Mathematics and the Canadian Mathematical Bulletin, as well as two publications aimed at mathematical exposition and problems, Crux Mathematicorum and ATOM (A Taste of Mathematics). Thirdly, we have a suite of activities that straddle the line between outreach and education. These include running national mathematics competitions at the high school level, the Canadian Open Math Challenge (COMC) and the Canadian Mathematical Olympiad (CMO), as well as sponsoring the Canadian International Mathematical Olympiad (IMO) team, which recently turned in another fantastic performance, finishing 12th in the world at the 2016 IMO in Hong Kong, with both the youngest gold medalist and the highest scoring female in the competition. The Society also supports a wide variety of Math Camps and other activities across the country, through Endowment and Competition grants.

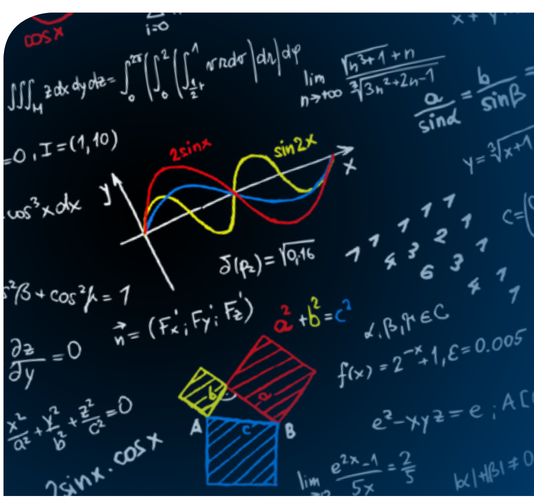
The CMS, through its national membership and breadth of disciplines represented, and through its permanent staff and base in Ottawa, is uniquely qualified and positioned to connect with government on the federal level. The new regime in Ottawa is certainly more accessible and responsive to calls for increased support and visibility for basic science. One of the CMS's primary roles can and should be to lobby for mathematics broadly, to help guide national policy and to interface with NSERC and other granting agencies, as well as other representative bodies for mathematics, both in Canada and internationally, including the CRM, the Fields Institute, PIMS, AARMS and CAIMS.

The challenges that we face are, at least on a certain level, primarily financial. Revenues from memberships are static at best. Our research journals have historically been the primary revenue driver for the Society, thanks in the most part to our dedicated teams of editors and the outstanding work of our Winnipeg-based publishing office, under the leadership of, Michael Doob and Craig Platt. Despite this, these revenues are declining, at least partially due to a worldwide trend in reduced library subscriptions. It would be a dangerous assumption for us to make that the current favourable exchange rates for our international subscriptions (based on a low Canadian dollar) will continue indefinitely. Our meetings run at either a loss or a minimal, marginal profit, depending on registration numbers. Essentially all of our other competition and outreach activities lose money. Ultimately, unless we are exceptionally successful in fundraising (efforts in this direction are currently underway, spearheaded by Gerri Jensen and David Rodgers), we simply must reduce our expenses. Which brings us back to the basic question of what, as a Society, should we be doing? Are there new initiatives in which we should take a leadership role? Do we need to identify "core" activities and focus our energies (and resources) on them?

One of the initiatives that the CMS is in the process of developing is an ambassador program. The CMS Ambassador program will allow a local representative to reach out to faculty and students within their institution with the aim of recruiting them to the Society in order to reinforce and enrich our mathematical community. If you would like to contribute directly to this effort, please contact the CMS membership department at **memberships@cms.math.ca**.

Input and guidance from our members is welcomed and appreciated as we may be forced to make hard decisions in the coming years. I fully realize that there is no simple answer to any of these questions and that it is very unlikely we will be able to reach an easy consensus on these issues. There are different aspects of the CMS's mandate that resonate with different members. Despite the complexities, I believe this is a conversation that we must have.

Canadian mathematics has never been stronger than it is now, on many, many levels. We need a Society that is relevant in the coming century, that advocates broadly for mathematics in Canada and that is responsive to the desires of its members. Help us to articulate a vision to achieve this. Please submit your ideas, feedback or comments to me at **president@cms.math.ca**.



*Suite de la couverture*

un forum permettant de reconnaître l'excellence de la communauté mathématique canadienne en matière de recherche, de leadership et d'éducation. Deuxièmement, nous publions deux revues de recherche, le Journal canadien de mathématiques et le Bulletin canadien de mathématiques, ainsi que deux publications destinées à exposer les mathématiques et les problèmes, Crux Mathematicorum et ATOM (A Taste of Mathematics). Troisièmement, nous organisons une série d'activités qui se situent entre la sensibilisation et l'éducation. Elles comprennent l'organisation de concours de mathématiques nationaux au niveau du secondaire, du Défi ouvert canadien de mathématiques (DOCM) et de l'Olympiade mathématique du Canada (OMC), ainsi que le parrainage de l'équipe de l'Olympiade internationale de mathématiques (OIM), qui a récemment obtenu un autre résultat fantastique, terminant à la 12e place mondiale de l'OIM 2016 à Hong Kong, et qui comprenait le médaillé d'or le plus jeune et la jeune femme ayant obtenu la meilleure note. La Société appuie également une grande variété de camps de mathématiques et d'autres activités dans tout le pays au moyen du fonds de dotation et de subventions de concours.

Grâce à ses membres nationaux, à l'étendue des disciplines représentées, à son personnel et à sa base de permanents à Ottawa, la SMC est particulièrement qualifiée et bien placée pour communiquer avec le gouvernement au niveau fédéral. Le nouveau régime en place à Ottawa est certainement plus accessible et sensible aux appels au soutien accru et à la visibilité des sciences fondamentales. Un des principaux rôles que la SMC peut et doit jouer est de faire du lobbyisme pour les mathématiques en général, d'aider à orienter les politiques nationales et d'interagir avec le CRSNG et d'autres bailleurs de fonds, ainsi qu'avec d'autres organismes représentatifs dans le domaine des mathématiques, tant au Canada qu'à l'échelle internationale, y compris le CRM, le Fields Institute, le PIMS, l'AARMS et la SCMAI.

Les défis à relever sont, au moins à un certain niveau, surtout d'ordre financier. Les revenus provenant des adhésions sont au mieux statiques. Nos revues de recherche ont toujours été notre principale source de revenus, en grande partie grâce à nos équipes dévouées de rédacteurs en chef et au travail exceptionnel de notre maison d'édition basée à Winnipeg, sous la direction de Michael Doob et Craig Platt. Malgré cela, ces revenus diminuent, au moins partiellement en raison de la tendance mondiale à la baisse des abonnements aux bibliothèques. Il serait faux de penser que le taux de change actuel qui favorise nos abonnements internationaux (basé sur un dollar canadien faible) va demeurer indéfiniment avantageux. Nos réunions génèrent une perte ou un profit marginal minimal, dépendamment du nombre d'inscriptions. Essentiellement, toutes nos autres activités, que ce soit les concours ou la sensibilisation, sont déficitaires. En fin de compte, à moins d'une collecte de fonds exceptionnellement fructueuse (des efforts en ce sens sont en cours, menés par Gerri Jensen et David Rodgers), nous devrons tout simplement diminuer nos dépenses. Ce qui nous ramène à la question fondamentale, à savoir : « Que devrions-nous faire en tant que Société? » Y a-t-il de nouvelles initiatives dont nous devrions être le chef de file? Avons-nous besoin de déterminer quelles sont nos activités « centrales » et y consacrer nos énergies (et nos ressources)?

L'une des initiatives que la SMC est en train de mettre sur pied est le programme des ambassadeurs. Ce programme permettra à un représentant local de prendre contact avec les professeurs et les étudiants dans leur établissement dans le but de les recruter afin de renforcer et d'enrichir notre communauté de mathématiciens. Si vous souhaitez contribuer directement à cet effort, veuillez communiquer avec le service des membres de la SMC à **adhesions@smc.math.ca**.

L'apport et les conseils de nos membres sont bienvenus et nous y sommes réceptifs, puisque nous pourrions être forcés de prendre des décisions difficiles dans les années à venir. Je comprends parfaitement qu'il n'existe pas de réponse simple à ces questions et qu'il est très peu probable que nous parvenions facilement à un consensus. Différents membres sont sensibles à différents aspects du mandat de la SMC. Malgré la complexité du sujet, je crois que nous devrions en discuter.

Les mathématiques canadiennes n'ont jamais été plus fortes qu'elles le sont actuellement à de nombreux niveaux. Nous avons besoin d'une Société è l'ère du temps, qui défend largement la cause des mathématiques au Canada et qui répond aux souhaits de ses membres. Je vous invite à nous aider à exposer clairement une vision pour atteindre cet objectif. Merci de m'envoyer vos idées, vos réactions ou vos commentaires à **president@smc.math.ca**.

*Book Reviews 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 comptes-rendus de livres présentent 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)*

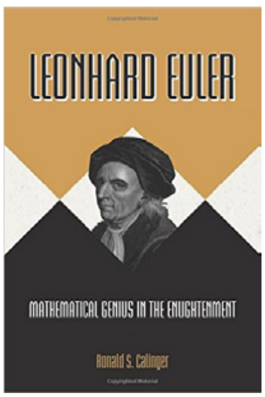
## Leonhard Euler: Mathematical Genius in the Enlightenment

by Ronald S. Calinger

Princeton University Press, 2015

ISBN: 978-0-691-11927-4

Reviewed by *Craig Fraser* (University of Toronto)




Ronald Calinger's biography provides a year-by-year account of Euler's life and mathematical work, from his youth in Basle through his long career in St. Petersburg and Berlin. Euler's research projects, academic relations and collegial connections are chronicled in detail, and there are accounts of his many contributions to mathematics. The book is an impressive and very substantial contribution to Euler studies.

Writings on Euler over the past fifty years are divided into two groups, with mathematicians focusing on the heritage of Euler's mathematics and its interest to a modern reader, while historians have examined the emergence and development of Euler's theories in the historical context of eighteenth-century exact science. Calinger draws on both bodies of work as well as the existing biographical studies (including some articles of his own) to construct this portrait of Euler. The amount of information and detail here about the administrative and institutional context of Euler's life is unsurpassed in biographical writings in the history of mathematics.

Various extra-mathematical subjects are broached in the course of Calinger's book, including Euler's views on theology, his philosophical disagreement with followers of Christian Wolff on the subject of monodology, his interest in teaching, his engagement with the game of chess, his administrative oversight of public works projects, the constant academic politics, and his relations with his political masters. Also covered are family matters, his two marriages and the arrival of his thirteen children (all by his first wife), eight of whom died in infancy or early childhood and only three of whom – all sons – outlived him.

Euler's career in St. Petersburg and Berlin was carried out against a backdrop of war and social upheaval. The War of the Austrian Succession, the Silesian Wars and the Seven Years' War occupied the attentions of the leaders of Russia and Prussia from the early 1740s to the late 1750s. Some of the details Calinger reports on provide a glimpse of how the larger events of the time affected Euler and his family. National treasuries could not afford barracks for all of the soldiers of their large standing armies (containing not a few "social misfits, criminals and vagrants") and private homes were required to billet these men. At one point during his first years in St. Petersburg eight soldiers were billeted at Euler's residence in a shed at the rear of his house, and they "could be crude, rowdy and dishonest, and their heavy smoking discolored the building's interior." When Euler moved to Berlin he negotiated with Frederick II to ensure that he would not be required to billet soldiers at his home. The journey from St. Petersburg to Berlin included a three-week rough voyage on the Baltic Sea by Euler and his young family, during which only Euler was free of seasickness.

In addition to his extensive contributions to analysis and number theory, Euler carried out research on practical projects, from the theory of music, the use of magnetic declination lines to determine longitude, the science of ballistics (of utmost interest to his military sponsors), to the stability of ships and the optics of telescope construction. He also contributed to theoretical mechanics and the rotation of rigid bodies. (Calinger uses the term "rational mechanics," a designation that does not appear in Euler's writings and came into substantial use in English only in the second half of the twentieth century.) Euler authored important writings on the mathematical motions of fluids and the theory of engineering structures, and contributed extensively to physical astronomy (what later became known as celestial mechanics).

Enormously creative in his own right, Euler was quick to recognize important new mathematical advances by others, sometimes conveyed to him in personal letters, sometimes presented in published articles. He would clearly credit the discoverers and go on to make very detailed and fundamental contributions to the subject. He did that for Jean d'Alembert's work on the derivation and integration of partial differential equations, Alexis Clairaut's solution to the lunar three-body problem, Giulio Fagnano's researches on elliptic integrals, and Joseph Lagrange's delta algorithm in the calculus of variations. Inevitably tensions concerning priority and approach arose in his relations with other researchers, but Euler displayed pragmatism and good sense in navigating these shoals.

Despite failing eyesight and other health problems, Euler remained remarkably productive into his seventies. Johann Bernoulli III reported in 1778 that "he cannot recognize people by their faces, nor read black on white, nor write with pen and paper; yet with chalk he writes his mathematical calculations on a blackboard very clearly and in rather normal size; these are immediately copied by one of his assistants ..., and from these materials are later composed memoirs under his direction." (Quoted in Emil A. Fellmann's Euler (Basle: Birkhäuser), p. 119, reproduced on p. 519 of Calinger's book.)

Although Calinger does not identify any overall pattern in the evolution of Euler's mathematical approach during his sixty years of active work, it appears that in his later researches there was a stronger synthetic conception of the mathematical material. In some of his last investigations he began to draw the outlines of a theory of functions of a complex variable. In researches completed up to his death in 1783 he obtained results in this area that would be the starting point for investigations of Simon Laplace, Siméon Poisson and Augustin Cauchy, a line of research that led some sixty years after Euler's death to a new and major branch of analysis.

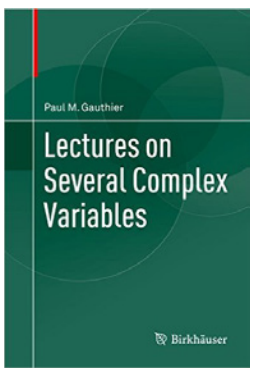
## Lectures on several complex variables

by Paul M. Gauthier

Birkhäuser, 2014

**ISBN: 978-3-319-11510-8**

Reviewed by *Thomas Bloom* (University of Toronto)




The origins of the theory several complex variables go back to the beginning of the twentieth century, with the discovery by F. Hartogs, E. E. Levi, H. Poincaré, (and others) of phenomena in several complex variables which had no parallel in the one variable case. Central problems in the theory were solved by the Japanese mathematician Kiyoshi Oka in the 1930s and 1940s. His theory was refined and formulated using the theory of sheaves by H. Cartan and J. P. Serre in seminars in Paris in the early 1950s. More explicit solutions to results in the general theory were given in the 1950s by H. Grauert and L. Hörmander. By the 1960s the basic theory and different approaches to it were known.

Textbook/reference books presenting the general theory or some aspect of it soon followed and today there are many such books. Three excellent ones which present the general theory are the classic book of Hörmander using partial differential equation methods and giving highly useful estimates to basic existence theorems [3], the three volume set of Gunning with a detailed presentation of the theory of sheaves [2], and the online book of Demailly where the emphasis is to present the theory on complex manifolds [1]. The book of Hörmander, at about 250 pages, is very tersely written and the books of Gunning and Demailly each run about 500 pages. It normally takes a dedicated and qualified graduate student a full year of concentrated study to master the essence of any one of these books.

The book under review, at a mere 100 pages or so, does not attempt to present the theory in general nor does it give a systematic or complete presentation of the topics discussed. Rather, it aims to give an introduction to the subject, but nevertheless to present complete proofs of some results in several complex variables.

The only prerequisites are standard undergraduate mathematics.

The first phenomena discussed is the example of Hartogs:

$$H = \{z \in \mathbb{C}^2 : |z_1| < 1/2, |z_2| < 1\}$$
$$\cup \{z \in \mathbb{C}^2 : |z_1| < 1, 1/2 < |z_2| < 1\}.$$

*Every* analytic function on $H$ extends to a holomorphic function on the unit polydisc

$$D = \{z : |z_1| < 1, |z_2| < 1\}.$$

In the terminology of several complex variables $H$ is not a *domain of holomorphy*. In keeping with the spirit of the book, for the complete characterization of domains of holomorphy and of course for the proofs, the reader is referred to other texts.

Plurisubharmonic functions, the Monge-Ampère equation and the related Dirichlet problem and the characterization of domains of holomorphy via pseudoconvexity are, however, discussed.

The Weierstrass preparation theorem, which is the basis of the study of the local geometry of the zero sets of holomorphic functions, is proved.

It is also proven that the natural domain of definition of an analytic function (i.e. the maximal domain into which it can be analytically continued) is a complex manifold spread (i.e. with a natural local isomorphism) over $\mathbb{C}^n$. This follows an extensive section on complex manifolds including a careful presentation of specific higher dimensional complex manifolds (projective space, Grassmanians, tori, quotient spaces, etc...) and also Hermitian, symplectic and almost complex manifolds.

The book concludes with a discussion of the difficulties in defining mereomorphic functions in several variables. The Cousin problem of writing a mereomorphic function globally as a quotient is briefly mentioned, as is the definition of subvariety.

The target audience for the book is graduate students, more ambitious undergraduate students or research mathematicians whose specialty is not several complex variables. The author engages the reader with well-chosen, interesting problems which advance the theory. The book is written with a delightful light touch and provides a very accessible introduction to several complex variables.

### References

[1] J. P. Demailly, **https://www-fourier.ujf-grenoble.fr/~demailly/manuscripts/agbook.pdf**

[2] R. C. Gunning, Introduction to Holomorphic Functions of Several Variables, three volumes, Wadsworth and Brooks/Cole (1990).

[3] L. Hörmander, An Introduction to complex analysis in Several variables, 3rd edition, North Holland (1990).

*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)*

*Notes pédagogiques présentent 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 les nouvelles d'intérêt. Vos commentaires, suggestions et propositions sont le bienvenue.*

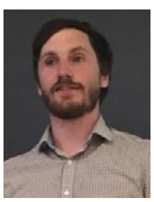
**Jennifer Hyndman**, *University of Northern British Columbia (hyndman@unbc.ca)*

**John McLoughlin**, *University of New Brunswick (johngm@unb.ca)*

*Submissions from people in the mathematical community shape Education Notes. Recent contributions from Christopher Duffy and Caroline Junkins are featured here. The contributing authors are postdoctoral fellows at Dalhousie University and University of Western Ontario respectively. These pieces focus attention on outreach and perceptions of mathematical ability.*

# AARMS Outreach in Atlantic Canada

**Christopher Duffy**, *Dalhousie University, christopher.duffy@dal.ca*



I am not sure if it was the few moments of echoing silence, the dull roar of excited activity that followed, or the juxtaposition of the two that convinced me that the things I thought I knew about successful mathematics outreach were just a hazy approximation of reality. In attending the first game of the *Nova Scotia Math League* I was in an outreach environment I found distinctly unfamiliar. Rather than students silently writing a contest, or an instructor holding their hands through an activity, these students were actively and collaboratively problem solving without any idea of the skills and knowledge they were meant to apply. It was only after their time was up that the students were given any confirmation that their intuition in problem solving had merit. If I had any doubt to the shortcomings of my own experiences, they were quickly confirmed in participating and overhearing the many ad-hoc discussions and explanations that took place during the breaks throughout the day.

AARMS

The *Atlantic Association for Research in the Mathematical Sciences* (AARMS) exists to encourage and advance research in mathematics, statistics, computer science, and mathematical sciences in the Atlantic region. As part of this mission it supports a variety of outreach activities in Atlantic Canada. In 2015 AARMS hired, for the first time, a post-doctoral fellow who would, in addition to research, act as the Outreach Coordinator in Atlantic Canada. I am that Outreach Coordinator, and in the first ten months in my position, I am coming to learn that the value of outreach programs really lies in providing a knowledgeable resource to those with the curiosity to ask questions. My job description and duties are as varied as the outreach activities that are happening through the eleven member universities of AARMS. The programs and events I have attended in the past year have convinced me that every single outreach activity is a unique blend of the age, motivation and skills of the students, together with the personality and spirit of those leading the event. The strengths of many of these programs lie not only in the overarching theme, topic, and presentation, but extend to opportunities for brief and impromptu personal interactions between learners and learned.

The *Nova Scotia Math League* owes it existence to the very successful *Newfoundland and Labrador Teachers' Association* (NLTA) *Senior Math League* and a pair of graduate students at Dalhousie who desired to start a similar program in Nova Scotia. It is now primarily run out of the Department of Mathematics and Computing at Saint Mary's University in Halifax. Students compete in teams of four to solve collaborative problems in a variety of formats. There are three regular season games, held at various sites throughout the province, and a final league championship game that brings together the best teams invited from each region. The questions posed are not purely curriculum based and the question author succeeds in the difficult task of posing questions that are simultaneously accessible to high-school students, challenging enough to be non-trivial, and connected to some broader area of mathematics. In the Halifax region alone, regular season games draw upwards of 80 high-school students on a Saturday morning to do mathematics.

There is no doubt that the students attending these games are already motivated and skilled. They arrive with pockets of their brain full of snappy pop-math facts about prime numbers, divisibility algorithms and counting problems. Among them are the type who watch Numberphile videos on *YouTube* and have a basic understanding of the RSA algorithm. Assuredly some of them will one day become contributing mathematicians, whereas others will make meaningful impacts in other areas of arts and science. For these students, the Nova Scotia Math League is a chance to do some mathematics for fun while catching a glimpse of the larger world of mathematics beyond their high-school mathematics experience. For those attending games in some regions, there is also the added benefit of interaction with knowledgeable mathematicians. And it is in these brief interactions that I believe the students stand to gain the most.

Of course trying to engineer these interactions is difficult, but when accomplished the results can be outstanding. However, by putting mathematicians in a room with curious and primed students, the outcome is almost inevitable. Before this year the entirety of my outreach experience had only been with outreach events structured around a particular theme or topic and a classroom of students with various degrees of willingness to participate. Lending a hand with classroom visits and math camps, I am well-versed with the type of outreach event that runs similar to a well-run undergraduate tutorial — a well-meaning and motivated speaker stands in front of the room and presents a topic; students participate by being asked questions and then are set upon a particular task or problem set; there are tenuous claims made for the real-world applicability of the material and a hope that the dynamism of the speaker and the topic at hand is sufficient to spark a mind or two into thinking further about extensions of the material. I have personally experienced a variety of successes with this model (and some very memorable failures). The *Nova Scotia Math League* succeeds by flipping this model around and compressing interesting topics into short vignettes of problem, solution and broader context.

As a young researcher trying to navigate the liminal space between Ph.D. defence and full-time academic employment, I am thankful for the opportunity afforded to me by AARMS. The experiences I am having in the world of outreach certainly are informing my views on undergraduate education and the value of personal and authentic interaction between the learning and the learned. Outreach is often an understandably low priority for researchers. To find time between grant writing, student supervision, committee work, undergraduate teaching and, of course, research, is no easy task. Contributing to an outreach program is well worth it for anyone with even a few spare slices of available time. The value of having young students believe that studying mathematics is a viable option notwithstanding, the feeling of walking away from a conversation with a student and knowing that you have given them insight into something they likely wouldn't have encountered on their own stands as an unexpected validation in a vocation so often requiring periods of isolation for success.

More information about the *Nova Scotia Math League* and the multitude of other outreach programs in Atlantic Canada can be found at aarms.math.ca.

## Changing the way we think about mathematical ability

**Caroline Junkins**, *University of Western Ontario*
*cjunkins@uwo.ca*

As a mathematician, many people I meet feel compelled to share with me their feelings toward math, good or bad. They tell stories of teachers, tests, or trigonometry, and how these experiences shaped their opinions and emotions tied to the subject. Over the years I've noticed two common themes in these stories. The first is that the storyteller provides an assessment of their mathematical ability, usually a variation of either "I was always good at math; it just comes naturally to me", or "I am just not a math person; I didn't get the math gene". The second is that regardless of that assessment, the storyteller will offer a statement along the lines of "The nice thing about math is that every question has a right and wrong answer; there's no ambiguity and there's only one way to do it."

Through my experience with mathematics I have learned that the latter statement is far from the truth. In an early calculus course, we are taught that the important part of an exam question is the process, not the final answer, and that there can be various successful approaches to the same question. In more advanced courses, we see that some questions may not have answers at all (for example "What is the sum of a divergent series?"), or that we may choose to work under the assumption that something is true, even if we are unable to verify its truth with proof (the Riemann Hypothesis for example). Even when answers do exist, they can be dependent on context, wording, or the set of agreed-upon axioms with which we are working (How do *you* feel about invoking the Axiom of Choice?).

From the viewpoint of a *user* rather than a creator of mathematics, these ambiguities - and the fascinating beauty they bring with them - are hidden. If one is told to use a specific tool for a specific task, without consideration of the *why*'s and *how*'s of it all, the task becomes routine and mindless. Many people exit the world of mathematics without making the transition from user to creator, and I believe this contributes to the false belief that every question in math has a right and wrong answer.

I started thinking about other judgments we make as a society about mathematics. If we could be so wrong about the black-and-whiteness of math, could we also be wrong about our understanding of mathematical ability? Is mathematical ability an innate attribute determined by genetics? Or is it part of ourselves that can be cultivated over time? This time, my personal involvement with math does not yield a clear answer.

There are areas of math towards which I feel more drawn, where the proof techniques seem more intuitive and the results more meaningful. I feel more confident and competent working in these areas, and success seems to come more easily. Does this mean that I'm just inherently *more able* in these areas, and *less able* in others?

Last year I had the opportunity to teach a course in a subject which I despised as an undergraduate. When I first encountered the material, I found it pointless and incomprehensible. How was I expected to now teach this subject, and to convince my students that it was worth learning? Thankfully, this turned out to be a positive experience; when I returned to the material with a new perspective, it seemed completely different. Results and techniques which previously seemed arbitrary now made sense, and I was able to appreciate the importance of the subject to other fields.

What if I had simply written myself off as *less able* in this subject and avoided it for the rest of my life? This certainly wouldn't have done me, or my students, any good. It seems to me that if mathematical ability is something we can mould over time then adopting an attitude of being "just not a math person" is incredibly unhelpful. Likewise, labelling our students as either low- or high-ability could limit their chances for success, or set them up for unnecessary failures.

So, which is it? Is mathematical ability determined at birth or something we can change with motivation and effort? As far as the psychological community is concerned, this is still a fiercely debated topic (see Kovas, Harlaar, Petrill, & Plomin 2005; Sigmundsson, Polman, Lorås, 2013). Luckily, however, our conversation about mathematical ability doesn't have to end here. It turns out that we can become better teachers and learners by simply *believing* this ability is malleable.

When it comes to our personal views of intelligence or ability, a social-cognitive approach pioneered by Carol Dweck (Dweck & Leggett, 1988; Dweck, 1999) classifies people as either *entity theorists* or *incremental theorists.* Entity theorists believe that one's ability is determined at a young age - or even at birth - and will not change over time. On the other hand, incremental theorists believe that ability is shaped over time and can be cultivated through effort.

Research by Dweck and her colleagues over various studies has consistently shown that both theories are held in roughly equal numbers throughout the population (Dweck, 1999). Furthermore, students from both groups demonstrate equal levels of overall academic performance (Licht & Dweck, 1984; Dweck, 1999). These theories of fixed ability (entity theory) or malleable ability (incremental theory) have been applied to various human traits such as personality, moral character, intelligence, and academic ability within a specific domain, such as language or mathematics. An individual can hold different theories for different traits, for example believing that personality is malleable but mathematical ability is fixed, or vice versa (Dweck, 1999).

Incremental theorists place higher value on *learning goals,* which reflect a desire to acquire new skills, master new tasks, or understand new things (Dweck, 1999). As students, incremental theorists are more likely to choose challenging problems, to persist after failure, and to develop strategies for improvement. As instructors, incremental theorists are more likely to offer effective feedback in response to both successes and failures, and to avoid making negative judgments of students from one or two poor test scores (Rattan, Good & Dweck, 2012).

It seems that in every way, holding an incremental theory of ability is an adaptive strategy which leads to success in both teaching and learning. So why do so many people, including successful students and instructors, seem to instead hold an entity theory when it comes to mathematics?

Dweck and her colleagues showed that both entity theorists and incremental theorists can have high or low self-esteem, as well as high or low confidence in their abilities (Dweck, 1999). The difference is that for entity theorists, these feelings are tied to performance: to them, a grade is not just a reflection of their current effort or skill, but a judgment of their overall intelligence and potential. If an entity theorist receives a low grade on a particular test, they tend to feel devastated, hopeless, and depressed. In the future, they are more likely to shy away from challenging problems in that subject, or avoid the subject all together (Dweck, 1999). In a society where math anxiety is unfortunately so common, the entity theorist's reaction is an accepted one and provides an easy way to rationalize failures and avoid them in the future.

On the other hand, when an entity theorist receives a good grade, or praise for their intelligence, this validates and strengthens the belief that they are "good at math". Holding this belief allows the student to approach new problems with an expectation of success, and may give them a feeling of superiority over those who struggle with math. As long as the student keeps succeeding, their belief is never challenged and their self-confidence will continue to grow. An entity theory may give one a sense of security and stability (Dweck, 1999), and can be very attractive since the negative consequences of holding such a theory are only visible in the face of failure.

Failure, however, is an inevitable part of learning, and it is in our best interest to be as prepared as possible for when it occurs, either to us or to our students. By believing in an incremental theory of intelligence, or at least by reacting and proceeding as if we did, we can mitigate the negative emotions which accompany failure and create an opportunity for growth. Within an incremental framework, a failure can be acknowledged as a sign that increased effort or new learning strategies are required (Dweck, 1999). The student and instructor can work together to identify deficiencies and develop a plan for addressing them. A key benefit of working within an incremental framework is that we have a better chance of separating feelings of identity and self-worth from current performance.

If our society were to hold the view that mathematical ability is something that grows along with us, it is possible that more people could be encouraged to make the transition from user to creator of math. At the very least, the conversations we have about math could involve more than a simple declaration of one's own perceived ability.

To the person who tells me that math "just comes naturally", I could present challenging ideas or problems to expand their understanding without damaging their self-esteem; to the person who "didn't get the math gene", I could offer suggestions for reviewing concepts or studying more effectively without labelling them as low-ability. Math itself is certainly not a fixed entity, and our relationship with it should not be either.

## References

[1] Dweck, C. S. (1999). *Self-theories: Their role in motivation, personality, and development*. Philadelphia, PA: Psychology Press.

[2] Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*(2), 256-273.

[3] Kovas, Y., Harlaar, N., Petrill, S. A., & Plomin, R. (2005). 'Generalist genes' and mathematics in 7-year-old twins. *Intelligence, 33*(5), 256-273.

[4] Licht, B. G., & Dweck, C. S. (1984). Determinants of academic achievement: The interaction of children's achievement orientations with skill area. *Developmental Psychology, 20*, 628-636.

[5] Rattan, A., Good, C., & Dweck, C. S. (2012). "It's ok — not everyone can be good at math": Instructors with an entity theory comfort (and demotivate) students. *Journal of Experimental Social Psychology, 48*(3), 731-737.

[6] Sigmundsson, H., Polman, R. C. J., & Lorås. H. (2013). Exploring individual differences in children's mathematical skills: a correlational and dimensional approach. *Psychological Reports*, *113*(1), 23-30.


## 2017 CMS Winter Meeting

**December 8-11, 2017**
**University of Waterloo, Waterloo, Ontario**

## CALL FOR SESSIONS

The Canadian Mathematical Society (CMS) welcomes and invites proposals for sessions for the 2017 CMS Winter Meeting in Waterloo. 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. All 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 directors.

### Scientific Directors:

Ken Davidson, University of Waterloo, **krdavids@uwaterloo.ca**
Cam Stewart, University of Waterloo, **cstewart@uwaterloo.ca**

## Réunion d'hiver de la SMC 2017

**8-11 décembre 2017**
**Université de Waterloo, Waterloo, Ontario**

## NOUS VOUS INVITONS

La Société mathématique du Canada (SMC) vous invitent à proposer des séances pour la Réunion d'hiver de la SMC 2017 qui se tiendra à l'Université de Waterloo du 8 au 11 décembre 2017. Ces propositions de séances doivent presenter une brève description de l'orientation et des objectifs de la séance, le nombre de conférenciers prévu, de même que le nom, l'adresse complète, le numéro de téléphone et l'adresse électronique de l'organisateur. Toutes les séances seront annoncées dans les Notes de la SMC, sur le site Web SMC et dans les AMS Notices. Les conférenciers devront présenter un résumé, qui sera publié sur le site Web SMC et dans le programme de la réunion. Toute personne qui souhaiterait organiser une séance est priée de faire parvenir une proposition aux directeurs scientifiques.

### Directeurs scientifiques:

Ken Davidson, Université de Waterloo, **krdavids@uwaterloo.ca**
Cam Stewart, Université de Waterloo, **cstewart@uwaterloo.ca**

*Research Notes brings mathematical research ideas forth to the CMS readership in a generally accessible manner that promotes discussion of relevant topics including research (both pure and applied), activities, and noteworthy news items. Comments, suggestions, and submissions are welcome.*

**Patrick Ingram**, *York University (notes-research@cms.math.ca)*

*Les articles de recherche présentent des sujets mathématiques aux lecteurs de la SMC dans un format généralement accessible qui favorise les discussions sur divers sujets pertinents, dont la recherche (pure et appliquée), les activités et des nouvelles dignes de mention. Vos commentaires, suggestions et propositions sont le bienvenue.*

**Patrick Ingram**, *York University (notes-recherche@smc.math.ca)*

# The detection of gravitational waves

**Sanjeev S. Seahra**, *University of New Brunswick*

The rumours starting flying well before any of the press releases. The primary channel was Twitter, and after that blogs, and after that mainstream media outlets. As an outside observer, I first "heard" the news via Lawrence Krauss' well shared tweet: "Rumor of a gravitational wave detection at LIGO detector. Amazing if true. Will post details if it survives." That was in September of 2015, almost six months before the LIGO (Laser Interferometer Gravitational-Wave Observatory) collaboration had anything to say officially.

Immediately after the burst of interest in the fall, there was nothing much for several months. The next big leak came from a colleague's February email to his department; an email that graduate students immediately posted to Facebook, and which was subsequently re-posted by a number of websites. This one was a lot more specific: Two black holes, both roughly thirty times the mass of the sun collided and merged 1.3 billion years ago. The peak rate of energy emitted from the merger was greater than the average luminosity of the rest of the visible universe.

Finally the press conference was scheduled, and the online exuberance really began. A number of scientists recorded videos of themselves making bizarre chirping noises (meant to mimic the sound LIGO's output would make if connected to a loudspeaker). Poetic messages such as "Up to now, we have only seen the universe. Tomorrow, we will hear it for the first time" (David Spergel) began circulating. The "Einstein was right" headline was ubiquitous. During the press conference, somewhat bewildered reporters from our local newspaper began to email with a common theme: "Why are you guys making such a big deal about this?"

It is a fair question. The LIGO detection was that of gravitational waves; and gravitational waves are, after all, really quite old news in theoretical physics. Einstein predicted their existence shortly after he published his theory of gravity in 1915. The fact that gravity should travel in waves is obvious once one accepts the basic premise of special relativity: The arena for physics is a spacetime manifold of Lorentzian signature. Or, stated slightly differently, the laws of nature must be invariant under Lorentz transformations. These contain within them familiar three-dimensional rotations, plus a class of "hyperbolic rotations" that mix space and time coordinates called "boosts". For example, in a world with one spatial dimension, a Lorentz boost takes the form

$$\begin{pmatrix} ct' \\ x' \end{pmatrix} = \begin{pmatrix} \cosh\phi & \sinh\phi \\ \sinh\phi & \cosh\phi \end{pmatrix} \begin{pmatrix} ct \\ x \end{pmatrix}, \tag{1}$$

where $t$ is the time, $x$ is the spatial coordinate, and $c$ is the speed of light. Practically, Lorentz invariance means that physical laws involve differential operators that preserve their form under transformations like (1). This leads us to the conclusion that the speed of light is the same for every observer, irrespective of their state of motion.

Now, Newton's old model of gravity—which Einstein's theory supplanted—is governed by Poisson's equation. This is an elliptic partial differential equation (PDE) for the "gravitational potential" $\phi$:

$$\nabla^2\phi = 4\pi G\rho, \quad \nabla^2 = \partial_x^2 + \partial_y^2 + \partial_z^2, \tag{2}$$

where $(x, y, z)$ are Cartesian coordinates, $\rho$ is the density of matter, and $G$ is the gravitational constant. A quick calculation shows that this equation is not invariant under boosts, and hence is incompatible with special relativity.

To "fix" Newtonian gravity and make it Lorentz invariant, the simplest thing one can do (arbitrarily) is to modify the differential operator in Poisson's equation:

$$(-c^{-2}\partial_t^2 + \nabla^2)\phi = 4\pi G\rho. \tag{3}$$

It is easy to see that this equation is indeed invariant under Lorentz transformations, and is hence consistent with special relativity. But notice that by changing the operator, we have demanded that the gravitational potential is governed by a hyperbolic PDE, not an elliptic one. If such an equation were to be true, then we must conclude that gravitational disturbances can travel in waves moving at a finite speed $c$.

Of course, if the only content of general relativity (GR) was the swap $\nabla^2 \mapsto -c^{-2}\partial_t^2 + \nabla^2$, it is likely that the theory would not be a cornerstone of modern physics. In reality, GR is a highly nonlinear theory of gravity that reduces to something similar to (3) in the appropriate limit. Einstein's key insight when formulating the model is that gravitation was not really described by a Newtonian gravitational potential $\phi$, it was rather described by the curvature of a pseudo-Riemannian manifold. Furthermore, this curvature is related to the distribution of matter in the universe. Consistency with special relativity is guaranteed by differential geometry: within small subregions, the spacetime manifold is well-described by a flat geometry of *Lorentzian* signature.

Einstein also realized that one could recover the Newtonian potential by identifying it with deviations of the geometry from flatness. After some tedious work, he showed that the Einstein equation reduces precisely to (3) when the energy content of matter is not too high and the curvature is not too big. Hence, in GR the analogue of the gravitational potential obeys a wave equation, and wave like solutions for $\phi$ are called gravitational waves.

Now, we know from Newton that the acceleration of small objects due to gravity is given by the gradient of $\phi$. So, if $\phi$ is a wave periodic in space and time, it will induce accelerations of particles that are also periodic in space and time. This suggested to American and Soviet scientists in the 1960s that if one could measure the separations of a set of masses very precisely as a function of time, and a gravitational wave were to pass by, those separations would oscillate. The most exquisite technique we have for measuring time-dependant changes in distance is via laser interferometers, and hence the main idea for LIGO was born.

But of course, there was a catch. Equation (3) suggests that time varying matter densities $\rho$ produce gravitational waves. But the value of Newton's constant $G$ is really quite small, which means that process of converting matter motion into gravitational waves is inefficient; i.e., gravitational waves are intrinsically very weak. Practically, this means the response of a conventional interferometer to a realistic gravitational wave is incredibly tiny. The way to mitigate this is to build a very large interferometer. Constructing such a device is expensive and risky, which essentially explains why it took around 40 years between the proposal and construction of a large scale gravitational wave detector such as LIGO (whose arms are 4 km long).

Hence the big deal. We've been aware of the gravitational wave phenomena for 100 years. They are a natural consequence of a spacetime symmetry we believe is a fundamental part of Nature. Yet before September of 2015, there was no direct experimental "proof"—we had never seen a small particle being shaken back and forth by a travelling gravitational disturbance. Indirect evidence for their existence was plentiful and intellectually convincing, but tangible laboratory observation was lacking. The unambiguous detection in September represented the culmination of a decades long endeavour that had a nontrivial probability of failure.

So what's next? The last letter in LIGO stands for "observatory", which is precisely what the device aims to be. Gravitational waves represent only the second type of radiation that we have the capability of detecting (the first being light). Hence, a whole new window on the universe has been opened. Before September 2015, the community was preoccupied with confirming something we were certain of. Now, we can look forward to using gravitational waves to tell us things we don't already know.

## CMS Member Profile / Profil membre de la SMC

# Robert P. Morewood


**HOME:** Born in Quebec City, but now permanently planted in Vancouver, BC.

**WORK:** Visier Inc. (a business intelligence software company).

**CMS MEMBER SINCE:** 1981

**RESEARCH AREA(S):** Abstract Algebra (my thesis was on Kac-Moody Lie Algebras), Mathematics Education, and I've dabbled in Actuarial Mathematics.

**MOST MEMORABLE "MATH MOMENT":** Listening to a friend describe their difficulties with the constraints in re-sizing a custom knitting patterns and realizing "That's just linear algebra!", which resulted in my doing all their re-sizing for the next year!

**HOBBIES:** Ballroom Dancing (and home maintenance as well as some ineffectual gardening).

**LATEST BOOK READ:** The English translation of The Housekeeper and the Professor by Yoko Ogawa.

**LATEST PUBLICATION:** "Solving Impossible Equations" in Vector: Journal of the British Columbia Association of Mathematics Teachers, Volume 33, Number 3, pages 43-45. I don't do much traditional publishing! I have put a significant amount (of mostly elementary material) on the internet, a rather fickle, and often ephemeral, medium.

**WHAT I WOULD CHANGE (ABOUT THE CMS):** CMS does a lot to promote mathematics at the primary and secondary school levels, but I'd still like to see those schools aspire to more. I have observed some laudable egalitarian ideals distorted into discrimination against more talented students, even leading some to study abroad, to the impoverishment of the local community.

**CMS ROLES:** Mostly IMO trainer and Olympiad contest marker, occasional IMO Team Leader or Deputy Leader or Observer, and once Chair of the IMO committee. I also represented BC twice at the Canadian Math Education Forum.

**WHY I BELONG TO THE CMS:** Partially to support mathematics in Canada. Mostly to try and stay connected with the mathematics community. Of all the various society and association meetings I've attended (math teacher / physics teacher / mensa / actuarial / software / etc), the CMS meetings are the ones that I truly enjoy.

# Visualizing Imaginary Quadratic Fields

**Katherine E. Stange**, *University of Colorado*

Imaginary quadratic fields $\mathbb{Q}(\sqrt{-d})$, for integers $d > 0$, are perhaps the simplest number fields after $\mathbb{Q}$. They are equal parts helpful first example and misleading special case. Like $\mathbb{Z}$, the Gaussian integers $\mathbb{Z}[\mathrm{i}]$ (the case $d = 1$) have unique factorization and a Euclidean algorithm. As $d$ grows, however, these properties eventually fail, first the latter and then the former.

The classical Euclidean algorithm (in $\mathbb{Z}$) expresses any element of $\mathrm{SL}_2(\mathbb{Z})$ as a product of elementary matrices in $\mathrm{SL}_2(\mathbb{Z})$. It is remarkable that among number fields $K$ (whose rings of integers we denote $\mathcal{O}_K$), $\mathrm{SL}_2(\mathcal{O}_K)$ fails to be generated by elementary matrices exactly when $K$ is a non-Euclidean imaginary quadratic field [1, 10].

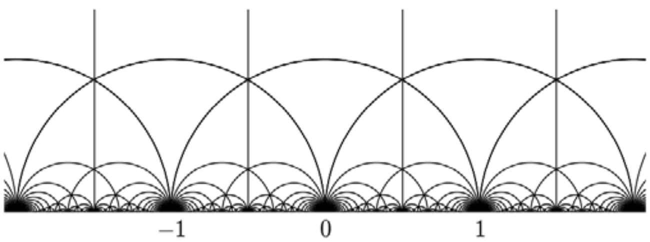



**Figure 1.** The upper half plane, tiled by images of a fundamental region for $\mathrm{PSL}_2(\mathbb{Z})$.

A particularly useful way to visualize the group $\mathrm{SL}_2(\mathbb{Z})$, or $\mathrm{PSL}_2(\mathbb{Z})$, is to study its action as Möbius transformations on the upper half plane, as in Figure 1. To study the *Bianchi group* $\mathrm{PSL}_2(\mathcal{O}_K)$, when $K$ is imaginary quadratic, consider instead the upper half space $H^3$ lying above the complex plane. This is a model of hyperbolic space with boundary $\widehat{\mathbb{C}} = \mathbb{C} \cup \{\infty\}$. The hyperbolic isometries of this model are exactly the Möbius transformations, extended from $\widehat{\mathbb{C}}$. Each Bianchi group forms a discrete subgroup of hyperbolic isometries; in other words it is a *Kleinian group*. In analogy to Figure 1, each has a 3-dimensional fundamental region.

For today, however, let us focus on the boundary: consider the orbit of $\widehat{\mathbb{R}} = \mathbb{R} \cup \{\infty\} \subseteq \widehat{\mathbb{C}}$. Möbius transformations take circles (including $\widehat{\mathbb{R}}$, a circle through $\infty$) to other circles. The full orbit of $\widehat{\mathbb{R}}$ is dense in the plane, but if we restrict ourselves to drawing only those circles having bounded curvature (recall that curvature is the reciprocal of radius), we obtain intricate images such as in Figure 2.

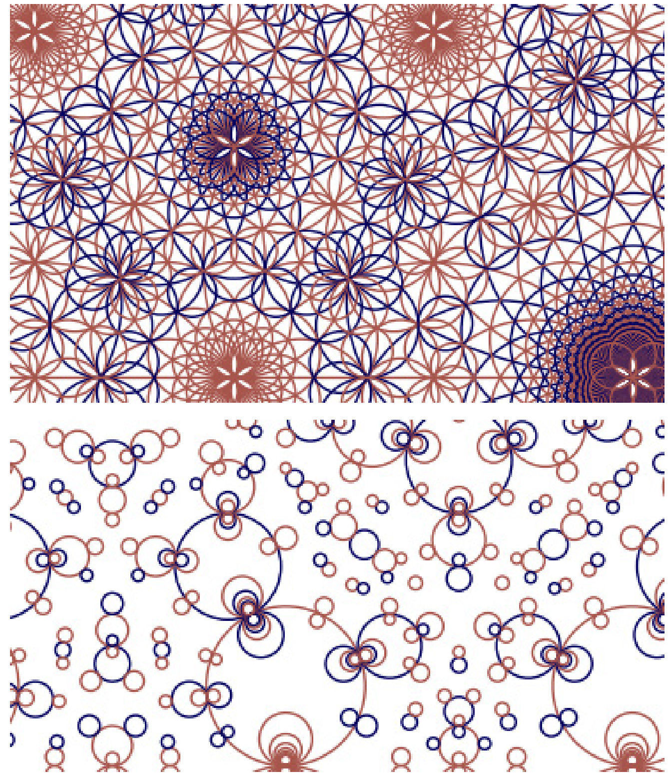


**Figure 2.** Schmidt arrangements of $\mathbb{Q}(\sqrt{-3})$ and $\mathbb{Q}(\sqrt{-19})$. Both fields are class number one; only the former is Euclidean. Colour indicates the parity of the curvature.

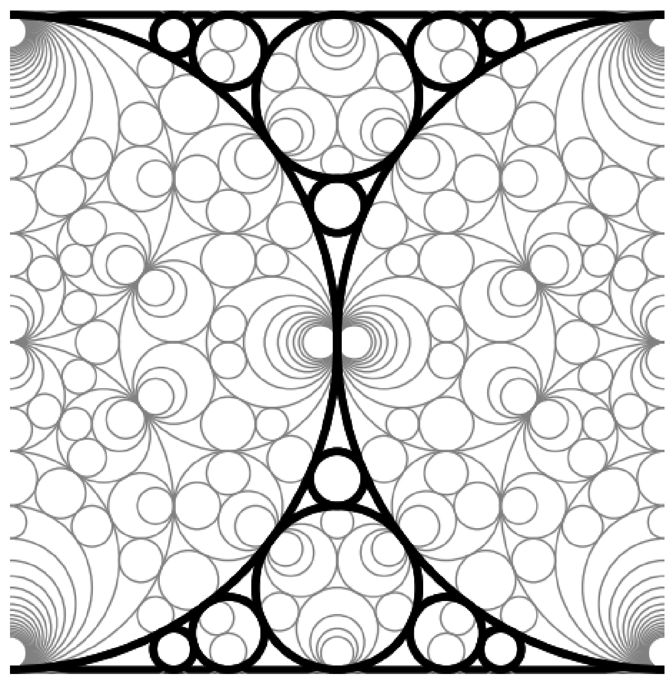


**Figure 3.** The unit square of $\mathcal{S}_{\mathbb{Q}(i)}$, showing curvatures $\leq 20$, with the Apollonian strip packing in bold. In each pencil of circles tangent at a point, a circle has an `immediate neighbour,' being the closest circle in the pencil, with disjoint interior. Apollonian circle packings are obtained by taking the closure of any one circle under such 'immediate tangency' [8].

We will call this the Schmidt arrangement $\mathcal{S}_K$ of $K$, for Asmus Schmidt's work on complex continued fractions, in which this picture first appears [6]. Schmidt's viewpoint is that the recursive subdivision of $\widehat{\mathbb{C}}$ into circles and triangles shown in Figure 3 is the natural analogue of the Farey subdivision of the real line. To approximate a complex number with Gaussian Farey fractions, one describes its 'address' in the Schmidt arrangement; nearby tangency points are good approximations.

Schmidt arrangments have a number of nice properties. After an appropriate scaling, all curvatures (inverse radii) are integral. Circles intersect only tangently, in all cases except the Eisenstein integers (where extra roots of unity add complication). At each $K$-rational point in $\widehat{\mathbb{C}}$, there is a pencil of circles whose curvatures form an arithmetic progression whose common difference is the norm of the denominator of the point. See [7].

The geometry of the Schmidt arrangement is controlled by the arithmetic of the field. For example, one can `move' from circle to tangent circle by the use of elementary matrices in the Bianchi group, so one can see the Euclidean algorithm:

**Theorem 0.1** (S. [7, Theorem 1.5]). $\mathcal{O}_K$ is Euclidean if and only if $\mathcal{S}_K$ is connected.

The circles themselves represent certain ideal classes.

**Theorem 0.2** (S. [7, Theorem 1.4]). Let $f \geq 1$ be an integer, and let $\mathcal{O}_f$ be the order of conductor $f$ in $K$. Circles of curvature $f\sqrt{-\Delta}$ in $\mathcal{S}_K$ (where $3 \neq \Delta < 0$ is the discriminant of $K$ ), up to translation by $\mathcal{O}_K$ and rotation by 180 degrees, are in bijection with the kernel of the natural map of ideal class groups $\mathrm{Pic}(\mathcal{O}_f) \to \mathrm{Pic}(\mathcal{O}_K)$.

In fact, a circle of curvature $f$ obtained by applying

$$\begin{pmatrix} \alpha & \gamma \\ \beta & \delta \end{pmatrix} \in \mathrm{PSL}_2(\mathcal{O}_K)$$

to $\widehat{\mathbb{R}}$ corresponds to the ideal class of $\mathcal{O}_f$ generated by the lattice $\beta\mathbb{Z} + \delta\mathbb{Z}$, which has covolume $f$.

The author's interest in Schmidt arrangements arose from the study of Apollonian circle packings; see Figure 4. There are many examples of Apollonian circle packings whose circles have only integer curvatures; it is conjectured that, except for certain congruence conditions, all sufficiently large integers appear in any such packing [3, 4]. The Apollonian group, which controls the curvatures, is a thin subgroup of $O_{3,1}$, and it represents the principle test case for new methods in thin groups. For an excellent overview, see [2].

The connection is that $\mathcal{S}_{\mathbb{Q}(i)}$ appeared, independently, in work of Graham, Lagarias, Mallows, Wilks and Yan as an *Apollonian super-packing* [5]. In general, it is possible to isolate an Apollonian-like circle packing – and therefore a thin subgroup of $\mathrm{PSL}_2(\mathcal{O}_K)$ of arithmetic interest – using the simple geometric criterion of Figure 3. See Figure 5, and [8].

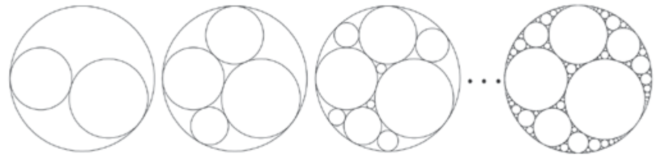


**Figure 4.** The iteration process generating an Apollonian circle packing from three mutually tangent circles.

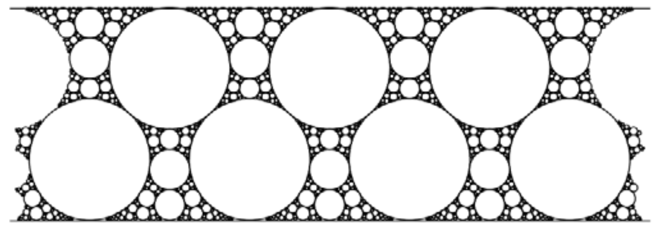


**Figure 5.** The $\mathbb{Q}(\sqrt{-7})$-Apollonian packing.

**A note on figures.** The figures in this document were produced using Sage Mathematics Software [9].

## References


[1] P.M. Cohn. On the structure of the $\mathrm{GL}_2$ of a ring. *Inst. Hautes Études Sci. Publ. Math.*, (30):5–53, 1966.

[2] Elena Fuchs. Counting problems in Apollonian packings. *Bull. Amer. Math. Soc. (N.S.)*, 50(2):229–266, 2013.

[3] Elena Fuchs and Katherine Sanden. Some experiments with integral {A}pollonian circle packings. *Exp. Math.*, 20(4):380–399, 2011.

[4] Ronald L. Graham, Jeffrey C. Lagarias, Colin L. Mallows, Allan R. Wilks, and Catherine H. Yan. Apollonian circle packings: number theory. *J. Number Theory*, 100(1):1–45, 2003.

[5] Ronald L. Graham, Jeffrey C. Lagarias, Colin L. Mallows, Allan R. Wilks, and Catherine H. Yan. Apollonian circle packings: geometry and group theory. {II}. Super-Apollonian group and integral packings. *Discrete Comput. Geom.*, 35(1):1–36, 2006.

[6] Asmus L. Schmidt. Diophantine approximation of complex numbers. *Acta Math.*, 134:1–85, 1975.

[7] Katherine E. Stange. Visualising the arithmetic of imaginary quadratic fields, 2014. **http://arxiv.org/abs/1410.0417** arXiv:1410.0417.

[8] Katherine E. Stange. The Apollonian structure of Bianchi Groups, 2015. **http://arxiv.org/abs/1505.03121** arXiv:1505.03121.

[9] W.A. Stein et al. *Sage Mathematics Software (Version 6.4).* The Sage Development Team, 2015. **http://www.sagemath.org**.

[10] L. N. Vaseršteĭn. The group $SL_2$ over Dedekind rings of arithmetic type. *Mat. Sb. (N.S.)*, 89(131):313–322, 351, 1972.

*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 présentent 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)*

# How Objects Reveal Mathematical Culture

**Sylvia Nickerson**, *York University*

In November 2015 I presented a paper about John C. Fields and his role in bringing about the first International Mathematical Congress (IMC) hosted in Canada. (See in this connection David Orenstein's column in CMS *Notes*, June 2016.) My talk discussed Fields' involvement in the conference and in the publication of its proceedings: two large, heavy, table-sized volumes filled with mathematical papers by participants from diverse fields and national contexts. I examined the *Proceedings of the International Mathematical Congress, Toronto, 1924* not for its mathematical content but for what other stories this "object" might tell.

I argued that this set of *Proceedings* was not primarily a communication device but rather the result of Fields' wish to use the research presented at IMC to build capacity for Canadian mathematics. For instance, the publication of the *Proceedings* trained the University of Toronto Press—then a relatively new printer/publisher—in the difficult craft of mathematical printing with individual pieces of moveable type. Access to skilled craftspeople who could translate formulas into printed mathematics was an important ingredient for a local culture of mathematics to rise. Indeed, it wasn't long after the *Proceedings* that the University of Toronto Press became a source of mathematical publications, including textbooks, monographs, and the *Canadian Journal of Mathematics* (launched in 1949).

Models credit to Ashley Goodfellow Craig, photographer

**Figure 1** One case of geometrical models on display at the University of Toronto. Photo by author.

After my talk, I found myself in conversation with David Pantalony, curator at the *Canada Science and Technology Museum (CSTM)* in Ottawa, and Erich Weidenhammer, coordinator at the University of Toronto Scientific Instruments Collection (UTSIC), about whether Fields might have brought to Canada some of the geometrical models in UT's collection. These items present another opportunity for considering how objects arise from, and serve within, mathematical practice. Geometrical models are invested with mathematical meaning, but they are also aesthetically pleasing objects produced by artisans and craftspeople.

Several historians of mathematics are exploring this aspect of material culture. For example, Peggy Aldrich Kidwell and David L. Roberts have written extensively about geometrical models owned by the Smithsonian Institution. June Barrow-Green is writing a history of Olaus Henrici's models that were displayed before the London Mathematical Society, while David E. Rowe is working on the relationship between Alexander Brill's models and research in geometry in the late 19th century. Marjorie Senechal is contemplating crystallographic models. Weidenhammer is in the process of cataloguing UT's collection of geometrical models for the UTSIC website, **utsic.escalator.utoronto.ca**.

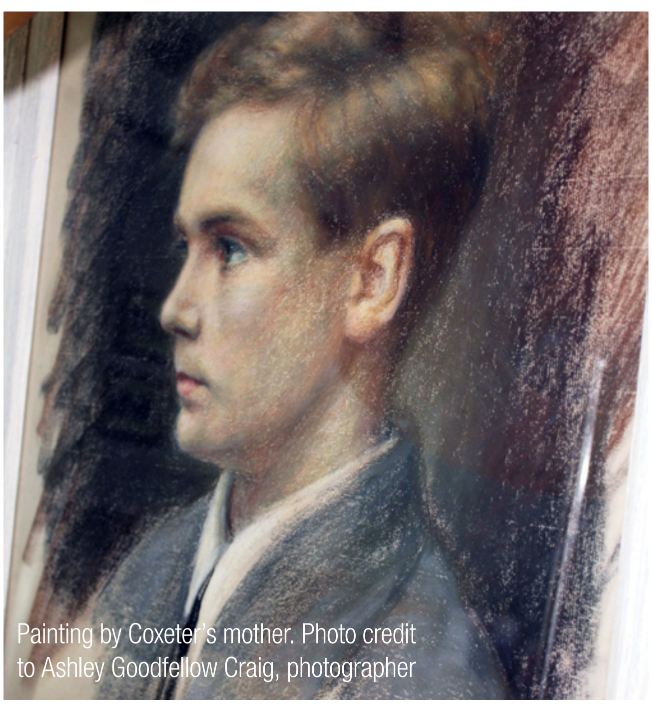
Intrigued by what I could discover locally about models, I headed to UT. There I found a beautiful display in several glass cabinets of perhaps one hundred geometrical models of various materials, sizes, and styles. While any connections to Fields remain unknown, many of the objects are known to have belonged to the renowned geometer Donald Coxeter.

Siobhan Roberts' 2006 *King of Infinite Space* explains that Coxeter acquired some of his models through correspondence. For example, Father Magnus Wenninger, a Benedictine monk, became a prolific model-maker after reading Coxeter's *Mathematical Recreations and Essays*. He produced roughly five hundred models a year for over forty years, and shared some of them with Coxeter (Roberts, p. 351, n. 53). George Odom from New York was a regular correspondent; "with nearly every letter [he] sent a model" (p. 223), including an interlocking shape of four hollow triangles. Former students Erik Moorhouse, Bruce Chilton, and George Olshevsky built models for Coxeter, as did amateur geometer Dorman Luke (Pantalony, p.15). The sculptor John Robinson was another correspondent who built objects inspired by Coxeter's mathematics.

**Figure 2** Coxeter models in Weiss's office at York. Photo by author.

M. C. Escher's *Circle Limit III* was inspired by Coxeter's 1957 presidential address to the Royal Society of Canada, "Symposium on Symmetry". Interestingly, Escher created his art through intuitive craft methods, not formal mathematical techniques. Upon getting a copy of *Circle Limit III*, Coxeter analyzed it and revealed that Escher had created the shape by connecting the lines of equidistant curves that cut through corresponding vertices of the underlying octagonal tessellation. Escher's form was not the product of hyperbolic lines, as Coxeter first assumed (Roberts, p. 228). Coxeter's study of Escher's art object thus resulted in a fresh mathematical insight, enabling him to provide a more elementary, Euclidean description of this design.

Coxeter's last PhD student, Asia Ivić Weiss, also has a collection of Coxeter's models. These have been on display in the mathematics department at York University, Toronto. On a visit there I took photos of objects in her office and in the glass cabinet in the departmental lounge. By the time this article appears, these models will have been acquired by the CTSM, where, Pantalony says, their delicate paper constructions will receive conservation and preservation treatment.



Painting by Coxeter's mother. Photo credit to Ashley Goodfellow Craig, photographer

Mathematical artifacts from ancient times are often looked upon for what they can tell us about mathematical culture. Mathematicians and historians expect them to provide evidence because written records are often scanty. However, artifacts from the modern period can be mined just as deeply for stories about how mathematical culture is defined and revealed. To use some of this research in your classroom, see the lists of resources cited below and in Amy Ackerberg-Hastings' column in the March/April 2015 issue of these *Notes*. To purchase geometrical models made today with a 3D printer, see **blog.mo-labs.com/**.

## References

[1] Fields, J.C., ed. *Proceedings of the International Mathematical Congress, Toronto, August 11–16, 1924.* 2 vol. Toronto: The University of Toronto Press, 1928. **www.mathunion.org/ICM/**.

[2] Pantalony, David. "H.S.M. Coxeter's Unusual Collection of Geometric Models." *Rittenhouse: Journal of the American Scientific Instrument Enterprise* 15, no. 1 (2001): 11–20.

[3] Roberts, Siobhan. *King of Infinite Space: Donald Coxeter, the man who saved geometry.* House of Anansi Press, 2006.

[4] Ashley Goodfellow Craig, "York prof donates important geometric models to Canada Science & Technology Museum," *yFile*, 3 June 2016, **yfile.news.yorku.ca/2016/06/03/york-prof-donates-important-geometric-models-to-canadian-science-and-technology-museum/**

## Online Collections of Geometrical Models

[1] Altgeld Math Models, University of Illinois: **www.mathmodels.illinois.edu/cgi-bin/cview?SITEID=4&ID=342**.

[2] Canada Science and Technology Museum: **techno-science.ca/en/collection-research/collection.php?q=*&fq=Mathematics&limit=20&sort=**.

[3] Julius Plücker Collection, London Mathematical Society: **www.lms.ac.uk/content/plucker-collection**.

[4] National Museum of American History: **americanhistory.si.edu/collections/object-groups/geometric-models** and **americanhistory.si.edu/collections/object-groups/maa-charter**.

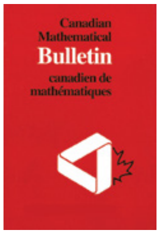
[5] University of Arizona Department of Mathematics: **math.arizona.edu/~models/**.

[6] University of Oxford Mathematical Institute: **www.maths.ox.ac.uk/about-us/history/models-geometric-surfaces**.

*Sylvia Nickerson (nickerso@yorku.ca) is a postdoctoral research fellow in the Science and Technology Studies department at York University. Her research looks at the material culture of mathematics and the book and print culture of science in the modern period. She also works on the John Tyndall Correspondence Project, collecting and transcribing the lifetime correspondence of this 19th-century experimental physicist.*

CMS Notes
Volume 48 No. 4, September 2016

# Call for Nominations — CJM/CMB Associate Editors


The Publications Committee of the CMS solicits nominations for 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, 2017. The current 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-2016@cms.math.ca** **before September 15th 2016.**

## 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 |
| Jason Bell (Waterloo) | 12/2020 | Associate Editor |
| Hans Boden (McMaster) | 12/2020 | Associate Editor |
| Alexander Brudnyi (Calgary) | 12/2020 | Associate Editor |
| Florin Diacu (Victoria) | 12/2016 | Associate Editor |
| Ilijas Farah (York) | 12/2020 | Associate Editor |
| Ailana Fraser (UBC Vancouver) | 12/2020 | 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 |
| Anthony To-Ming Lau (Alberta) | 12/2016 | Associate Editor |
| Alexander Litvak (Alberta) | 12/2016 | Associate Editor |
| Javad Mashreghi (Laval) | 12/2020 | Associate Editor |
| Marco Merkli (Memorial) | 12/2020 | Associate Editor |
| Assaf Naor (Princeton) | 12/2018 | Associate Editor |
| Erhard Neher (Ottawa) | 12/2016 | Associate Editor |
| Nilima Nigam (Simon Fraser) | 12/2020 | 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 |

# Appel à candidatures — Rédacteur(trice) associé(e) pour le JCM et le BCM

Le Comité des publications de la SMC sollicite des mises en candidatures pour des 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 2017. Les membres actuels (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-2016@smc.math.ca** **au plus tard le 15 septembre 2016.**

## 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 |
| Jason Bell (Waterloo) | 12/2020 | Rédacteur associé |
| Hans Boden (McMaster) | 12/2020 | Rédacteur associé |
| Alexander Brudnyi (Calgary) | 12/2020 | Rédacteur associé |
| Florin Diacu (Victoria) | 12/2016 | Rédacteur associé |
| Ilijas Farah (York) | 12/2020 | Rédacteur associé |
| Ailana Fraser (UBC Vancouver) | 12/2020 | Rédactrice associée |
| 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 |
| Anthony To-Ming Lau (Alberta) | 12/2016 | Rédacteur associé |
| Alexander Litvak (Alberta) | 12/2016 | Rédacteur associé |
| Javad Mashreghi (Laval) | 12/2020 | Rédacteur associé |
| Marco Merkli (Memorial) | 12/2020 | Rédacteur associé |
| Assaf Naor (Princeton) | 12/2018 | Rédacteur associé |
| Erhard Neher (Ottawa) | 12/2016 | Rédacteur associé |
| Nilima Nigam (Simon Fraser) | 12/2020 | Rédactrice associée |
| 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 |

# Math Team Canada 2016 places 12th at the International Mathematical Olympiad

Six Canadian high school students are celebrating their 12th place success upon their return from the 57th International Mathematical Olympiad (IMO) in Hong Kong.

Each student earned an award for Canada after competing against over 600 students at the world's most challenging high school mathematics competition. Both **Kevin Sun** (Phillips Exeter Academy, Exeter, NH, USA) and **William Zhao** (Richmond Hill High School, Richmond Hill, Ont.) were awarded with gold medals, **Kai Sun** (A.B. Lucas Secondary School, London, Ont.) and **Qi Qi** (Phillips Exeter Academy, Exeter, NH, USA) were awarded with silver medals, **Ruizhou Yang** (University Hill Secondary School, Vancouver, B.C.) was awarded with a bronze medal and **Andrew Lin** (University Hill Secondary School, Vancouver, B.C.) was awarded an honourable mention.

Kevin Sun's gold medal pushed him into the top echelon of high school mathematics with the IMO ranking him as the 17th best mathematics student in the world. Additionally, William Zhao, a grade 9 student, was the youngest participant to win a gold medal and Qi Qi was ranked as the highest scoring female participant in the competition.

Math Team Canada was selected through several CMS competitions, including the Sun Life Financial Canadian Mathematical Olympiad. Under the direction of Robert Morewood (Team Leader), Hunter Spink (Deputy Team Leader) and Patrick Lopatto (Deputy Team Observer), the members of Math Team Canada 2016 trained for two weeks at the Banff International Research Station (BIRS), before travelling to Hong Kong.

Canada's success at the IMO would not be possible without the assistance of our corporate and provincial sponsors, particularly Sun Life Financial, as well as CAE, Invention Development Fund, McLean Foundation, Government of Manitoba, Government of the Northwest Territories, Government of Nova Scotia, Government of Ontario, Government of Prince Edward Island, the Banff International Research Station (BIRS), Le centre de recherches des mathematiques (CRM), the Fields Institute, the Pacific Institute for Mathematical Sciences (PIMS) and York University.

# Équipe Math Canada au 12e rang à l'Olympiade internationale de mathématiques 2016

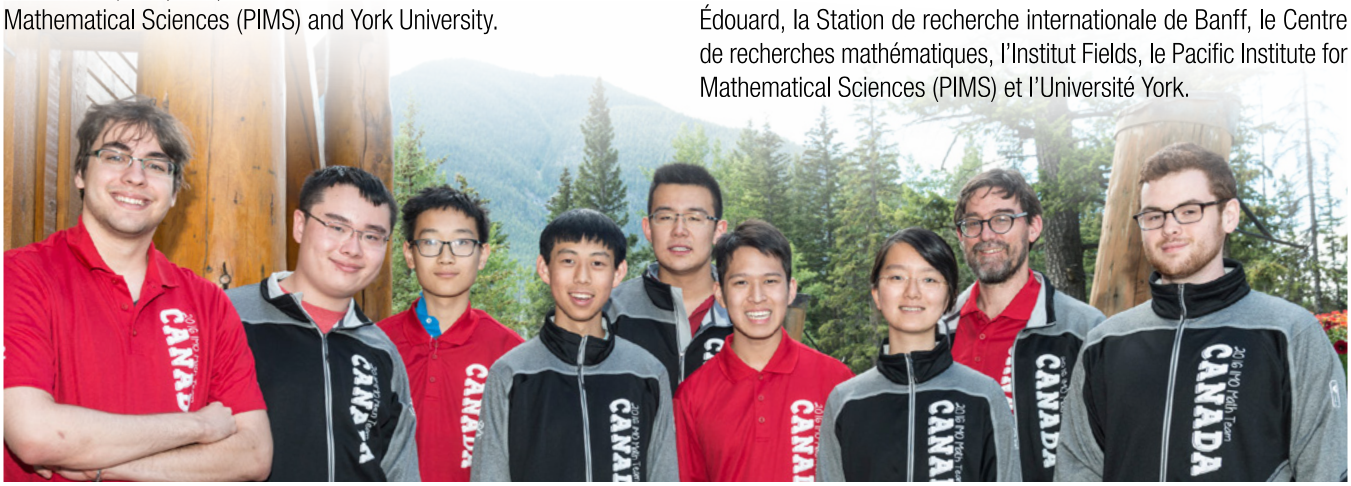
De retour de la 57e Olympiade internationale de mathématiques (OIM) tenue à Hong Kong, six élèves d'écoles secondaires canadiennes célèbrent leur 12e place.

Chacun a remporté une médaille pour le Canada après s'être mesuré à plus de 600 élèves dans le cadre du concours de mathématiques le plus difficile du monde pour les élèves de niveau secondaire. **Kevin Sun** (Phillips Exeter Academy, Exeter, NH, É.-U.) et **William Zhao** (Richmond Hill High School, Richmond Hill, Ont.) ont reçu des médailles d'or; **Kai Sun** (A.B. Lucas Secondary School, London, Ont.) et **Qi Qi** (Phillips Exeter Academy, Exeter, NH, É.-U.), des médailles d'argent; **Ruizhou Yang** (University Hill School Secondary, Vancouver, C.-B.), une médaille de bronze; et **Andrew Lin** (University Hill School Secondary, Vancouver, C.-B.), une mention honorable.

La médaille d'or de Kevin Sun l'a poussé dans le peloton de tête des mathématiques du secondaire, l'OIM le classant au 17e rang des meilleurs élèves en mathématiques au monde. En outre, William Zhao, qui n'est qu'en 9e année, était le plus jeune participant à remporter une médaille d'or, et Qi Qi a obtenu la meilleure note des élèves féminines participant à cette Olympiade.

Les membres d'Équipe Math Canada ont été sélectionnés d'après leurs résultats à plusieurs concours de la SMC, dont l'Olympiade mathématique du Canada Financière Sun Life. Sous la direction de Robert Morewood (chef d'équipe), Hunter Spink (chef d'équipe adjoint) et Patrick Lopatto (observateur adjoint), les membres d'Équipe Math Canada 2016 se sont entraînés pendant deux semaines à la Station de recherche internationale de Banff avant de se rendre à Hong Kong.

Le succès du Canada à l'OMI serait impossible sans le soutien de nos commanditaires privés et provinciaux. La SMC souhaite remercier sincèrement la Financière Sun Life, commanditaire en titre d'Équipe Math Canada 2016. La Société remercie également de leur aide CAE, Invention Development Fund, la Fondation McLean, les gouvernements du Manitoba, des Territoires du Nord-Ouest, de la Nouvelle-Écosse, de l'Ontario et de l'Île-du-Prince-Édouard, la Station de recherche internationale de Banff, le Centre de recherches mathématiques, l'Institut Fields, le Pacific Institute for Mathematical Sciences (PIMS) et l'Université York.




## December 2-5, 2016

Site: Sheraton on the Falls, Niagara Falls (Ontario)

**cms.math.ca/events/winter16**

## 2-5 décembre 2016

Site: Sheraton on the Falls, Niagara Falls (Ontario)

**smc.math.ca/reunions/hiver16**

## Prizes | Prix

### Adrien Pouliot Award | Prix Adrien-Pouliot
recipient to be announced | lauréat à confirmer

### Doctoral Prize | Prix de doctorat
Vincent X. Genest (MIT)

### G. de B. Robinson Award | Prix G. de B. Robinson
recipient to be announced | lauréat à confirmer

### Public Lectures | Conférence publiques
to be announced | à venir

### 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
Daniel Wise (McGill)

### Coxeter-James Prize and Lecture | Prix Coxeter-James et conférence
Louigi Addario-Berry (McGill)

### Plenary Lectures | Conférences plénières
to be announced | à venir

### Scientific Directors | Directeurs scientifique
Hans Boden, McMaster University, boden@mcmaster.ca
Bartosz Protas, McMaster University, bprotas@mcmaster.ca

## Supported by | Soutenu par

pims FIELDS CRM AARMS

## Related Events | Événements liés

The Canadian Mathematical Society invites you to their **awards banquet** on Saturday, December 3, to highlight exceptional performance in the area of mathematical research and education. Prizes will be awarded during the event taking place at Elements on the Falls Restaurant.

The **CMS Town Hall** meeting will occur on Sunday, December 4, 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 Société mathématique du Canada vous invite à son **banquet** le samedi 3 décembre pour souligner des contributions exceptionnelles en recherche mathématique et en enseignement des mathématiques. Les prix seront remis durant la soirée, qui se déroulera au restaurant Elements on the Falls.

La **Séance de discussion de la SMC** auront lieu le samedi 4 décembre, à partir de 12h30-14h00. 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.


## Regular Sessions | Sessions générales

### Analytic number theory | Théorie analytique des nombres
Patrick Ingram and Youness Lamzouri (York University)

### Combinatorial Algebraic Geometry | Géométrie algébrique combinatoire
Kiumars Kaveh (University of Pittsburgh) and Frank Sottile (Texas A&M University)

### Combinatorial, Geometric, and Computational Aspects of Optimization | Optimisation: aspects combinatoire, géométrique et calculatoire
Antoine Deza (McMaster), Ricardo Fukasawa and Laura Sanita (Waterloo)

### Complex Analysis and Applications | Analyse complexe et applications
Maxime Fortier Bourque (University of Toronto) and Malik Younsi (Stony Brook University)

### Financial Mathematics | Mathématiques financières
Petar Jevtic and Traian Pirvu (McMaster), and Adam Metzler (Wilfred Laurier)

### Fractal Geometry, Analysis, and Applications| Géométrie fractale, analyse, et applications
Franklin Mendivil (Acadia) and József Vass (York)

### Geometric Group Theory and Topology in Low Dimensions | Théorie des groupes géométriques et topologie en basses dimensions
Adam Clay (University of Manitoba) and Ying Hu (UQÀM)

### Geometric PDEs, the Einstein equation, and mathematical relativity | Équations aux dérivées partielles géométriques, équation d'Einstein et relativité mathématique
Hari Kunduri (Memorial University) and Eric Woolgar (University of Alberta)

### Geometry and Topology in Low Dimensions: Interactions with Floer theory | Géométrie et topologie en basses dimensions : interactions avec la théorie de Floer
Cagatay Kutluhan (University of Buffalo) and Liam Watson (Sherbrooke University)

### History and Philosophy of Mathematics | Histoire et philosophie des mathématiques
Maritza M. Branker (Niagara University)

### Improving success rates in first year calculus | Améliorer le taux de réussite en première année de calcul différentiel et intégral
Jaimal Thind and Maria Wesslén (University of Toronto)

### Integrable systems and applications | Systèmes intégrables et applications
Stephen Anco (Brock University) and Gino Biondini (University of Buffalo)

### Large Scale Optimization: Theory, Algorithms and Applications | Optimisation à grande échelle : théorie, algorithmes et applications
Heinz Bauschke (University of British Columbia, Kelowna) and Henry Wolkowicz (University of Waterloo)

### Mathematical Logic | Logique mathématique
Bradd Hart and Matthew Valeriote (McMaster)

### Mathematical Population Biology | Biologie mathématique des populations
Ben Bolker, Jonathan Dushoff and David Earn (McMaster University)

### Matrix Theory | Théorie matricielle
Hadi Kharaghani (University of Lethbridge) and Javad Mashreghi (Université Laval)

### Optimization Techniques in Quantum Information Theory | Techniques d'optimisation en théorie de l'information quantique
Nathaniel Johnston (Mount Allison University), Rajesh Pereira (University of Guelph) and Sarah Plosker (Brandon University)

### Recent Advances in Commutative Algebra | Percées récentes en algèbre commutative
Sara Faridi (Dalhousie University), Federico Galleto (McMaster University) and Adam Van Tuyl (McMaster University)

### Stochastic Properties of Dynamical Systems | Propriétés stochastiques des systèmes dynamiques
Jacopo De Simoi and Ke Zhang (Toronto), and HongKun Zhang (Massachusetts Amherst)

### Symmetry, Dynamics, and Bifurcations in Functional Differential Equations | Symétrie, dynamique et bifurcations dans les équations différentielles fonctionnelles
Israel Ncube (Alabama A&M University)

### AARMS-CMS Student Poster Session | Présentations par affiches des étudiants - AARMS-SMC
Svenja Huntemann (Dalhousie) and Aaron Berk (University of British Columbia)

### Contributed Papers | Communications libres
Organizer to be announced | Organisateur à venir

## Call for Nominations – CMS Research Prizes

The CMS Research Committee is inviting nominations for three prize lectureships. These prize lectureships are intended to recognize members of the Canadian mathematical community.

The ***Coxeter-James Prize*** Lectureship recognizes young mathematicians who have made outstanding contributions to mathematical research. The recipient shall be a member of the Canadian mathematical community. Nominations may be made up to ten years from the candidate's Ph.D. A nomination can be updated and will remain active for a second year unless the original nomination is made in the tenth year from the candidate's Ph.D. For more information, visit: **https://cms.math.ca/Prizes/cj-nom**

The ***Jeffery-Williams Prize*** Lectureship recognizes mathematicians who have made outstanding contributions to mathematical research. The recipient shall be a member of the Canadian mathematical community. A nomination can be updated and will remain active for three years. For more information: **https://cms.math.ca/Prizes/jw-nom**

The ***Krieger-Nelson Prize*** Lectureship recognizes outstanding research by a female mathematician. The recipient shall be a member of the Canadian mathematical community. A nomination can be updated and will remain active for two years. For more information: **https://cms.math.ca/Prizes/kn-nom**

The deadline for nominations, including at least three letters of reference, is **September 30, 2016**. Nomination letters should list the chosen referees and include a recent curriculum vitae for the nominee. Some arms-length referees are strongly encouraged. Nominations and the reference letters from the chosen referees should be submitted electronically, preferably in PDF format, to the corresponding email address and **no later than September 30, 2016 :**

Coxeter-James: **cjprize@cms.math.ca**
Jeffery-Williams: **jwprize@cms.math.ca**
Krieger-Nelson: **knprize@cms.math.ca**

## Appel de mises en candidature – Prix de recherche de la SMC

Le Comité de recherche de la SMC lance un appel de mises en candidatures pour trois de ses prix de conférence. Ces prix ont tous pour objectif de souligner l'excellence de membres de la communauté mathématique canadienne.

Le ***Prix Coxeter-James*** rend hommage aux jeunes mathématiciens qui se sont distingués par l'excellence de leur contribution à la recherche mathématique. Cette personne doit être membre de la communauté mathématique canadienne. Les candidats sont admissibles jusqu'à dix ans après l'obtention de leur doctorat. Toute mise en candidature est modifiable et demeurera active l'année suivante, à moins que la mise en candidature originale ait été faite la 10$^{e}$ année suivant l'obtention du doctorat. Pour les renseignements, voir : **https://cms.math.ca/Prix/cj-nom**

Le ***Prix Jeffery-Williams*** rend hommage aux mathématiciens ayant fait une contribution exceptionnelle à la recherche mathématique. Cette personne doit être membre de la communauté mathématique canadienne. Toute mise en candidature est modifiable et demeurera active pendant trois ans. Pour les renseignements, voir : **https://cms.math.ca/Prix/jw-nom**

Le ***Prix Krieger-Nelson*** rend hommage aux mathématiciennes qui se sont distinguées par l'excellence de leur contribution à la recherche mathématique. La lauréate doit être membre de la communauté mathématique canadienne. Toute mise en candidature est modifiable et demeurera active pendant deux ans. Pour les renseignements, voir : **https://cms.math.ca/Prix/info/kn**

La date limite pour déposer une candidature, qui comprendra au moins trois lettres de référence, est le **30 septembre 2016**. Le dossier de candidature doit comprendre le nom des personnes données à titre de référence ainsi qu'un curriculum vitae récent du candidat ou de la candidate. Nous vous incitons fortement à fournir des références indépendantes. Veuillez faire parvenir les mises en candidature et lettres de référence par voie électronique, de préférence en format PDF, à l'adresse électronique correspondante et **au plus tard le 30 septembre 2016** :

Coxeter-James : **prixcj@smc.math.ca**
Jeffery-Williams : **prixjw@smc.math.ca**
Krieger-Nelson : **prixkn@smc.math.ca**

# Jonathan M. Borwein (1951-2016)

It is with great sadness that the Canadian Mathematical Society announces the passing of our dear colleague and friend, Dr. Jonathan Borwein, Laureate Professor at the School of Mathematical and Physical Sciences and Director of the Centre for Computer-assisted Mathematical Research and Applications (CARMA) at the University of Newcastle in Australia.

Borwein completed an Honours Mathematics degree at the University of Western Ontario (1971) and received his Ph.D. from Oxford University (1974) as an Ontario Rhodes Scholar. He started his academic career at Dalhousie University (1974-1991) before moving to the University of Waterloo (1991-1993). In 1993, Dr. Borwein became the Shrum Professor of Science (1993-2003) and founded the Centre for Experimental and Constructive Mathematics (CECM) at Simon Fraser University (SFU). He later served as a Canada Research Chair in Information Technology (2001-2008) at SFU before returning to Dalhousie University in the Faculty of Computer Science as a Canada Research Chair in Distributed and Collaborative Research, with a cross-appointment in Mathematics (2004-2009).

In 2009, Jonathan and his family moved to Australia, where he accepted the position of Laureate Professor of the School of Mathematical and Physical Sciences at the University of Newcastle, while holding an adjunct appointment at Dalhousie University. The next year, Borwein was elected as a Fellow of the Australian Academy of Science. Soon after, he accepted a second adjunct professorship at Chiang Mai University in Thailand (2013 onwards). In 2015, he received the honour of becoming a Fellow of the American Mathematical Society and of the Royal Society of New South Wales. From April to July 2016, Jonathan Borwein served as the Distinguished Scholar in Residence at Western University from April to July.

"Jon was an extraordinarily productive and diverse researcher, widely recognized as one of the world's foremost practitioners of Experimental Mathematics," said CMS President Michael Bennett (UBC).

Dr. Borwein was passionate about promoting the advancement, discovery, learning and application of mathematics at both the local, national and global levels. Over several decades, he held various CMS Executive and Board appointments, including serving as Chair of the Electronic Services Committee (1995-1996), Editor-in-Chief of the CMS/Wiley Book Series (1998-2000), Editor-in-Chief of CMS/Springer Books in Mathematics (1998, 2000-2005), Chair of the Fundraising Committee (1999-2001), CMS President (2000-2002), Chair of the Advancement of Mathematics Committee (2001-2002) and Associate Publisher of CMS Books and Rich Media (2004-2007). He also served as delegate to the American Mathematical Society (AMS) Council (2000-2002), as the Governor at Large of the

*Continued on page 26*

La Société mathématique du Canada a le grand regret d'annoncer le décès de notre cher collègue et ami Jonathan Borwein, professeur lauréat à l'École des sciences mathématiques et physiques de l'Université de Newcastle, en Australie.

Titulaire d'un baccalauréat en mathématiques de l'Université Western Ontario (1971), M. Borwein obtient ensuite son doctorat de l'Université d'Oxford (1974) à titre de boursier Rhodes de l'Ontario. Il entame sa carrière professorale à l'Université Dalhousie (1974-1991), avant de faire le saut à l'Université de Waterloo (1991-1993). En 1993, à titre de Shrum Professor of Science (1993-2003), M. Borwein fonde le Centre pour les mathématiques expérimentales et constructives (CECM) de l'Université Simon Fraser. Titulaire de la Chaire de recherche du Canada en technologie de l'information à SFU (2001 à 2008), il décide ensuite de rentrer à l'Université Dalhousie, dans la Faculté d'informatique, pour occuper la Chaire de recherche du Canada en recherche distribuée et concertée, en plus d'un poste en mathématiques (2004-2009).

En 2009, Jonathan Borwein déménage en Australie avec sa famille afin d'occuper le poste de professeur lauréat de l'École des sciences mathématiques et physiques à l'Université de Newcastle, tout en conservant un poste de professeur auxiliaire à l'Université Dalhousie. L'année suivante, M. Borwein est élu membre de l'Australian Academy of Science. Peu après, il accepte un second poste de professeur adjoint, cette fois à l'Université de Chiang Mai, en Thaïlande (2013-2016). En 2015, il a l'honneur d'être reçu membre de l'American Mathematical Society et de la Royal Society of New South Wales. D'avril à juillet 2016, M. Borwein était chercheur invité en résidence à l'Université Western.

« Jon était un chercheur extraordinairement productif et polyvalent. Il était reconnu mondialement comme l'un des plus grands experts en mathématiques expérimentales », souligne le président de la SMC, M. Michael Bennett (UBC).

M. Borwein se passionnait pour la promotion de l'avancement, de la découverte, de l'apprentissage et de l'application des mathématiques à l'échelle locale, nationale et mondiale. Au cours de ses nombreuses années d'implication, il a occupé toute une série de postes au sein de la SMC : président du Comité des services électroniques (1995-1996), rédacteur en chef de la série d'ouvrages SMC-Wiley (1998-2000), rédacteur en chef des ouvrages de mathématiques SMC-Springer (1998, 2000-2005), président du Comité pour la collecte des fonds (1999-2001), président de la SMC (2000-2002), président du Comité pour l'avancement des mathématiques (2001-2002) et éditeur adjoint de CMS Books et de Rich Media (2004-2007). De plus, il a aussi été délégué auprès du conseil de l'American Mathematical Society (AMS) (2000-2002),

*Suite à la page 26*

## 2016 Excellence in Teaching Award

The CMS Excellence in Teaching Award Selection Committee invites nominations for the 2016 Excellence in Teaching Award.

The CMS Excellence in Teaching Award focuses on the recipient's proven excellence as a teacher at the undergraduate level, including at universities, colleges and cégeps, as exemplified by unusual effectiveness in the classroom and/or commitment and dedication to teaching and to students. The dossier should provide evidence of the effectiveness and impact of the nominee's teaching. The prize recognizes sustained and distinguished contributions in teaching at the post-secondary undergraduate level at a Canadian institution. Only full-time teachers or professors who have been at their institution for at least five years will be considered. The first award was presented in 2004.

The deadline for nominations, including at least three letters of reference, is **November 15, 2016**. Nomination letters should list the chosen referees and include a recent curriculum vitae for the nominee, if available. Nominations and reference letters should be submitted electronically, preferably in PDF format, to: **etaward@cms.math.ca no later than November 15, 2016**.

## Prix d'excellence en enseignement 2016

La Comité de sélection du Prix d'excellence en enseignement de la SMC sollicite des mises en candidature pour le Prix d'excellence en enseignement 2016.

Le Prix d'excellence en enseignement de la SMC récompense l'excellence reconnue d'un enseignant ou d'un professeur de niveau postsecondaire (universités, collèges et cégeps), telle qu'illustrée par son efficacité exceptionnelle en classe et/ou son engagement et son dévouement envers l'enseignement et les étudiants. Le dossier de candidature doit montrer l'efficacité et les effets de l'enseignement du candidat ou de la candidate. Ce prix récompense des contributions exceptionnelles et soutenues en enseignement collégial et de premier cycle universitaire dans un établissement canadien. Seules les candidatures d'enseignants et de professeurs à temps plein qui travaillent dans le même établissement depuis au moins cinq ans seront retenues. Ce prix a été décerné pour la première fois en 2004.

Les proposants doivent faire parvenir au moins trois lettres de référence à la SMC au plus tard **le 15 novembre 2016**. Le dossier de candidature doit comprendre le nom des personnes données à titre de référence ainsi qu'un curriculum vitae récent du candidat ou de la candidate, dans la mesure du possible. Veuillez faire parvenir les mises en candidature et lettres de référence par voie électronique, de préférence en format PDF, à : **prixee@smc.math.ca** avant la date limite du **15 novembre 2016**.

*Jonathan M. Borwein, continued from page 25*

Mathematical Association of America (MAA) (2005-2007) and Chair of the CMS International Affairs Committee (2004-2005).

Borwein was fundamental to the vision and the growth of the Canadian Mathematical Society. He held permanent seats on the CMS Special Consultations Group and the President's Advisory Committee where he was consistently prepared to offer insightful comments and guidance to the Board of Directors and the Presidents of our Society.

The CMS wishes to extend our sincere condolences to the family, friends and colleagues of Dr. Borwein. We are humbled to have been in the presence of a true visionary and leader, and we are truly grateful for his unwavering dedication to our rich and diverse community.

In a future issue, we plan to have articles commemorating Jonathan Borwein's research and his contributions to the Canadian Mathematical Society.

*Jonathan M. Borwein, suite de la page 25*

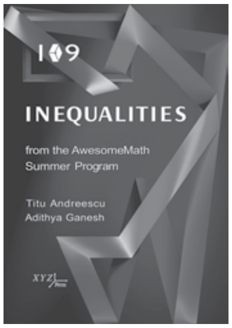
administrateur de la Mathematical Association of America (MAA) (2005-2007) et président du Comité des affaires internationales de la SMC (2004-2005).

Jonathan Borwein a joué un rôle essentiel dans la croissance de la Société mathématique du Canada et dans l'établissement de sa vision. Il occupait un siège permanent au Groupe de consultations spéciales de la SMC et au Comité consultatif du président, où il était toujours prêt à offrir ses commentaires et ses conseils judicieux aux membres du conseil d'administration et aux présidents de notre Société.

La SMC souhaite exprimer ses sincères condoléances à la famille, aux amis et aux collègues de M. Borwein. Ce fut un honneur d'avoir pu côtoyer un leader et un visionnaire de sa trempe, et nous sommes extrêmement reconnaissants pour son dévouement de tous les instants envers notre communauté riche et diversifiée.

Dans un prochain numéro, nous prévoyons avoir des articles commémorant la recherche de Jonathan Borwein ainsi que ses contributions à la Société mathématique du Canada.

# NEW BOOKS FROM THE AMS




## 109 Inequalities from the AwesomeMath Summer Program

**Titu Andreescu**, *University of Texas at Dallas, Richardson, TX,* and **Adithya Ganesh**, *Stanford University, CA*

Explore the theory and techniques involved in proving algebraic inequalities.

A publication of XYZ Press. Distributed in North America by the American Mathematical Society.

**XYZ Series**, Volume 16; 2015; 203 pages; Hardcover; ISBN: 978-0-9885622-8-8; List US$59.95; AMS members US$47.96; Order code XYZ/16

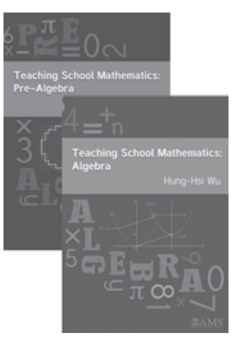

## The Case of Academician Nikolai Nikolaevich Luzin

**Sergei S. Demidov**, *Russian Academy of Sciences, Moscow, Russia* and **Boris V. Lëvshin**, Editors

Translated by Roger Cooke

This book chronicles the 1936 attack on mathematician Nikolai Nikolaevich Luzin during the USSR campaign to "Sovietize" all sciences.

**History of Mathematics**, Volume 43; 2016; 416 pages; Hardcover; ISBN: 978-1-4704-2608-8; List US$59; AMS members US$47.20; Order code HMATH/43




## Teaching School Mathematics: From Pre-Algebra to Algebra

**Hung-Hsi Wu**, *University of California, Berkeley, CA*

This two-volume set includes a systematic exposition of a major part of the mathematics of grades 5–9 (excluding statistics) written specifically for Common-Core era teachers.

Parts 1 and 2 available for individual sale.

Set: 2016; approximately 667 pages; Hardcover; ISBN: 978-1-4704-3000-9; List US$90; AMS members US$72; Order code MBK/98/99


## Gallery of the Infinite

**Richard Evan Schwartz**, *Brown University, Providence, RI*

This book is a mathematician's unique view of the infinitely many sizes of infinity.

2016; 187 pages; Softcover; ISBN: 978-1-4704-2557-9; List US$29; AMS members US$23.20; Order code MBK/97


## Socks Are Like Pants, Cats Are Like Dogs

Games, Puzzles & Activities for Choosing, Identifying & Sorting Math!

**Malke Rosenfeld** and **Gordon Hamilton**

*"Mathematical thinking and calculating are two different things. Of the two, the former skill is far more important to develop than the latter, especially today, when electronic calculators and computers are everywhere. Young children, who may know nothing of calculating, can be remarkably good at mathematical thinking. They do it naturally in their play. The puzzles in this book are meant to be approached playfully, and they help children build upon their natural capacities for mathematical thought."*

*—**Peter Gray**, Research Professor, Boston College, and author of "Free to Learn: Why Releasing the Instinct to Play Will Make Our Children Happier, More Self-Reliant, and Better Students for Life"*

Explore the mathematics of choosing, identifying, and sorting through a diverse collection of math games, puzzles, and activities.

A publication of Delta Stream Media, an imprint of Natural Math. Distributed in North America by the American Mathematical Society.

**Natural Math Series**, Volume 4; 2016; 84 pages; Softcover; ISBN: 978-0-9776939-0-0; List US$15; AMS members US$12; Order code NMATH/4

AMS Bookstore
bookstore.ams.org

(800)321-4267 (U.S. & Canada),
(401)455-4000 (Worldwide)

facebook.com/amermathsoc
@amermathsoc
plus.google.com/+AmsOrg

# Mathematical Congress of the Americas
# Congrès Mathématique des Amériques

# MCA 2017

## July 24-28 juillet Montréal, Canada

The second Mathematical Congress of the Americas (MCA) will take place on July 24-28, 2017, at Centre Mont-Royal and McGill University, Montreal, Canada. The congress is expected to attract mathematicians and students from throughout North America, Central America, South America and the Caribbean.

MCA 2017 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** (MCofA). MCA 2017 is being supported by a Canadian 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.

There will be a large number of special sessions. Follow this link to view the confirmed scientific sessions: **https://mca2017.org/program/scientific-program**

Registration opening soon!

Le deuxième Congrès mathématique des Amériques (CMA) aura lieu du 24 au 28 juillet 2017 au Centre Mont-Royal et l'Université McGill, à Montréal, Canada. 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 CMA 2017 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** (MCofA). Le CMA 2017 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.

Un grand nombre de sessions spéciales seront au programme. Consultez la page **https://mca2017.org/program/scientific-program** pour voir les sessions confirmées.

La période d'inscription commencera bientôt!

**mca2017.org** **mca2017.org/fr**

**If undelivered, please return to:**
**Si NON-LIVRÉ, veuillez retourner à :**

**CMS Notes / Notes de la SMC**
209 - 1725 St. Laurent Blvd Ottawa, ON K1G 3V4 Canada